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Enhanced Optical Response of Al, Rh, Ag, and Au Nanosphere Dimer in Uniform Electric Field

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ABSTRACT

Localized Surface Plasmon Resonance (LSPR) mediated electromagnetic field enhancement play a vital role in enhancing the performance of bio-molecular sensors, photovoltaic cells and Raman spectroscopy (e.g., in SERS) etc., to name only a few. It is now well established that the field amplification factor (mode squared field) ~10^6 for spherical shaped plasmonic nanoparticle dimers is significantly higher than the amplification factor of a monomer which is ~10^3. In this work, a theoretical and semi-analytical approach based on multipole spectral expansion is used to investigate the electric field enhancement in the gap region of spherical nanoparticle dimers of Al, Rh, Ag, and Au. The dimer exhibit rich spectra compared to its isolated counterpart. For example, in contrast to a monomer, the dimer spectra consists of multiple resonant peaks which can be fine tuned by varying particle size and/or inter-particle separation. Moreover, the enhancement in dimer is several orders higher than that in monomers. Rich spectral features in dimer spectra arise from the interaction between particle plasmons of constituent NPs and their hybridization, which results in the splitting of plasmonic energy levels. We carry out, systematic investigation of these systems to quantify the effect of particle size, interparticle separation and metal type (Al, Ag, Au, Rh) on electric field enhancement.

Keywords**:** Enhancement, nanoparticle, dimer, plasmonics, hybridization

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1. INTRODUCTION

The recent explosive progress in Plasmonic Nanostructures has been based on the optical properties of metallic nanoparticles. The appeal of surface plasmon excitations at metal dielectric interface due to huge and various applications typically arise due to large electromagnetic field enhancement near metallic nanoparticles.

Recently the near field enhancement in the vicinity of metallic nanostructures upon excitations of their surface plasmon resonances have attracted substantial attention and are used to amplify linear optical effects, such as surface enhanced Raman spectroscopy [1], surface plasmon enhanced photoluminescence, fluorescence [2] and also support many non-linear optical process like second/ third harmonic generation [3], two photon absorption induced luminescence [4].

The optical response or electric field enhancement of Plasmonic nanostructures is strongly dependent on geometry as well as combination of plasmonic nanostructures. For example isolated spherical nanoparticle shows electric field enhancement of the order of 103 which is quite insensitive for SERS measurements. Moreover in case of spherical nanoparticle the spectrum can be tuned by varying the radius of nanoparticle and dielectric constant of embedded medium. A class of new plasmonic nanoparticle called core@shell or nanoshell (NSH) which is widely used in medical and spectroscopic measurement due to more tunable properties. NSH consist of core material coated by concentric thin shell layer [5, 6].

This feature of NSH makes more tunable and adjustable for different applications. Nanoshell also supports the plasmon resonances and gives a relatively large electric field enhancement (10^4) as compared to isolated spherical nanoparticle (10^3). But for SERS measurement (detection of single molecule technique), this electric field enhancement is not sufficient. To amplify this field enhancement, dimer geometry is an appropriate choice for SERS enhancement. Monomer and dimer geometry shows drastically different optical response.

This different behavior can be easily understood by hybridization theory [7]. Nanoparticle dimers are useful for researchers because they have large electromagnetic field enhancements in the gap region due to particle-particle interaction. The plasmonic properties of nanoparticle dimers have been studied by various methods [8, 9], but still there is a wide scope to harness the unexplored potentials in the field of plasmonics.. A quantam mechanical approach is used to study the plasmon resonances of dimer system as a function of interparticle separation.

It is analyzed that for above 1 nm interparticle separation, classical electromagnetic theory is obeyed to study the dimer plasmons [10]. Finite element method (FEM) is used to study the optical response of core shell silver nanoparticle dimer in the visible region as a function of inter surface gap [11]. Here we consider coupled nanosphere (dimer) placed in uniform electric field. For proposed geometry, specific multipoles can be choosing according to system parameters. Inspite of direct solution, we consider Multipole spectral expansion method MSE) based approach for the present study.

The manuscript is organized as follows. Section II describes the theoretical formulation of the problem and its implementation to NSP Dimer. Sec. III includes the results discussion. Finally, Sec. 4 presents summary with significant remarks and future scope of the work.

2. THEORY

Schematics of the system which consist nanosphere dimer placed in uniform electric field is shown in Fig. 1. To extend MSE based approach to the nanosphere dimer, an interaction matrix approach based on using the eigenstates of the single inclusion has been used. In this picture, we consider a plasmonic system consisting of two nanospheres having interparticle separation S. The centre of one nanosphere can always be considered at the origin (here Left) and hence the centre of other nanosphere (here Right) will always be shifted relative to the origin.

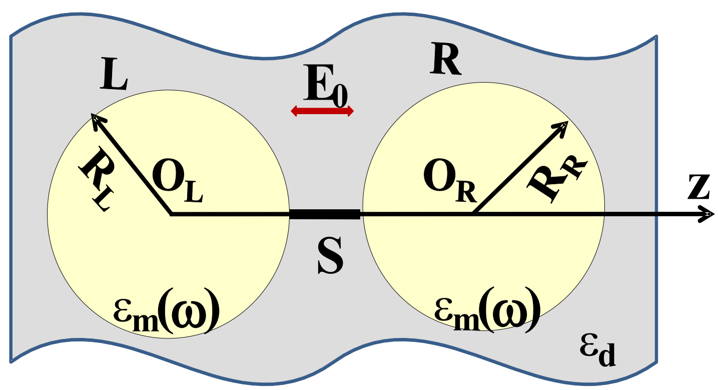

Figure 1. The schematic of dimer system of coupled spherical nanoparticles (SNPs) under consideration. Here, left and right NPs are labeled as L and R, their centre as O_L and O_R and their radii as RL and RR, respectively. Both NPs are considered embedded in a homogeneous dielectric medium (ε_d). The dimer system is exposed to homogenous external electric field Eo along z-direction which excites localized surface plasmons (LSPs) of NPs.

To analyze such a plasmonic system relative to a common origin, the eigenstates of this nanosphere will have to be expressed relative to defined common origin. In order to deal with a nanosphere which is not centered at the origin, we need to make transformation of eigenstates. In such a case, the function consisting of multipoles has to be expanded about the shifted origin. Both metallic nanospheres may be described through frequency dependent dielectric function, $\varepsilon_m(\omega\omega$ and assumed to be embedded in a host medium characterized by its dielectric permittivity, εd. This system is placed in a uniform external electric field ($\vec{E} = E_0\hat{z}$) of magnitude E0 and directed along +z-direction (or, external potential $\Phi_{ext} = -E_0 z = -E_0 r\cos\theta$). The presence of the nanosphere dimer modifies the potential or electric field. By using proposed numerical approach which is valid within quasi-static approximation, the general expression for the potential at point P, outside the inclusion is given by

$$\Phi_{induced}(\mathrm{r}) = \sum_{\lambda}\sum_{l}\sum_{l'} \frac{s_{l'}}{s(\omega) - s_{\lambda}} \left(I_{L,l} B_{Ll}^{\lambda} + I_{R,l} B_{Rl}^{\lambda}\right)\left[(B_{Ll'}^{\lambda})\psi_{L,l'}(\mathrm{r}) + (B_{Rl'}^{\lambda})\psi_{R,l'}(\mathrm{r})\right]$$

By solving overlap integrals, calculating dimer matrix element and eigenfunctions of left & right sphere in above Eq., we get the induced potential, $\Phi_{induced}(\mathrm{r})$ at a given position r. The overall electrostatic potential in the gap region is obtained by adding external potential and induced potential. The evaluation of electric potential is done at two neighboring positions and electric field is then calculated using basic relation, $\mathbf{E} = -\nabla\Phi$.

3. RESULTS AND DISCUSSION

This section provides the results of our investigations based on theoretical approach described in Sec. II. Present study considers plasmonic nanoparticles (PNPs) made of aluminum ($_{13}$**Al**), silver ($_{47}$**Ag**), gold ($_{79}$**Au**) and rhodium ($_{45}$**Rh**) in spherical, core@shell (NSH) and dimer configuration. Radius of each constituent nanoparticle is denoted by R, aspect ratio (a/R) of core @shell (NSH) is denoted by x and the interparticle separation (surface to surface) in dimer configuration is denoted by S. Unless mentioned otherwise, both plasmonic nanoparticles (PNPs) in the dimer system will be considered spherical in shape and identical in size (R) and composition ($\varepsilon_m(\omega)$).

The optical response of PNPs is described through photon energy (ħω) dependent optical constants of Johnson and Christy for Au and Ag [12], A. D. Rakic for Al [13], and Palik for Rh [14].

The field amplification factor $A(\omega) = \left|\frac{\mathbf{E(r)}}{\mathbf{E}_0}\right|^2$. as a function of ħω of isolated spherical nanoparticles of Ag, Al and Au is presented in Fig. 2.

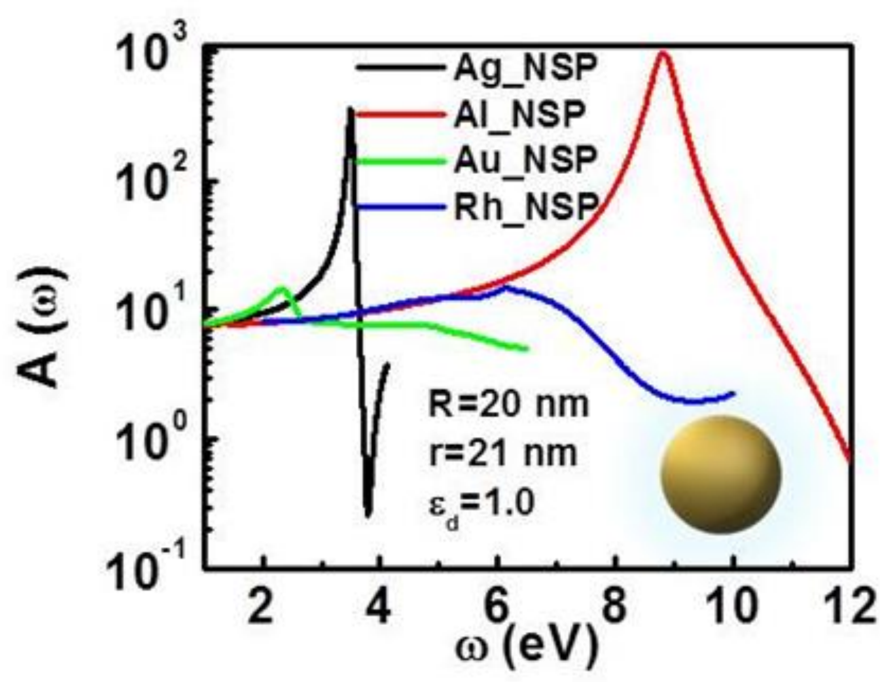

Figure 2. Amplification factor A(ω) as a function of ħω for isolated spherical nanoparticles of Ag, Al, Au and Rh of nanoparticle radii, R = 20 nm embedded in a medium of dielectric constant εd = 1.0

In Fig. 2, shows the field amplification spectrum as a function of energy (eV) of isolated spherical nanoparticle (NSP) at observation point, r = 1.0 nm away from the particle surface. it is observed that in case of isolated spherical nanoparticle, the electric field amplification factor is the order of 10^3. In case of isolated spherical nanoparticle, silver shows field amplification is 3.27×10^2 at 3.43 eV, aluminium shows field amplification 1.07×10^3 at 8.79 eV, gold shows field amplification 1.3×10^1 at 2.32 eV and rhodium shows field amplification 1.54×10^2 at 5.98 eV. It is noticed that the field amplification spectrum in case of isolated spherical nanoparticles is not sufficient for many applications like SERS measurements. Only single peak is observed and tuning parameters is very less for isolated nanoparticle.

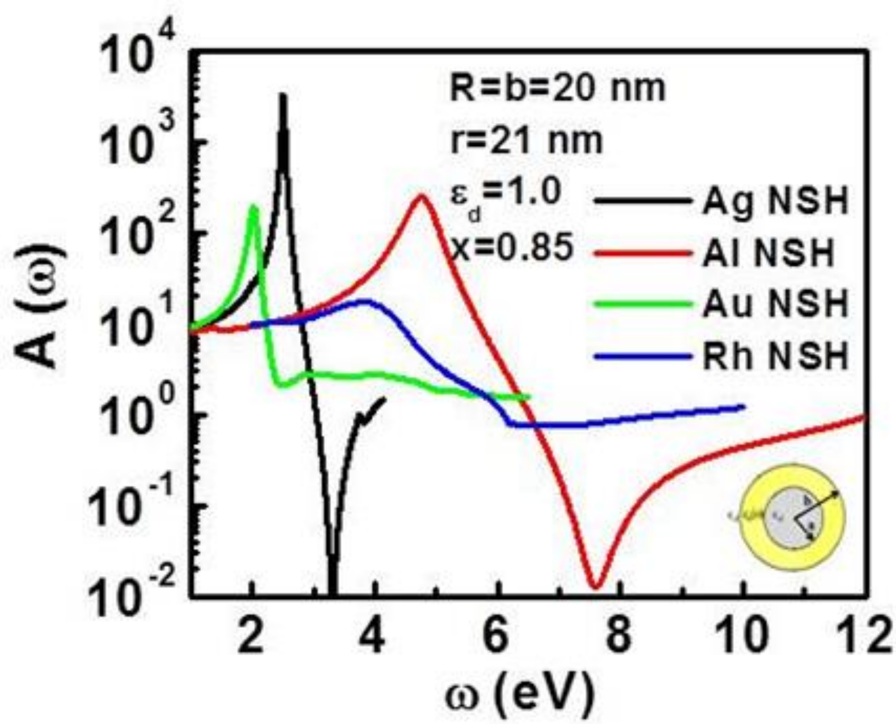

Figure 3. Amplification factor A(ω) as a function of ħω for core@shell (NSH) nanoparticles of Ag, Al, Au and Rh of nanoparticle radii, R = 20 nm embedded in a medium of dielectric constant ε_d = 1.0.

It is observed that in this case the field amplification is the order of ~10^3 to 10^4. Silver shows field amplification is 3.8×10^3 at 2.48 eV, aluminum shows field amplification 2.60×10^2 at 4.80 eV, gold shows field amplification 1.85×10^2 at 1.99 eV and rhodium shows field amplification 1.7×10^1 at 3.88 eV. NSH geometry has superior to NSP geometry due to more spectral tuning options. By changing aspect ratio, the spectrum can be tuned in desired spectrum region. But still, the field amplification in case of NSH geometry is also quite insensitive for SERS measurements. To overcome this bottle neck, dimer geometry is used to calculate the field amplification factor which can be used for SERS measurements. Fig. 3. shows the spectral variation of electric field enhancement with photon energy (eV) of Ag, Al, Au and Rh in dimer configuration.

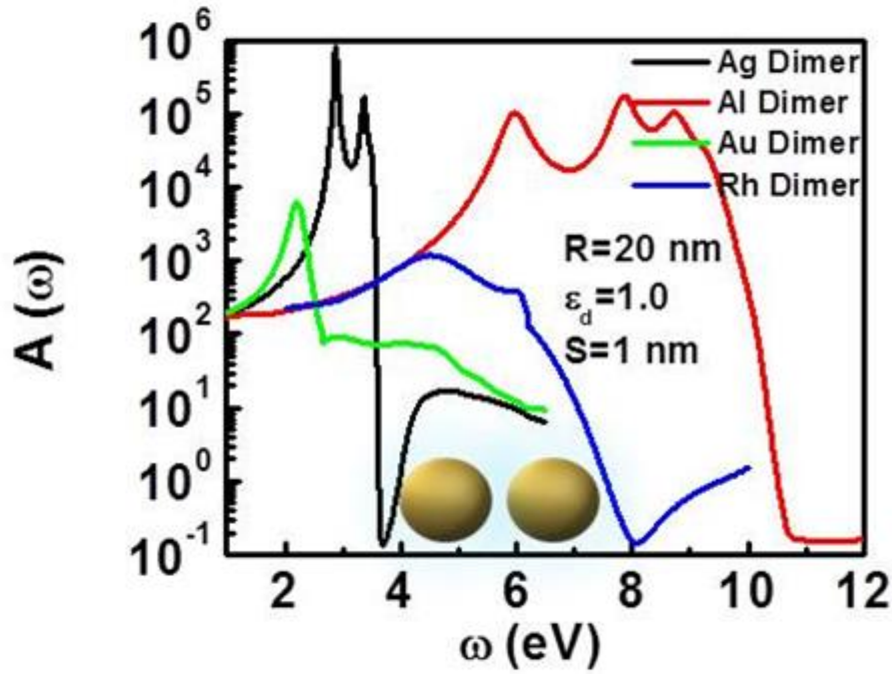

Figure 4. Amplification factor A(ω) as a function of ħω for nanosphere dimer nanoparticles of Ag, Al, Au and Rh of nanoparticle radii, R = 20 nm embedded in a medium of dielectric constant εd = 1.0. Surface to surface separation (S) is 1 nm.

The important observations of Fig. 4 are summarized as follows: (I) the multiple peaks are observed in dimer configuration (II) multiple resonant peaks showing field amplification of order of $\sim 10^6$. (III) It is also found that resonant position for silver is 2.86 eV/ 7.1×10^5, aluminum is 5.93/1.0×10^5, gold is 2.21 eV/ 7.1×10^3 and rhodium is 4.42 eV/ 1.34×10^3 in dimer.

Silver and gold shows resonant peaks in visible or near infrared region, while resonant peaks of aluminium and rhodium lies in Deep-UV region of spectrum. The electric field enhancement is due to the interaction between surface plasmon modes of two nanosphere in the presence of electric field.

4. CONCULSION

A theoretical model for Electric Field Enhancement or field amplification of Nanosphere (NSP) dimer is used using Multipole Spectral Expansion method. The proposed model is efficient to deal with other complex geometry. For the system means NSP dimer $\sim 10^6$ order field enhancement is predicted. Role of higher order multipoles are explored.

We have investigated the field enhancement behavior of Al, Rh, Ag, and Au nanoparticle dimers, covering UV-Vis spectral rang which enables to deal with SERS spectroscopic measurements due to extensive exhibit tunable optical properties.

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2-Repeated Solid Burst Error Detecting Cyclic Codes

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ABSTRACT

In modern era, coding theory has found various applications in almost every field whether it is theoretical or practical. Such as: digital data transmission, medical science, space science, geographical sciences etc. It is natural that bursts have different behavior in different channels. But the burst errors are found to occur mostly in various communication channels. In some of the systems, lightening and other short term irregular disturbances introduce various types of repeated burst errors. Usually they operate in such a way that over a specific length, some digits in a message are received correctly, while all other are corrupted. It is very common in some extra noisy channels that all the digits in a burst are corrupted. Such type of errors is called 'solid burst errors'. It may also be mentioned that cyclic codes play a significant role in error detection and correction. In this paper, we obtain results for cyclic codes that are capable of detecting 2-repeated solid bursts of length *b*.

Keyword: Repeated solid burst errors, cyclic codes, burst error detection, parity-check digits

1. INTRODUCTION

It is perceptible that from last few decades, communication devices and computing have become essential parts of human life. Although current communication devices are very efficient and reliable yet unlimited usage causes interrupted data transmission. There may be any cause of that e.g., server fading, call-drop, dynamic noise, jamming multi access interference etc. These problems arise due to the occurrence of various types of multiple burst errors in the channel in use.

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Among the various types of errors, known so far, repeated solid burst error is much more frequently occur in a very busy channel. The study of this particular error was introduced by Das [6]. Basically repeated solid burst error can be considered as an extension of the solid burst error [1] combined with repeated burst error [5]. Under specific consideration, repeated solid burst error is a generalization of random errors.

The study of burst errors, respective of cyclic codes, has always been centre of attraction for researchers as cyclic codes have very interesting mathematical structure and can easily be implemented using shift registers. Following this fact, Jain [4] obtained results for cyclic codes detecting Moderate-density open-loop burst error detection for cyclic codes.

In this paper, our study is précised to cyclic codes detecting 2-repeated solid burst errors.

The paper is organized as follows:

Section 2 presents basic definitions related to our study.

In section 3, results on cyclic codes for the detection of 2-repeated solid bursts are obtained.

In section 4 represents the conclusion of the paper. Some future scope for the study is also given in this section.

2. PRELIMINARIES

Definition 1: A *solid burst of length* b is a vector with non-zero entries in some b consecutive positions and zeros elsewhere.

Example 1: (000**111111**) is a solid burst of length 6 over $GF(2)$.

A 2-repeated burst of length b may be defined as follows:

Definition 2: A *2-repeated burst of length* b is a vector of length n whose only non-zero components are confined to two distinct sets of b consecutive components the first and the last component of each set being non zero.

Example 2: (0**110101**00**110111**) is a 2-repeated burst of length 6 over $GF(2)$.

Definition 3: A *2-repeated solid burst of length* b is a vector with non-zero entries in some b consecutive positions of two distinct sets and zeros elsewhere.

Example: (00**11**000**11**) is a 2-repeated solid burst of length 2 over $GF(2)$.

3. 2-REPEATED SOLID BURST ERROR DETECTING CYCLIC CODES

Theorem 3.1: *Any 2-repeated solid burst-error, each of length up to n-k digits, can be detected by an (n, k) cyclic code.*

Proof: It is clear that a 2-repeated solid burst will have two segments each having b consecutive non-zero entries. Let, the first segment starts from *ith* position where $1 \le i \le n-2b$ and is of the form $x^i T_1(x)$, where $T_1(x)$ is a polynomial of degree $(b-1)$. The second segment then will start from $(i+j+b)th$ position where $1 \le j \le n-b$ and will be of the form $x^{i+j+b} T_2(x)$, where $T_2(x)$ is a polynomial of degree $(b-1)$.

So let,

$$T(x) = x^i T_1(x) + x^{i+j+b} T_2(x), \tag{3.1}$$

be a 2-repeated solid burst, each burst having length $b \geq 1$. If $\phi(x)$ is the codeword transmitted, then with $T(x)$ as error, the received n-tuple $\phi'(x)$ is given by

$$\phi'(x) = T(x) + \phi(x), \tag{3.2}$$

or

$$\phi'(x) = (x^i T_1(x) + x^{i+j+b} T_2(x)) + \phi(x)$$

Thus,

$$\{\phi'(x)\}_{g(x)} = \{(x^i T_1(x) + x^{i+j+b} T_2(x)) + \phi(x)\}_{g(x)}. \tag{3.3}$$

where: $\{\phi'(x)\}_{g(x)}$ is the remainder polynomial that is obtained after dividing the n-tuple by the generator polynomial $g(x)$.

Now the syndrome, obtained in (3.3) must be zero. For this $g(x)$ must divide $(x^i T_1(x) + x^{i+j+b} T_2(x))$. But $g(x)$ is not divisible by x because $g(x)$ divides $x^n - 1$. This concludes that x^i and x^{i+j+b} both are relatively prime to $g(x)$. Hence $g(x)$ must divide both $T_1(x)$ *and* $T_2(x)$. But it is impossible because

$$\deg g(x) = n - k, \tag{3.4}$$

and

$$\deg T_1(x) = \deg T_2(x) = b - 1 < n - k = \deg g(x). \tag{3.5}$$

Therefore, $T(x)$ cannot be a codeword and it will be detected.

This proves the theorem.

Theorem 3.2: *The fraction of 2-repeated solid bursts of length b> n-k that can go undetected by any (n, k) cyclic codes is*

$$\begin{cases} \dfrac{2q^{-2(n-k-1)}}{(n-2b+1)(n-2b+2)(q-1)^2} & \text{if } b = n-k+1 \\ \dfrac{2}{(n-2b+1)(n-2b+2)}\, q^{-2(n-k)} & \text{if } b > n-k+1. \end{cases} \tag{3.6}$$

Proof: Let us consider 2-repeated solid bursts of length $b \geq 1$. Each such burst will be of the form

$$T(x) = (x^i T_1(x) + x^{i+j+b} T_2(x)), \tag{3.7}$$

where: $T_1(x)\, and\, T_2(x)$ have degree $(b-1)$ each. There are $(q-1)$ choices for the each component of both sets. Thus there are $(q-1)^{2b}$ distinct polynomials $T_1(x)\, and\ T_2(x)$.

The error will go undetected if and only if $T_1(X)\, and\ T_2(X)$ have $g(X)$ as a factor, that is

$$T_1(x) = g(x)R_1(x),$$

$$T_2(x) = g(x)R_2(x).$$

Since $g(x)$ has degree $(n-k)$, $R_1(x)$ and $R_2(x)$ both must have degree $b-1-(n-k)$. If $b-1=(n-k)$, then $R_1(x)$ and $R_2(x)$ are nonzero constants and there are $(q-1)^2$ values they may take. The ratio of undetected 2-repeated solid bursts to the total number of 2-repeated solid bursts is, refer [6],

$$\frac{(q-1)^2}{\frac{(n-2b+1)(n-2b+2)}{2}(q-1)^{2b}} = \frac{q^{-2(b-1)}}{\frac{(n-2b+1)(n-2b+2)}{2}} = \frac{2q^{-2(n-k)}}{(n-2b+1)(n-2b+2)}.$$

Now if $b-1 > (n-k)$, $T_1(x)$ may have any of the $(q-1)$ non- zero field element as its each coefficient. There are therefore, $(q-1)^b$ choices of $T_1(x)$ which give undetected error patterns. Similarly, there are $(q-1)^b$ choices of $T_2(x)$ which give undetected error patterns.

The ratio in this case is

$$\frac{(q-1)^{2b}}{\frac{(n-2b+1)(n-2b+2)}{2}(q-1)^{2b}} = \frac{2}{(n-2b+1)(n-2b+2)}.$$

This proves the result.

4. CONCLUDING REMARKS

The results, presented in this paper, are inspired by the study of cyclic codes detecting burst errors by Peterson and Weldon [3].Such type of errors generally occurs in channels like super computers, space communication and semiconductor devices. By developing such codes, the number of parity-check digits required can be economized and hence the efficiency of the transmission of the code through anoisy channel can be increased.

Moreover, results obtained in this paper are with the consideration of Hamming weight. One can do similar study in a more generalized manner by considering other types of weight such as Lee weight, Sharma- Kaushik weight, Euclidean weight, generalized Hamming weight etc.

Remark 1: Technique used here to prove the results is based on [2].

Remark 2: It is clear from results obtained here that if we consider bursts of length 1 then the error pattern is same as of random errors. This verifies that repeated solid burst errors are generalization of random errors.

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CHAPTER 10

ANALYZING LONG-TERM BENEFITS IN THE FACE OF HIGHER UPFRONT COSTS FOR GREEN AFFORDABLE HOUSING: A STUDY OF GHAZIABAD, UP (INDIA)

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10.1 INTRODUCTION

A green building is one which uses less water, optimizes energy efficiency, conserves natural resources, generates less waste, and provides healthier spaces for occupants as compared to a conventional building. Considering the tremendous benefits that it offers, green building concept is gaining major importance in India. A common man wants an affordable house to live in which may fit in his pocket whereas the demand of the society is to go green as the pollution is increasing day by day. Affordable housing refers to housing units that are affordable by that section of society whose income is below the median household income. Though different countries have different definitions for affordable housing, it is largely the same, that is, affordable housing should address the housing needs of the lower or middle-income households. Affordable housing becomes a key issue especially in developing nations where a majority of the population is not able to buy houses at the market price.

To go green with green building is a bit costlier for common man somehow in the short run but studies say that a green building uses less water, optimizes energy efficiency, conserves natural resources, generates less waste, and provides healthier spaces for occupants, as compared to a conventional building which becomes quite cheaper in long run. Hence, there are four basic elements of the green building that is smart design, energy efficiency, eco-materials, water conservation (Cleveland, 2012).

According to urban Economist Mark Smith and architect Deborah Weintraub, green building "includes three important components: resource conservation during design and construction, resource conservation during operations, and protection of occupants' health, well-being, and productivity." Others emphasize the protection of more ephemeral things like "community and cultural sensitivity," saying that green projects "blend in with the natural environment and protect open space, increase a sense of community, and address cultural issues."

The Government of India has already taken too much initiative toward Go Green. The green buildings are identified by the environment ministry on the basis of the use of water\energy conservation methods, recycled materials, solar power, natural lighting, and energy self-sufficiency under "Go Green" initiatives. Apart from this, The Indian Green Building Council (IGBC), part of the Confederation of Indian Industry (CII) offers a wide array of services which include developing new green building rating programs, certification services, and green building training programs. In spite of having so many facilities and services, the real estate world, as well as the residents, are still not so much concerned about the urgent need for green housing. Keeping this in view, the present study is focused on the following:

1. This chapter aims to highlight the said three issues related to green housing and to identify why affordability of such house becomes unreachable due to higher upfront cost. An analysis is proposed for its long-term benefits against the inclusive higher cost of green housing.
2. A systematic review of green housing is discussed with a review of related literature. Primary data is analyzed which was collected through personal interview with 300 respondents from Ghaziabad, Raj Nagar Extension, Vasundhara, Sahibabad of Uttar Pradesh (India).
3. This study reveals that India is still lagging behind in the effective implementation of green housing concepts due to the high cost

involved in construction. This may be justified that "if the intention is to construct a new home to live in, it is advisable to go for a green home rather than the ordinary conventional home. Because the percentage increase of 12.94% in the total cost is not a negligible amount when the intention is just to renovate or retrofit an old home."
4. The research is based on original thought and views collected from respondents and reliable resources.
5. This research will benefit the researchers, academicians, innovators, real estate business, residents, and so forth.

10.2 ENVIRONMENTAL ISSUES

The environment is not only a huge area in which we keep on living but also a huge ecosystem in which millions of creatures live. The environment provides raw materials for the economy. This raw material gained through the production process turns out to be a consumer product. Then, these raw materials and the energy used in production return to the environment as pollution. Therefore, sustainability of environment is reasonably important with regard to economic development (Kolukisa, 2012).

In relation to the environment, the first comprehensive arrangements concerning international cooperation have been considered in the early 1970s. In 1972 in Stockholm "United Nations Human Environment Declaration" (Stockholm declaration), the first global evaluation of many countries whose socioeconomic structures and development levels differ from one another was accepted. Sustainable development concept was first defined in 1987 with the Brundtland Report, prepared by World Commission on Environment and Development and since then began to be widely used.

One of the important developments which support the sustainable development vision has come into effect with the 1992 Rio Earth Summit. Rio Earth Summit, the largest meeting including 172 countries as well as India, was an important meeting in which the said countries have approved of the economic and global issues to be achieved in accordance with the environmental values and sustainable development principles.

At this summit conclusion regarding sustainable development were declared in a declaration called "Agenda 21." In spite of not being legally bounding, with this declaration, the countries' political responsibilities about the environment are defined. In Agenda 21, some basic principles of sustainable development which focus on the environmental dimensions are:

- Humankind is the center of sustainable development. She/he has the right to have a healthy and efficient life in accordance with nature.
- On condition that they are not disturbing other countries' environment, all countries have the right to use their natural resources according to their own politics.
- In view of "right to development for current and forthcoming generations," it is required to acknowledge the environment and mankind.
- Environmental protection should be seen as a complementary part of the development process.
- In terms of ecosystem protection and development, countries shall cooperate in global association spirit.
- In environmental protection, countries have common but different levels of responsibility.
- National authorities, in terms of "the one who pollutes pays it" principle, should make the environmental costs international and the use of economic devices improved.

As to activities, which have effects beyond borders, the activist country should inform the related countries in time and provide them with necessary information.

Briefly, the living environment provided by sustainable development means using of water resources so carefully that current and forthcoming generations can benefit adequately, keeping the weather clean in order to breath fresh air, making use of the benefaction of nature, and living in good health today and in the future (Taylor, 2012).

Providing sustainable development is not only limited to management of natural resources, supplying equipment, or controlling them but also to their proper utilization and allocation. Individuals should fulfill their duties as responsible citizens in order to achieve sustainable development with regard to environmental protection. Therefore, it is compulsory that individuals be taught in the subject of sustainable development education beginning from primary school, as well as making them aware of the environment.

UNESCO (2003) has declared the vision of sustainable development education as "societies should work in order to improve their level of civilization and economical power while being aware of the value of natural resources." Sustainable development education improves the ethical attitudes, which are necessary for lifetime learning, and encourages us to use the natural resources necessary for our planet according to our needs. The aims of sustainable development education in terms of the environment are:

- Improving the perception in accordance with economy and environment, and resulting in social peace.
- Encouraging the studies for the protection and improvement of the values of people living in the ecologic and social environment.
- Altering the daily behavior of individuals for supporting sustainable development.
- Preparing individuals as active and participant citizens working for their society and environment.

There are additional urgent needs associated with the investments in infrastructure. The first is the global challenge to the Earth's environment including the long-term availability of nonrenewable resources, concentrations of pollution and waste from human activity, and global climate change. For example, the recent report from the Intergovernmental Panel on climate change could not have been clearer regarding the impact of human activity on global climate change and its potential impact on the planet. People may disagree on the causes of climate change and the exact nature and severity of the impact, but there is a near-universal acknowledgment that the planet is warming, the climate is changing, and resources are being depleted. The impact of human activity upon the environment is not limited to climate change alone. For example:

- Poor land management and the overuse of fertilizer are causing land degradation, soil erosion, and desertification on a massive scale in agricultural areas from the Amazon to the Yangtze.
- One-third of the world's population does not have access to adequate sanitation.
- Armed conflict affects more than 20 of the world's 34 poorest countries, mainly in Africa.
- Almost half the world's population will be living in areas of high water stress by 2030.
- Irrigation accounts for 70% of the world's water demand. More than half the water distributed by irrigation systems is lost due to leaks and wasteful practices.

Clearly, the action is required if we intend to sustain a planet that can support a human society in perpetuity that provides the opportunity for all people to realize the quality of life enjoyed in the developed world. The choice is ours that we go for a global society in regard to infrastructure investments that will directly affect the level of the quality of human life and the long-term health of the planet.

10.3 ISSUES ON ENERGY, ENVIRONMENT, SUSTAINABLE CONSTRUCTION, AND BUILDINGS

Indian construction industry is one of the largest in terms of economic expenditure, the volume of raw materials/natural resources consumed, the volume of materials and products manufactured, employment generated, environmental impacts, and so forth. A large variety of materials are manufactured and consumed in the construction industry (UNESCO, 2003). Production levels and energy expenditure of some of the building materials consumed in bulk quantities are given in Table 10.1. Total energy expenditure on bricks, cement, aluminum, and structural steel consumed in bulk quantities is 1684×10^6 GJ per annum. It has been estimated that 22% of greenhouse gas (GHG) emissions are contributed by the construction sector in India. There is an ever-increasing demand for building materials. For example, demand for houses has doubled in about two decades from 1980. Projected demand for the building materials like bricks, steel, and cement consumed in bulk quantities is given in Table 10.2. Compounded growth rates of 2.5, 5, and 5% have been assumed for bricks, steel, and cement, respectively, to compute the projected demand. In case of brick making activity, at present topsoil equivalent of 300 mm from 100,000 ha (1000 sq km) of fertile land, 22×106 t of coal and 10×10^6 t of biomass are consumed annually. We have an arable land area of 1.62×10^6 sq km comprising alluvial, black, red, laterite, and desert soils. Alluvial, laterite, and red soils are suitable for brick making. The area under the soils suitable for brick making may not exceed 50% of the arable land. Brick-making activity to meet the present and future demand can result in consuming the 300 mm depth fertile topsoil of arable land in about 90 years (assuming 2.5% compounded growth rate).

TABLE 10.1 Volume and Energy Consumption of Building Materials in India.

Material	Volume of materials manufactured per annum	Thermal energy (MJ per kg)	Total energy (GJ)
Bricks	160×10^9 nos.	1.5	650×10^6
Cement	98×10^6 t	4.25	410×10^6
Structural steel	14×10^6 t	45.0	476×10^6

Similarly, the pressure on raw materials like limestone to manufacture cement and energy requirements to produce these materials has to be addressed. Production of building materials has slowly and steadily moved from highly decentralized and labor-intensive methods and processes to centralized, machine-dependent industry mode. Centralized mode of production necessitates hauling of raw materials and distribution of finished materials over great distances. These activities again require the expenditure of fossil fuels for transportation. Transportation of raw and finished building materials is another key issue that can contribute to the cost of materials, increased energy requirements, and environmental issues. Energy (fossil fuel energy) spent in the transportation of some of these building materials using trucks is given in Table 10.3. Sustainability of the present mode of production, consumption, and distribution of building materials and currently adopted construction practices are questionable.

TABLE 10.2 Projected Demand for Building Material (the Years 2000–2020).

Material	2000	2020
Bricks (Nos.)	160×10^9	256×10^9
Structural steel (t)	12×10^6	40×10^6
Cement (t)	98×10^6	265×10^6

TABLE 10.3 Energy in Transportation of Building Materials.

Building material	Unit	Energy in transportation for 100 km (MJ)
Bricks	m^3	210
Sand	m^3	180
Cement	t	110
Steel	t	110

10.4 NEED FOR SUSTAINABLE ALTERNATIVES

Steel, cement, glass, aluminum, plastics, bricks, etc. are energy-intensive materials, commonly used for building construction. Generally, these materials are transported over great distances. Extensive use of these materials can drain the energy resources and adversely affect the environment. On the other hand, it is difficult to meet the ever-growing demand for buildings by adopting only energy efficient traditional materials (like mud, thatch, timber, etc.) and construction methods (TEDDY, 1990). Hence, there is a need for optimum utilization of available energy resources and raw materials to produce simple, energy efficient, environment-friendly, and sustainable building alternatives and techniques to satisfy the increasing demand for buildings. Some of the guiding principles in developing the sustainable alternative building technologies can be summarized as energy conservation, minimize the use of high energy materials, concern for environment, environment-friendly technologies, minimize transportation and maximize the use of local materials and resources, decentralized production and maximum use of local skills, utilization of industrial and mine wastes for the production of building materials, recycling of building wastes, and use of renewable energy sources. Building technologies manufactured by meeting these principles could become sustainable and facilitate sharing the resources, especially energy resources, more efficiently, causing minimum damage to the environment.

10.5 APPLICATION OF SCIENCE AND TECHNOLOGY FOR RURAL AREAS (ASTRA)'S INITIATIVES AND DEVELOPMENTS IN SUSTAINABLE BUILDING TECHNOLOGIES

Centre for ASTRA (Application of Science and Technology for Rural Areas) was formed in 1974 at Indian Institute of Science (IISc), Bangalore, to cater to developing technologies for sustainable development. Recently, this center has been renamed as "Centre for Sustainable Technologies." Developing environment-friendly, energy efficient, simple and sustainable building technologies utilizing maximum local resources and skills is one of the thrust areas of ASTRA's activities. R&D and dissemination of building technologies became an interdisciplinary work, where the Department of Civil Engineering actively pursued this work since over 2.5 decades of time.

Large number of building technologies were developed and successfully disseminated. ASTRA's approach to develop sustainable building technologies was not confined to laboratory work. Field trials and laboratory work went hand in hand to develop viable technologies. ASTRA's made its sincere efforts in alternative building technologies since 1976 on issues of R&D, dissemination, training and establishing mechanisms for spreading the technologies, and the recent developments. The table indicates that considerable amount of time has been spent initially at the Ungra Extension Centre (UEC) in field experimentation of building technologies initially. There was a need for some buildings at UEC for carrying out other activities of ASTRA and this need had thrown up an open ground for the buildings research group to experiment. This opportunity gave scope for experimenting and monitoring long-term performance over a period of several years. Important lessons on building technologies were learned during the initial period. Some of these building technologies are: stabilized mud blocks, steam cured blocks, fine concrete blocks, rammed earth blocks, mud concrete blocks, lime-pozzolana cements, soil-lime plaster, composite mortars for masonry, composite beam and panel roofs, Reinforced brickwork/tile-work roof, ferrocement and ferro-concrete roofing systems, unreinforced masonry vaults and domes, ribbed slab construction, filler slab roofs, rammed earth foundations, reinforced block-work lintels and precast *chajjas*, solar passive cooling techniques and containment reinforcement for earthquake-resistant masonry. A large number of buildings (>12,000) have been built using these alternative building technologies.

10.6 GREEN BUILDING MOVEMENT IN INDIA

The green building movement in India was triggered off when CII-Sohrabji Godrej Green Business Centre building in Hyderabad was awarded the first and the prestigious platinum-rated green building rating in India. Since then, green building movement in India has gained tremendous impetus over the years. With a modest beginning of 20,000 sq. ft green built-up area in the country in the year 2003, today (as on 31 December, 2016) more than 3921 green buildings projects coming up with a footprint of over 4.48 Billion sq. ft are registered with the IGBC, out of which 942 projects are certified and fully functional in India. This growth has been possible with the participation of all stakeholders in the green building movement. Today, all types of buildings are going the green way—government, IT parks, offices, residential, banks, airports, convention center, institutions, hospitals, hotels, factories, SEZs, townships, schools, metros, and so forth.

10.7 THE INDIAN GREEN BUILDING COUNCIL (IGBC)

IGBC, part of the CII was formed in the year 2001. The vision of the council is "to enable a sustainable built environment for all and facilitate India to be one of the global leaders in the sustainable built environment by 2025." The council offers a wide array of services which include developing new green building rating programs, certification services, and green building training programs. The council also organizes green building congress, its annual flagship event on green buildings. The council is committee-based, member-driven, and consensus-focused. All the stakeholders of construction industry comprising architects, developers, product manufacturers, corporate, government, academia, and nodal agencies participate in the council activities through local chapters. The council also closely works with several state governments, central government, world green building council, bilateral multilateral agencies in promoting green building concepts in the country.

IGBC has about 1700 members, 1200 accredited professionals, and 15 vibrant chapters in all major metros. Now, all types of buildings are going the IGBC "greenway" including airports, banks, colleges, convention centers, factories, government buildings, hospitals, hotels, institutions, IT parks, malls, metros, offices, residential buildings, schools, SEZs, townships, etc. varying from 1200 sq. ft to 120 million sq.ft. Any IGBC-rated green building mirrors India's rich architectural heritage blending with modern technological innovations. IGBC-rated green buildings ensure that energy is saved to the tune of 40–50% and water is saved by 20–30%, and intangible benefits like enhanced ventilation, daylighting, and good design with eco-friendly materials improve the productivity of the occupants (https://igbc.in/igbc/redirectHtml.htm?redVal=showAboutusnosign&id=about-content).

10.8 GREEN BUILDING AS PER IGBC

Features and basic requirements of a green building are given below:

Basic requirements of green buildings are to reduce or eliminate negative environmental impacts of development, conserve energy, conserve water, reduce usage of natural resources and construction materials, and improve workplace environmental quality.

1. Challenge for architects, a green building: It is, indeed, a challenge for both architects and developers. However, considering the rapid global warming taking place and depletion of natural resources, we cannot sustain ourselves too long. Therefore, it only requires concern for the environment, commitment to social responsibility, and application of mind and passion to do something to conserve resources to help future generations.
2. The cost involved in green compared to a nongreen structure: It really does not cost extra to develop a green building. It is a simple application of conventional wisdom, the orientation of the building, concern for our neighborhood, and application of mind to minimize the use of materials, best described by reduce, reuse, recycle. Even

the platinum green buildings of IGBC that used to cost 15% more about 8 years ago, now cost just around 9–12% more than nongreen buildings.

3. Top green buildings in India: Some of the best green buildings in India are the buildings designed to house the new Tamil Nadu Legislative Assembly at Chennai (now converted into a hospital), IGP Office at Gulbarga, Suzlon "One Earth" at Pune, ITC Hotel–The Royal Gardenia at Bangalore, Godrej Plant II-IT Park at Mumbai, Infosys Pocharam at Hyderabad and Bearys Global Research Triangle at Bangalore. Energy efficiency, water use reduction, construction waste management, and use of local materials are some of the salient features of these projects. Bangalore is in the forefront of the green building movement and the construction community represented by CREDAI has taken it very seriously and soon it could be in their DNA. Bangalore has some of the highest rated buildings of India. NCR, Chennai, Hyderabad, Pune, and Mumbai are doing well in popularizing the green building movement and registering buildings for green certification. With the concept of green buildings gaining prominence in India, developers are now focusing on developing structures that are eco-friendly and use energy efficient techniques. Some other top green buildings in India are as below:

    a) ITC Green Centre, Gurgaon
    b) Patni Knowledge Centre, Sahibabad
    c) Olympia Tech Park, Chennai
    d) Infinity Benchmark, Kolkata
    e) CRISIL House, Mumbai
    f) Indira Paryavaran Bhawan, New Delhi
    g) ITC Maurya Hotel, New Delhi
    h) Infosys Hyderabad
    i) CISCO Building, Bangalore
    j) CII building, Hyderabad

10.9 COMPARISON OF MATERIALS USED IN CONVENTIONAL BUILDING AND GREEN BUILDING

The table below shows the materials used in the conventional and green home, respectively for different items:

TABLE 10.4 Comparison of Materials used in Conventional Building and Green Building

S. No.	Materials	In conventional building	In green building
1	Windows and openings	Aluminum paneled plain glasses	Insulated glass (IG units)
2	Lighting fixtures	Tube lights and CFLs	Low Watt LED tube lights and bulbs
3	Plumbing fixtures	Conventional fixtures	Special green fixtures
4	Flooring	Vitrified and glazed tiles and China mosaic	PVC flooring, glazed tiles, and China mosaic
5	Doors	Pinewood	Engineering Wood
6	Paints	Plastic VOC	Plastic non-VOC
7	Bricks	Clay bricks	Fly ash bricks
8	Cement	OPC	PPC
9	Installation of rainwater harvesting system	Not provided	Provided

LED: light emitting diode; PVC: polyvinyl chloride; VOC: volatile organic compounds; PPC: Portland pozzolana cement; ODC: ordinary Portland cement

10.9.1 THE PRIME MATERIALS USED IN GREEN BUILDINGS (VENKATARAMA REDDY AND LOKRAS, 1998)

1. LED fixtures:

- In green buildings, the only type of the lighting fixtures used is LED (light emitting diode) fixtures.
- These types of lighting fixtures are somewhat costly, approximately 4 times higher price than the normal ones.
- These are solid lights which are extremely energy-efficient.
- A significant feature of LEDs is that the light is directional, as opposed to conventional bulbs which spread the light more spherically.

2. Plumbing:

- In the green plumbing, the plumbing fixtures discharge ranges from 5 to 15 l p m.
- Green plumbing includes the fixtures as below:
  - Faucets discharge ranges between 5 and 8 l p m.
  - Showers discharge ranges between 10 and 15 l p m.
  - Water closet discharge ranges between 7 and 12 l p m.

3. **Polyvinyl chloride (PVC) flooring:**
   - PVC flooring is a type of synthetic flooring.
   - Floors such as wood and marble are made from natural materials, but PVC flooring is made from a synthetic plastic called polyvinyl chloride.
   - It is easy to install.
   - PVC flooring is affordable, water resistant, and very durable. Due to its synthetic nature, PVC flooring is also more customizable than natural flooring.
   - To keep PVC flooring in optimal condition, regularly vacuum and polish the floor. Never use any rough-surfaced cleaning tools on the floor as they often result in scratches.

4. **Green paints:**
   - Paints with reduced levels of volatile organic compounds (VOCs) are more eco-friendly than conventional paints, some house paints have an even lower environmental impact.
   - Homeowners can select premium-grade zero-VOC paints that also use VOC-free colorants, are free of vinyl and other plasticizers and include no toxic biocides.

5. **Bricks:**
   - Fly ash bricks are considered as the green material of construction.
   - So, in this case, it is used in the green construction.

6. **Cement:**
   - If PPC (Portland pozzolana cement) is used in construction, it will be green material because PPC contains the fly ash as the main ingredients.

10.10 CHALLENGES TO BUILDING GREEN AFFORDABLE HOUSING

Notwithstanding the motivations for a community-based nonprofit in green housing development, barriers remain that hinder the ability of community-based organizations (CBOs) to successfully build green housing development projects. Such barriers include the following:

1. Perceived risk: CBOs have little room for risk or project failure. There is a reluctance to use new materials and methods for publicly funded projects. Anything new is considered risky, innovative, or untested green features can reduce confidence. Many developers, funding sources, and contractors fear that following a green agenda will delay project schedules and raise costs. This has led to the widespread perception in the nonprofit affordable housing community that it is difficult to retain the full developer's fee if a project is going to concern itself with environmental issues. Developer's fees are crucial to CBOs' abilities to finance future projects.
2. Multiple funding sources: Affordable housing projects often have many funding sources, making it difficult for all parties to agree to and negotiate the inclusion of new and innovative ideas. In addition, funding sources are becoming more and more difficult to find even for conventional projects, and it follows that innovative green development projects face stiff competition.
3. Many players: There are often more players in an affordable housing project than in a conventional market-rate private development (e.g., underwriters, development consultants, builders, maintenance staff, residents, and the surrounding community), all requiring buy-in. Moreover, new affordable housing projects often face local opposition.
4. Regulatory burdens: Affordable housing projects which include public financing having even a harder time building green than privately financed projects. In addition to per unit cost caps, they are often subject to local design requirements that limit the opportunity for green design.
5. Lack of documented success: With the exception of energy efficiency, green building principles have not been widely applied to affordable housing, and actual experience in terms of incremental costs and benefits has not been well documented.
6. Contracting constraints: CBO construction contracts must often be granted to the lowest bidder, making it difficult to select a contractor with specialized training and knowledge in green building.
7. Limited institutional capacity: Low salaries, high turnover, lack of experience drafting green specifications, limited construction supervision expertise, and limited resources to adequately document innovative projects are common problems at CBOs.
8. Learning curve: There is a significant learning curve required of leaders in any field, and that is especially true with green development. Many CBOs that would like to develop projects that are more

environmentally responsible lack readily available information on green contractors and consultants, materials, systems, techniques, and technologies.

9. Short-Term Cost Focus: Developers and funders often think front-loaded planning and design for green projects will cost more and delay project schedules.

10.11 PROBLEMS IDENTIFIED

In the present study, the following problems have been identified:

1. People having low income even dare to dream for a self-owned house.
2. Urban poor people are not able to get the good environment neither for themselves nor for their children.
3. There is a lack of awareness regarding greenhouses.
4. Greenhouses are much costlier than conventional houses.
5. It is a general belief that a green home will cost much more than a conventional home, but some middle way is required to be found by analyzing the real situations and conditions in the market.
6. In these days, when everyone is talking about the green construction, there is a need for a way by which a common person can afford a green home.

10.12 RESEARCH METHODOLOGY

The present research primarily focuses on residents of West UP, India. The judgmental sampling method has been used to select the sample. Primary data has been analyzed through a personal interview conducted with 300 respondents from Ghaziabad, Raj Nagar Extension, Vasundhara, Sahibabad of West Uttar Pradesh, India with the help of the scheduled questionnaire. Various statistical tools are applied to analyze and conclude the study. The secondary data has been collected from various research journals, periodicals, research reports. The research methodology used in the present study is divided into the following subparts:

- Sample size:300 (Persons having own houses or wish to buy own house)
- Sampling method: Judgmental sampling

- Data collection:
    - Primary: Through a structured questionnaire
    - Secondary: Books, journals, magazines, and internet
- Mode of the survey: Personal interview
- Tools: Tabulation, graphical presentation as pie chart, bar graph, line graph, and so forth
- Places of the survey: West Uttar Pradesh, India (Ghaziabad, Raj Nagar Extension, Vasundhara, Sahibabad)

10.13 HYPOTHESIS

This research is based on the following hypotheses:

H_0: Greenhouses are much costlier than conventional houses.
H_1: Greenhouses are not much costlier than conventional houses.

10.14 ANALYSIS OF CONVENTIONAL BUILDING AND GREEN BUILDING THROUGH COST COMPARISON

The table below shows the cost comparison of each item:

TABLE 10.5 Cost Comparison of Conventional Building and Green Building.

Sr. No.	Item Name	Cost in conventional home	Cost in green home	Difference
1	Windows and openings	140,800	217,350	76,550
2	Lighting fixtures	15,800	46,150	30,350
3	Plumbing fixtures	45,885	108,300	62,415
4	Flooring	230,540	295,295	64,755
5	Doors	79,830	165,510	85,680
6	Paints	166,380	168,880	2,500
7	Bricks	60,175	40,105	(20,070)
8	Cement	976,000	995,250	19,250
9	Rainwater harvesting system	0	90,700	90,700
	Total	1,715,410	2,127,540	412,130

Total development costs for the green buildings reviewed in this study ranged from 9 to 18% above the costs for comparable conventional affordable housing.

10.15 ATA ANALYSIS

1. Question: Do you have your own house or are you interested in buying a new house?

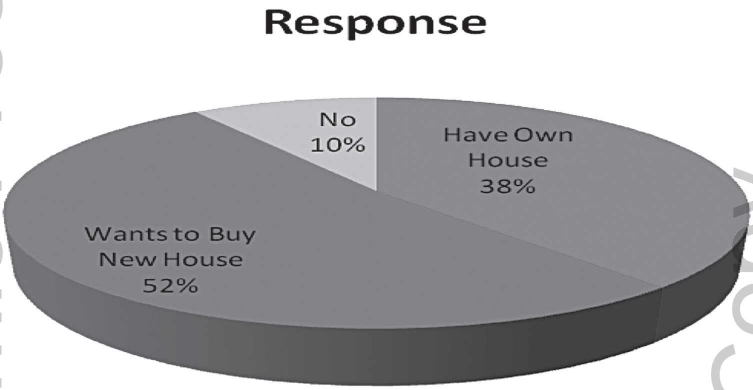

FIGURE 10.1 Response toward owning or buying house.

Interpretation:

52% persons showed interest in buying a new house, 38% already have their own house, whereas 10% were not interested to buy.

2. Question: Are you aware of green housing?

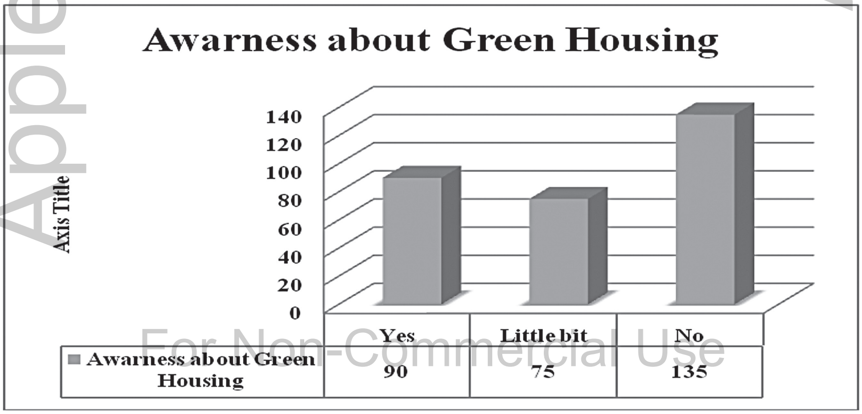

FIGURE 10.2 Response toward awareness about the greenhouse.

Interpretation:

The above graph presents that out of surveyed 300 persons, 90 are aware of the concept of green housing, 75 had little bit information whereas the rest of 135 respondents did not have any idea about this. The researcher made them aware of this concept.

3. Question: Is the environment good in the society due to building construction?

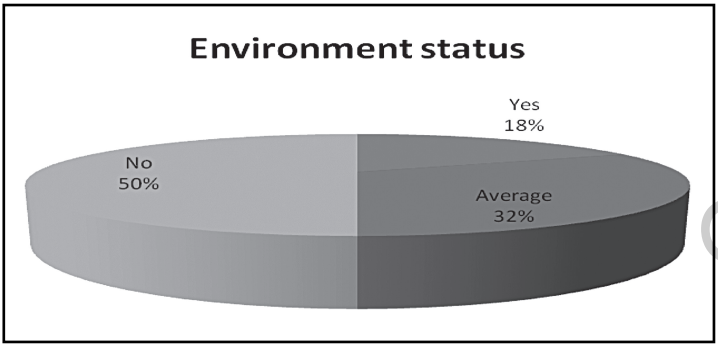

FIGURE 10.3 Response toward environment status.

Interpretation:

We can see in the above graph that the from surveyed 300 persons 50% feel that the environment of the society is not good to live, 32% said that they are just compromising, whereas 18% did not have any complaint.

4. Question: Why you don't want to go for a greenhouse?

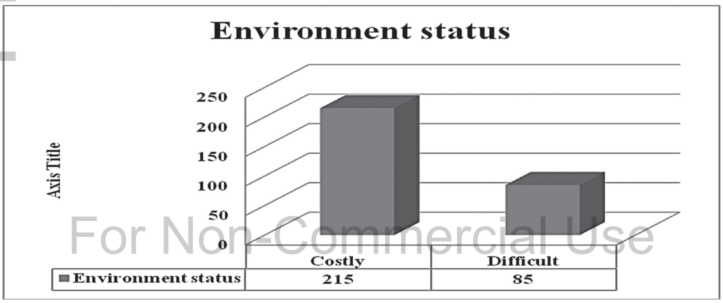

FIGURE 10.4 Response toward greenhouse.

Interpretation:

The above graph presents the feedback of 300 persons about the factors which stop them to purchase a greenhouse. It showed that 215 persons feel that greenhouses are very much costlier then general conventional houses, the rest, 85 respondents feel that it is difficult to construct.

10.16 FINDINGS

The present study has the following findings:

1. If the home is constructed as identified in this study, the total cost increases by 402,130 in addition to the total construction cost of the conventional home which is found to be 3,107,415.
2. The percentage increase in total construction cost is 12.94% (say, 12–15%).
3. The saving in money, which is about 10,000, will be the clear saving after the payback period of LED fixtures is completed.
4. Water saving is about 444 (say, 440) l/day.
5. Payback period, considering savings only in the electricity bills, is found to be 35 years.

Now, this may be justified that "If the intention is to construct a new home to live in, it is advisable to go for a green home rather than the ordinary conventional home. Because the increase of 12.94% in the total cost is not a negligible amount when the intention is just to renovate or retrofit an old home."

10.17 CONCLUSION

1. The following points may be concluded as:
   Creating an infrastructure that sustains human society: As we have outlined here, infrastructure is absolutely vital to realize the global sustainability objectives for society at large, specifically as it relates to meeting the basic human needs of all people on our planet. The basic needs of all people will not be met without investments in infrastructure.
2. Creating an infrastructure that sustains the global environment:
   Infrastructure assets mediate the impact of human activities on the environment. Infrastructure assets themselves impact the

environment. The impact in both cases can be either sustaining or destructive. Infrastructure can remediate the destructive impact of past activities and even increase the regenerative capacity of the planet. Therefore, the nature of our investments in infrastructure will have a direct impact on sustaining our planet

3. Sustaining the world's infrastructure so that it can continue to provide critical services to society and the environment:
   Infrastructure assets are long-lived, but they are subject to entropy and degradation as well. In order to continue providing the services to sustain society and the environment, these assets must themselves be sustained.
4. Sustaining the environment (World Development Report, 2010):
   The second sustainability challenge is to become good stewards of our planet including its environment and its resources. One element of sustaining the environment is increasing the sustainability factor above 1.0 and then keeping it there, maintaining sufficient bio-capacity to continue renewal while accommodating current and future activities by humans. Approaches include increasing bio-capacity, reducing ecological footprint, and more efficient use of nonrenewable resources.
5. Increase bio-capacity:
   This includes not only increasing the bio-capacity of the earth per se but taking advantage of the existing, untapped bio-capacity of the earth. Finally, this would include initiatives to increase the bio-capacity of the infrastructure itself such as buildings that are net producers of power or factories that emit clean water as a by-product.
6. Take advantage of natural energy potential:
   The earth provides many natural energy potentials such as solar, wind, geothermal, ocean temperature gradients, hydroelectric, nuclear, and so on. The technology for taking advantage of these potentials for commercial energy production has long been a reality.
7. Expandability to absorb waste:
   This refers primarily to increasing the natural ability of the earth to absorb GHG by increasing green space through the recovery of waste sites, plankton growth in the oceans, reforestation, recovery of arid land, increased urban green space, green building roofs, and so on.
8. Remediate impact of human activity:
   The bio-capacity of the earth can be increased by recovering bio-capacity lost to prior human activity. This includes solutions such as

hazardous waste recovery and disposal, treatment of polluted water, cleaning polluted air (with urban forests, for example), recovering green spaces lost to activities such as mining and landfills, mining landfills for resource recovery, and so on.

9. More efficient use of nonrenewable resources:
Given the current global dependence on many nonrenewable resources, consumption of nonrenewable resources continues for the foreseeable future. More efficiently extracting, processing, and consuming these resources will extend the window for replacing them with renewable sources. Infrastructure projects that result in the more efficient use of resources have the potential of improving both the numerator and denominator of the sustainability factor.
10. More efficient consumption:
The obvious initiative in regard to nonrenewable resources is to consume them more efficiently. This involves, for example, greater energy efficiency, alternate modes of transportation (such as mass transit), elimination or replacement of unnecessary activities (by telecommuting, video conferencing, and so on), and use of new materials that require less energy to produce and transport. These are all examples of more efficient consumption. Likewise, designs which result in products that are more readily and efficiently recycled, including "Cradle to Cradle" certified products, are further examples of more efficient consumption.
11. Expand global resource supplies:
Given the ultimate limits on nonrenewable resources, expanding the global resource supplies is also an approach to extending the availability of nonrenewable resources, and ensuring their continuing availability even as they are being replaced for some uses by renewable sources. These approaches could include more complete and efficient extraction methods, more effective and accurate exploration, more eco-friendly exploration and extraction, and so on.

The environmental issue is not a new issue. Even it is not limited to global warming, climate change, pollution, chronic hunger, unsafe bridges, public health, or contaminated water—it is all of these and more. It is not a problem that we will solve and then move on—it will require constant, continuing, and unrelenting attention. The issues and challenges surrounding environment are broad, complex, and interrelated.

To completely satisfy our objectives will mean more investment in infrastructure, not less. It will mean more economic development, not less. If our goal is for all people to be concerned with global sustainability, then the prerequisite is to enable all people to enjoy a quality of life which affords them that luxury. This is a significant challenge for society, a significant challenge for the world's infrastructure, and a challenge for all of us as members of the infrastructure professions. Currently, R&D efforts in developing green building technologies are limited in the Indian context. There is a large scope for R&D efforts in developing alternative building technologies, addressing the following issues.

- A clear understanding of the sector-wise demand and growth of the Indian construction scenario.
- Estimating current building stock and the contribution of unorganized sector in manufacturing and supply of energy-intensive building materials.
- Assessing the availability (region wise) of local resources, raw materials/traditional materials for developing and manufacture of building products.
- Developing alternative building technologies to meet the region-specific needs/demands for buildings.

The null hypothesis is rejected and it is concluded that greenhouses are costlier than conventional houses but only in short run. As per the need of society and livelihood, greenhouses are very much required and will surely be much cheaper than conventional houses in long run.

KEYWORDS

- **green housing**
- **affordability**
- **real estate companies**
- **green housing policies**
- **technology**
- **cost**

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Prevailing Approaches and PCURE for Data Retrieval from Large Databases

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Conference paper
First Online: 20 November 2018

Part of the Lecture Notes in Networks and Systems book series (LNNS, volume 56)

Abstract

Tremendous and exceedingly vast data is collected, nowadays, by every organization which is getting continually increased. It became very difficult to retrieve relevant information from these endlessly rising large group of data. Data mining has emerged to retrieve precious information that gets buried in large databases. Among various functionalities of data mining, clustering became very effective in determining related data. This work is focused on CURE which is one of the most widely used hierarchical clustering techniques of data mining. It started its work by reducing the size of the original database. For that, it made the use of simple random sampling (SRS) technique, followed by partitioning of the reduced database. It also made use of other important techniques but still resulted in a number of shortcomings. It is required to eradicate the limitations in the traditional working of CURE clustering. So, this paper avoids the use of sampling and focuses on its enhancement by integrating it with the concept of “Map-Reduce” along with “Corewise Multithreading”. This combination is useful for analyzing-searching huge voluminous data by providing the most effective ability of parallel processing, fault tolerance, and load balancing. The proposed approach is parallelization of one of the data mining clustering techniques—CURE and thus named as PCURE (ParallelCURE).

Keywords

Data mining | Clustering | CURE | Sampling | Parallelism | M2ing

Comparative Analysis of Position-Based Routing Protocols for VANETs

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***Abstract*— Vehicular ad hoc networks (VANETs) have fetched great interest in both industry and research oriented fields owing to the highly mobile nature and randomly changing topology exhibited by these networks. These characteristics make them susceptible to frequent disconnections, contention and collision related problems. Designing a set of protocols which would cater to the characteristic features of VANETs is a very daunting task. This paper presents a detailed survey of a wide variety of Position-based routing (PBR) protocols. PBR protocols exploit the on-board global positioning receivers to acquire location information of vehicles. Moreover on-board maps are used to fetch the details regarding layout of the road thereby purging the need to set up and maintain routes between the vehicular nodes, making these protocols highly desirable for VANETs. Further a novel classification methodology of the protocols under study along with a comparative analysis depicting their similarity and dissimilarities has been presented.**

Keywords*— Position-based routing protocols; Junction; ITS; Data packet transmission; Routing strategies

I. Introduction

The concept of VANETs, foundation of which was laid by a Japanese association named as JSK (Association of Electronic Technology for Automobile Traffic and Driving) in 1980 [1] has tapped many researchers into its deep exploration. Reason behind this is the unique characteristic features that VANETs are endowed with such as swiftly changing network topology leading to intermittent connectivity further, vehicular density, extent of mobility, unbounded network size, availability of abundant storage, energy facilities for the nodes, along with real time exchange of data packets to enable wireless communication, making them easily distinguishable from its super-class MANETs. These networks form self-organized paradigms of MANETs [2], where direction, traffic flow and traffic policies guide their course of action. Owing to the aforementioned characteristics VANETs form the focal point of Intelligent Transportation Systems (ITS) [3].

In VANETs vehicles act as mobile nodes comprising an on-board unit such global positioning system and digital map to gather information related to the vehicle's mobility and road layout [4]. Fixed infrastructure units in the network termed as RSUs are also been taken into consideration to form Vehicular ad-hoc networks. These RSUs are responsible for relaying messages among different vehicles as well as other RSUs in order to deal with connectivity issues, more prevalent in sparse regions.

This entire network layout forms a complete VANET environment where communication can be promoted via any of the three architectures [5]: Pure Cellular (I2V) where vehicles communicate only via road side units (RSUs) thereby eliminating direct communication between vehicles, Pure ad-hoc (V2V) which facilitates direct communication amid vehicles via sensors and no intervention of RSUs Is needed and lastly Hybrid architecture, offering functionality of either of the other two architectures as per the need.

Vehicular ad-hoc networks find applicability in several areas like dealing emergency situations by helping drivers to make accurate decisions during hazardous road or weather conditions, infotainment applications such as distributed games, micro-blog and so on, comfort related applications, concerned about making driver's journey comfortable by use of vehicular services so on. Considering the diverse set of applications which VANETs serve and the highly dynamic features with which they are characterized, finding a suitable set of routing protocols becomes quite troublesome.

Researchers however have made several successful attempts in creating VANET oriented protocols [6] with the aim of ensuring communication by reducing overhead as well as minimizing the amount of network resources consumed. VANET routing protocols can be classified as: Topology based routing, Geo cast routing, Cluster based routing and Position based routing. *Topology based routing protocols* such as DSDV, AODV [7], HARP aim at finding link details among a pair of nodes and storing them in a table so that this data can be used in future. They are further categorized into proactive (table-driven), reactive (on-demand) routing and hybrid routing protocols [8]. These protocols are however not able to cope up with the highly frequent topology changes exhibited by VANETs, thus making them unfit for these networks. *Geocast-based routing protocol* is a position based multicast routing protocol with the aim of delivering the packet from source node to a group of vehicles within a specified geographical region called as zone of relevance (ZOR) [9]. The disadvantage of these protocols is that they are quite prone to showcasing

18 | OriginalPaper | Chapter

Exploration of Apache Hadoop Techniques: Mapreduce and Hive for Big Data

Authors: Poonam Rana, Vineet Sharma, P. K. Gupta

Publisher: Springer Singapore

Published in: Advances in Computing and Data Sciences

Abstract

With the rapid growth of technology, huge amount of data is being proliferated from various sources like sensor networks, IoT, online transactions, social media, etc. Big data is a collection of huge voluminous and complex data sets that include the large amount of data, social media analytics, real time data and data management capabilities. In some cases, the volume of this data has reached upto ZettaBytes. To analyze such a huge amount of data, traditional technologies are found inefficient. So, the new technologies of Apache Hadoop Distributed File System (HDFS) came into existence. In this paper, we have presented tools and technologies used in big data along with detailed description of MapReduce and Hive programming framework of Hadoop. Apache Hadoop consist of techniques and technologies that require new forms of combination to reveal large unknown values from large data sets that are diverse, complex and of massive scale.

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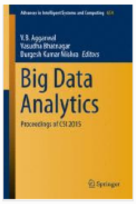
Abstract

Tremendous and exceedingly vast data is collected, nowadays, by every organization which is getting continually increased. It became very difficult to retrieve relevant information from these endlessly rising large group of data. Data mining has emerged to retrieve precious information that gets buried in large databases. Among various functionalities of data mining, clustering became very effective in determining related data. This work is focused on CURE which is one of the most widely used hierarchical clustering techniques of data mining. It started its work by reducing the size of the original database. For that, it made the use of simple random sampling (SRS) technique, followed by partitioning of the reduced database. It also made use of other important techniques but still resulted in a number of shortcomings. It is required to eradicate the limitations in the traditional working of CURE clustering. So, this paper avoids the use of sampling and focuses on its enhancement by integrating it with the concept of “Map-Reduce” along with “Corewise Multithreading”. This combination is useful for analyzing-searching huge voluminous data by providing the most effective ability of parallel processing, fault tolerance, and load balancing. The proposed approach is parallelization of one of the data mining clustering techniques—CURE and thus named as PCURE (ParallelCURE).

Keywords

Data mining · Clustering · CURE · Sampling · Parallelism · M2ing



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Query Optimization: Issues and Challenges in Mining of Distributed Data

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Abstract

The technique of finding the optimal processing method to answer a query is called Query optimization, whereas a collection of various sites, distributed over a computer network is called Distributed Database. In Distributed Database, the site communicates with each other through networks. There are various issues arise during evaluation of query cost, among which the processing cost and a transmission cost are important. There are several algorithms developed to find the best possible solution for a particular query, but they all have their certai limitations. The optimizer is mainly concern on search space, search strategy, and the cost model. It primarily focuses on these three factors. The mining cost of a query depends on the order of evaluation of the operators, for the same query we can have different cost if the order i changed. Hence, to find the optimal cost for a particular query is emerging as an open challeng for many researchers. Therefore, the cost-based query optimization technique has emerged as an important concept for dealing with the query optimization. This paper explores the issues and challenges of query optimization in mining of distributed data.

Keywords

Query optimization | Distributed database | Cost-based optimization

Proceedings of 4th International Conference on Computers and Management (ICCM) 2018

A Novel study of Continuous Monitoring with their Application into Various Domains

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Abstract: Continuous monitoring is both a process and technology used to analyze data associated with an operational environment. This is becoming a must now-a-days, as it provides an independence from an operative management. In this paper, we have carried out a survey of continuous monitoring and their application into various domains. We have prepared a tabular structure presenting its application into various domains.

Keywords: Continuous Monitoring, Risk Management

I. Introduction :

"Continuous Monitoring" a term that is both a process and technology, means different things to different people. NIST describes it as "a risk management approach to cyber security that maintains a picture of an organization's security risk posture, provides visibility into assets and leverages use of automated data feeds to quantity risk, ensure effectiveness of security controls, and implement prioritized remedies." It can be defined as a concept of monitoring to have data that causes certain action and relieve the analyst from operative management. It is a set of technology driven process, helping to fulfill a core organizational requirement.

Continuous monitoring is becoming a must now. With the advancement in technology and increased operational dynamics enables the system to change more rapidly. The traditional operative management techniques are no longer adequate, which highlights the high need of "Continuous Monitoring".

In this paper, we have reviewed the work carried out by various researchers on "Continuous Monitoring" and its applications. In the second section of this paper, we have presented a literature review of various applications of

"Continuous Monitoring" towards providing useful solutions for some critical real time situations. In the third section, we have presented the applications of Continuous Monitoring . In the fourth section, we have discussed the present scenario of continuous monitoring. In the fifth section, we have discussed the implementation of Continuous Logging from a string it receives from the network, in order to study continuous monitoring. In the sixth section, we have concluded that continuous monitoring has proven its worth into various real time applications by providing useful results.

II : Literature Review

In this section, we have presented a literature review of applications of Continuous Monitoring in various domains.

[1] GUIDE YVL C presented continuously operating radiation monitoring systems whose main purpose is continuous measurement of radioactive releases and sampling from the stack, and the determination of concentrations in a laboratory

[2] Oryong-dong, and Puk-gu, Gwangju proposed a Continuous water toxicity monitoring system that can be used as an alternative tool for the quick monitoring and controlling the water quality, as well as aid in the setting up of a new monitoring strategy to protect the source of tap water and in the prevention of polluted water discharge.

[3]Jean Bedard, and Ryan Sanders, provided the guidance on how to protect Time and temperature sensitive pharmaceutical product (TTSPP) from damage by the correct use of electronic temperature monitoring systems. It also described the establishment of requirements and how to define specifications for these systems and how to assure data traceability which is generated.

[4] Minimax explained the continuously monitoring by smoke detectors and Gas extinguishing systems via using Novec™ 1230 extinguishing agent.

[5]Aleksandar Milenković, Chris Otto, Emil Jovanov presented health monitoring system using their prototype sensor network which utilizes off-the-shelf 802.15.4 compliant network nodes and custom-built motion and heart activity sensors.they represented system architecture and hardware and software organization. they also reported their solutions for time synchronization, power management, and on-chip signal processing.

[6] Dushyant Pande, Jeetender Singh Chauhan, Nitin Parihar proposed "temperature and lighting monitoring and control system" as an integrated device designed and implemented as cost efficient as possible that is intended to allow users to input specific requirements for a environment of some industrial as well as experimental setup to monitor as well as control temperature and light continuously.

[7]K.C. Kavitha, A.Bazila Banu proposed a design and developed a "Wireless health monitoring system" for remote patient monitoring in healthcare field. The main purpose of remote health monitoring system for patient monitoring is to continuously monitor patient's physiological health parameters such as pulse rate,breathing rate, blood pressure rate and patient's body movement, and project the same data of the patient's health to the doctor or hospital staff.but in their proposed system,extracting abnormal condition data from the

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Smart Solar Energy Management to Power Computer Lab in Rural Areas

Publisher: IEEE

Neeraj Kumar Gupta ; Aditya Kumar Singh ; Ashish D. Thombre ; Kirti Pal **All Authors**

Abstract: An isolated solar PV system is a reliable solution to providing electricity in rural and remote locations. Such systems require an array of PV panels, charge controllers,... **View more**

Metadata

Abstract:

An isolated solar PV system is a reliable solution to providing electricity in rural and remote locations. Such systems require an array of PV panels, charge controllers, battery bank to compensate the supply & demand mismatch. The paper presents an evaluation of stand-alone photovoltaics (PV) system installed on the roof of EN Dept. building, KIET Group of Institutions, Ghaziabad. The experimental data was recorded for month of August 2018 through IoT. This project aims to encourage the use of small stand-alone solar PV system to supply power to laboratories in rural areas & remote locations. In this project we also develop a cost-effective energy management solution for data logging & monitoring is done by Wi-Fi based Internet of things (IoT) system that can be accessed from anywhere.

Keywords

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Contents

I. Introduction

Electricity plays a crucial role in the development of the society. It is a fundamental part of our life and one can't think of a world without electricity. Yet, over 1 billion people in the world do not have access to electricity. Of this, over 95% live in developing countries and over 84% reside in rural areas [1]. At the same time, we face the issue of depleting reserves & increasing cost of fossil fuels. Additionally, there is special focus on the major problem of Global Warming and pollution. These issues prompt us to reduce our dependence on fossil fuels as the primary source of energy. Due to this, the need of the hour is to develop and utilize renewable resources like solar, wind, geothermal, bioenergy& many more. Amongst these, solar energy is the one with the most potential. The approximate emission power from the sun is 1.8×10^{11} MW [2].

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Figures

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SMALL SCALE POWER GENERATION FOR RURAL HOUSEHOLDS

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Abtract: This paper includes details about a project to build a human powered generator with the help of a bicycle. This can be used for upto 120watts DC. This project will help to develop a clean way of generating electricity. It is intended to be both achievable and affordable.

Keywords: ***portable generator, clean electricity, low cost power generation***

I. INTRODUCTION

The purpose of this project is to build a human powered generator with the help of a bicycle which is also portable and can be used to power small appliances such as dc fans, light bulbs etc. This project will help to develop a clean way of generating electricity. It is intended to be both achievable and affordable. By using principles of energy conversation a small amount of power source can be developed which can be used in rural and remote areas. The chemical energy in a person's body is converted into mechanical energy using a bicycle and then further into the electrical energy with the motor. This energy is stored in a battery for further use.

II. LITERATURE REVIEW

[10] A remote village has limited access to electrical power and, as a result, the village homes are lit with candles and kerosene lamps after dark. Narrow mountain paths limit the access to neighbouring villages and limits the supply of diesel for the village's generators. The task is to develop a small and sustainable source of electricity for the village. [7] The intention is to create a system that can be used to generate and store enough energy to light an LED or any other small appliance for about 10

minutes.It is intended to be both achievable and affordable. [1] The chemical energy in a person's body is converted into mechanical energy with the use of bicycle and then further into the electrical energy with the motor. By hand-cranking the bicycle pedal at different speeds we will discover that at higher speeds the lamp will get brighter. We shall also discover that the sound emitted by the speaker gets higher in frequency and amplitude (volume) as the pedaling speed is increased. If the speaker or lamp has weak output, we will connect one at a time. An oscilloscope can also be connected to the dynamo to show the sinusoidal waveform. The loads provided should be appropriately matched to the dynamo's output. This energy can be measured by using a microcontroller and LCD display to display instantaneous power.

III. PROPOSED ARCHITECTURE

The various components which are required to build this project are mentioned below [2] A bicycle which can be of any size, the dynamo will be fixed at the hub of its rear wheel, Dynamo, bridge rectifier, voltage regulator and a LED bulb. [8] Its working can be explained as follows. The AC from the dynamo(present at the hub of the rear wheel) passes through a full-wave rectifier and feeds the LED bulb through the connected circuit elements. The current in the LED is limited by the dynamo to about 0.5Amps - 0.6Amps.LED should be capable of handling this much amount of current without getting fuse. [6] The charge (q) stored in a capacitor is the product of its capacitance (C) value and the voltage (V) applied to it. Capacitors offer infinite reactance to zero frequency so they are used for blocking DC components or bypassing the AC signals. The capacitor undergoes through a recursive cycle of charging and discharging in AC circuits where the voltage and current across it depends on the RC time constant. For this reason, capacitors are used for smoothing power supply variations. The instantaneous voltage produced by pedaling at normal speed is about 14 volts when measured through a multi meter. The light flickers when pedaling is done at low speed. Hence a smoothing capacitor is used to reduce the flicker at low speed and also to increase a little bit of brightness. Capacitor C1 used has a high value so as to reduce the flickering caused at low speed. A small value of capacitor C1will increase the flickering at low speeds. The capacitor should withstand at least 4V.Its value is limited by the size & its cost hence these factors should be kept in mind while choosing a capacitor. LED should be disconnected from the circuit after the capacitor has charged to its full value otherwise it can charge to a higher voltage level. This could be dangerous to the operator as well as for the LED. A sudden very high peak current will most likely destroy the LED or change its color. [9] By revolving the bicycle pedal at different speeds, we will find that at higher speeds the lamp will get brighter. We will also discover that the sound emitted by the speaker will be higher in frequency and amplitude. If the output of the speaker or lamp is weak, we will connect one at a time. An oscilloscope can also be connected to the dynamo to show the output sinusoidal waveform. **7805** is a **voltage regulator** integrated circuit. It is a member of 78xx series of fixed linear voltage regulator ICs. The voltage source in a circuit may have fluctuations and would not give the fixed voltage output. The **voltage regulator IC** maintains the output voltage at a constant value. The xx in 78xx indicates the fixed output voltage it is designed to provide. 7805 provides +5V regulated power supply. Capacitors of suitable values can be connected at input and output pins depending upon the respective voltage levels.

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits.A **16x2 LCD** means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data.

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IV. WORKING METHODOLOGY

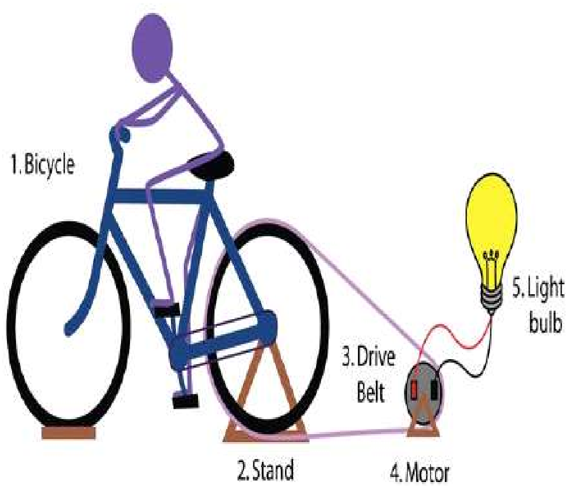

Figure1: Block diagram of small power generation.

A PMDC motor which is used as a generator is fixed at the hub of the rear wheel of the cycle.It is then connected to any dc appliance to which it gives power.[5] The generated electrical power could be used to charge a battery and could be stored or could be used to directly power appliances.The instantaneous voltage developed is around 14 volts which can be checked with the help of a multimeter. We could design an energy storage device that can be hooked up to the bicycle and is portable. It should be easily removable, compact, durable and capable of illuminating the LED via a current limiting resistor for at least 10 minutes.

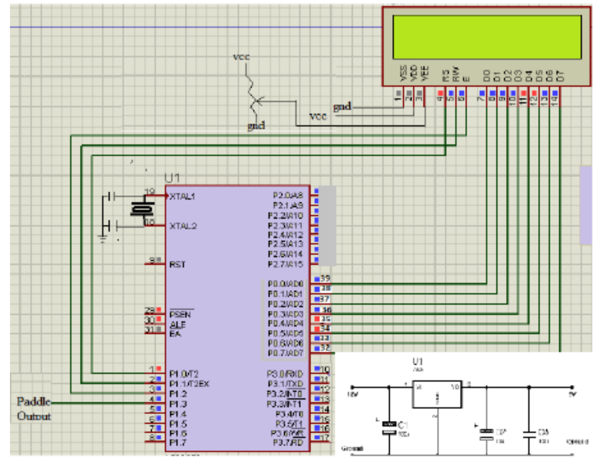

fig: complete circuit connection

This energy can be measured by using a microcontroller and LCD display to display instantaneous power. The chemical energy in a person's body is converted into mechanical energy with the use of bicycle and then further into the electrical energy with the motor. This electrical energy is stored in a battery which can be used to drive LED light and some other small appliances. If we want to use AC power than a inverter can also be used with this apparatus. VCO is used for constant output voltage. In this project we are using 7805 voltage regulator which has an output of 5V.For an average adult cycling at a normal rate it would take around 1 hour to store approximately 150W of power .Several cycle generators can be connected in parallel and connected to a battery which can store power or to an appliance which consumes more amount of power.More the cycling speed more is the instantaneous power developed.But a smoothing capacitor is to connected in the circuit which removes the ripples or the spikes from the voltage or current waveform produced.This can also be used to power AC appliance by connecting an inverter in intermediate stages.The PMDC motor selected should be according to the needs i.e for high power high rating and more rpm motor should be used.The total energy loss in a cycle generator will be around 42 to 67.5 percent (calculation example for highest loss: 100 watt input = 80 watt after 20% loss in motor/generator = 57.5 watts after 25% energy loss in voltage regulator = 37.5 watts after 35% loss in battery = 32.5 watts after 15% loss in converter = 32.5 watts output = efficiency of 32.5% or energy loss of 67.5%).

V. CONCLUSION

This project will help one develop engineering skills while learning about a clean way of generating electricity. This project is affordable as the total cost is around 1000 /-Rs only. By revolving the flywheel at normal speed the instantaneous power generated is around 80 watts. At high speeds it may go upto 110-120 watts. This setup can be installed on a bicycle. Therefore the user did not need to do extra efforts to charge this battery. As in rural areas and remote areas people mostly use a bicycle to go from one place to the other, so they can charge these batteries during their journies to their fields. This will reduce the efforts. We can light a LED of around 15 watts and a small DC fan around 2 hours with a fully charged battery of 12 volts. Project is easy to understand and develope as it is made basically for rural area purposes.

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An Ultra Thin Body Nanoscale Dual Material Double Gate SOI MOSFET

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***Abstract*—In this paper, we compare the performance of symmetrical dual material double gate (SDMDG) SOI MOSFETs and asymmetrical dual material double gate (ADMDG) SOI MOSFETs. We investigate the influence of gate engineering on the analog performances of both the device structure for system-on-chip applications using a 2D device simulator (Silvaco TCAD). The gate engineering technique used here is the dual metal gate technology. The SDMDG structure shows better immunity to DIBL, near ideal Sub-threshold Slope (SS), high I_{on}/I_{off} ratio and improved analog performance like trans conductance generation factor, TGF (g_m/I_d), output conductance (g_d).**

***Keywords*— SDMDG, ADMDG, DIBL, trans conductance generation factor.**

I. INTRODUCTION

As the bulk MOSFET is scaled down, the control of short channel effects becomes increasingly difficult leading to increased sub-threshold leakage current.[1] This is because the source/drain influence over the channel potential becomes significant relative to the gate control. Advanced transistor structures such as the UTB and the DG-MOSFET eliminate sub-surface leakage paths and extend the scalability of Si CMOS technology.[2] In the DMDG SOI MOSFETs structure, the surface potential is characterized by a step function, due to this potential profile the drain voltage is screened, reducing the drain induced barrier lowering (DIBL). The step potential profile is achieved by the use of different gate materials.[3] The use of DMG also increases the carrier transport efficiency and in turn increases the I_{on} of the device.[4] In the DMDG MOSFETs structure, P^+ poly is close to the source end, named M1, and N^+ poly is close to the drain end, named M2. In conventional single metal gate device, the electric field near the source is lowest and reaches the peak value at the drain end. Due to this reason, the hot electron injection between the gate and drain makes the device unreliable, and reduces its lifetime. Thus, the primary intention is to keep the peak electric field under the gate, and not near the drain end, without degrading the Ion. Hence, DMDG architecture is implemented for which the carriers will be accelerated more rapidly and the hot electron injection problem is also avoided. This architecture will thus improve the average carrier velocity which in turn enhances the I_{on}. The improvement in I_{on} and DIBL suppression is achieved for lower work-function metal near the drain side (M1 > M2). [5-9]

In this paper, the parameters considered for the comparison between SDMDG and ADMDG SOI MOSFETs are drain induced barrier lowering (DIBL), the Sub-threshold Slope (SS), the I_{on}/I_{off} ratio, the threshold voltage (V_{th}), the trans conductance (g_m), the trans conductance generation factor (g_m/I_d) and the intrinsic gain (A_v). For ultralow-power, high gain analog/RF circuits, the gate oxide thickness, ($t_f = t_b = t_{ox}$) and the silicon body thickness, t_{si} are optimized with the help of ATLAS 2-D numerical device simulator and a comparison is performed between these devices.

The model used in the simulation are the inversion-layer Lombardi constant voltage and temperature (CVT) mobility model, that takes into account the effect of transverse fields, along with doping and temperature dependent parts of the mobility and the Shockley–Read–Hall (SRH) model simulates the leakage currents that exist due to thermal generation. The Gummel's method (or the decoupled method) which performs a Gummel iteration for Newton solution.

II. DEVICE STRUCTURE

Depending upon the way the gate material used, DMDG MOSFETs may be categorized as following:

A. Asymmetrical DMDG (ADMDG)

An asymmetric DMDG-MOSFET consist of front gate having P^+ poly and N^+ poly Si material contacting laterally whereas the back gate have N^+ poly Si material only. The device structure is shown below as:

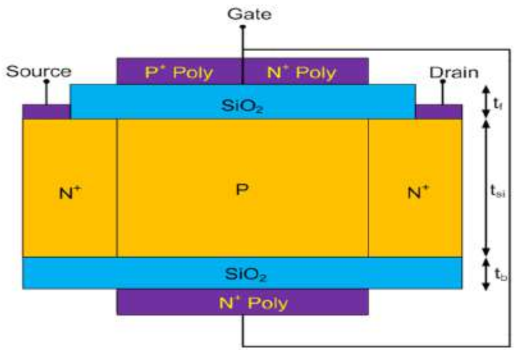


Fig.1. Structure of ADMDG SOI MOSFET.

B. Symmetrical DMDG (SDMDG)

A symmetric DMDG-MOSFET consist of front gate and back gate having P^+ poly Si and N^+ poly Si material contacting laterally.

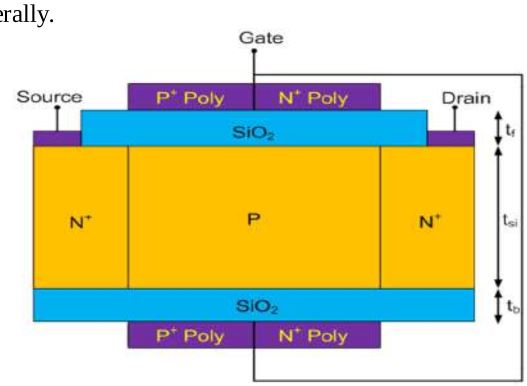


Fig.2. Structure of SDMDG SOI MOSFET.

TABLE I
TYPICAL PARAMETER VALUES

S. No.	DMDG SOI MOSFETs	
	Parameters	***ADMDG / SDMDG***
1.	Channel Length, L	20nm
2.	Front gate oxide, t_f	2nm
3.	Back gate oxide, t_b	2nm
4.	Film thickness, t_{si}	4nm
5.	Body doping, N_A	$1x10^{21}$ m^{-3}
6.	Source / drain doping, N_D	$5x10^{25}$ m^{-3}
7.	Length of source/drain regions	10nm
8.	Distance between S/D contact and gate	5nm
9.	Work function P^+ poly	5.25eV
10.	Work function N^+ poly	4.17eV

III. SURFACE POTENTIAL AND ELECTRIC FIELD

The unique feature of ADMDG and SDMDG SOI MOSFET device is the step function in the surface potential along the channel. Due to this the area under the P^+ poly in the gate of the DMDG structures is essentially screened from the drain potential variations. Hence, DIBL is reduced.

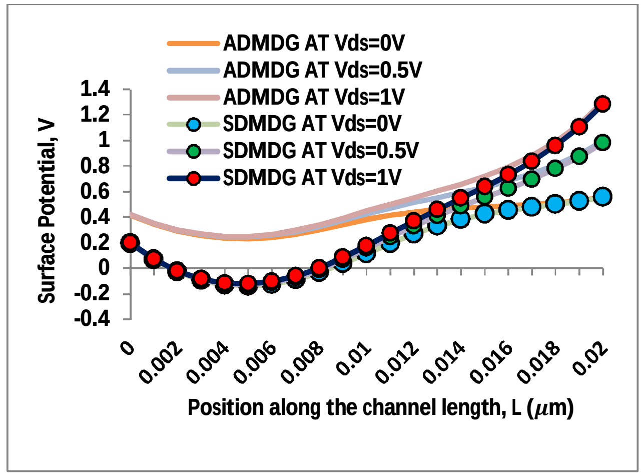


Fig.3. Surface-potential profiles of ADMDG and SDMDG SOI MOSFETs for a channel length L = 20nm, V_{gs} = 0V, V_{ds} = 0V, 0.5V and 1V.

Fig.3 shows the variation of surface potential along channel length. It can be seen from fig.3 that as the drain voltage increases (V_{ds}= 0V, 0.5V and 1V) the surface potential increases at the drain end and the source side is screened by the N^+ poly gate. Further it can be observed from fig.3 that the gate control over the surface potential is more in case of SDMDG compared to ADMDG. Hence, the SCEs are reduced in case of SDMDG.

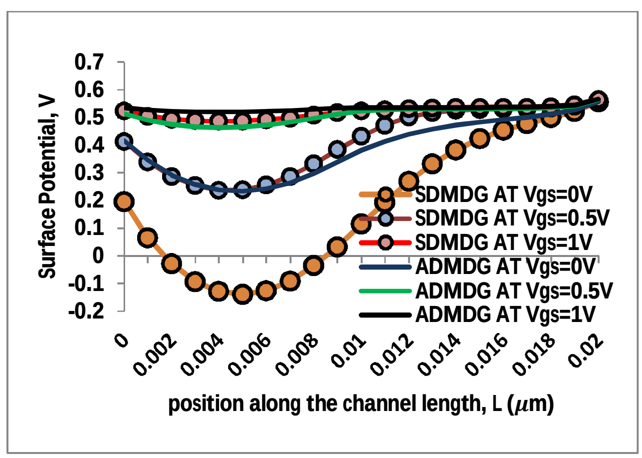


Fig.4. Surface-potential profiles of ADMDG and SDMDG SOI MOSFETs for a channel length L = 20nm, V_{ds} = 0V, V_{gs} = 0V, 0.5V and 1V.

Fig.4. Shows the variation in the Surface potential along with the channel length for different value of gate voltage (*Vgs = 0V, 0.5V and 1V*) and drain voltage (*Vds =0V*) for both the structures, we can observe that as the gate voltage is increases the surface potential curve shifted upwards because of the vertical electric field increases. The surface potential curve is more deeper which shows that the SDMDG structure has more control over the channel in comparison to ADMDG structure.

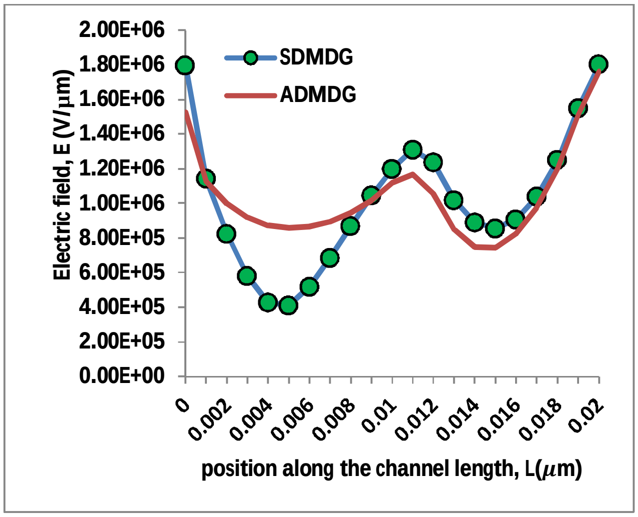


Fig.5. Electric-field variation along the channel length of the ADMDG and SDMDG SOI MOSFETs for Vds = 1V and Vgs = 1V. Channel length, L = 20nm, *L1 = L2*.

Fig.5. Shows the variation in the Electric field along with the channel length for gate voltage (*Vgs = 1V*) and drain voltage (*Vds=1V*) for both the structures, we can observe that in case of SDMDG SOI MOSFET the electric field at the source and in the middle of the channel where the two gate material (P^+ poly and N^+ poly) contacted laterally, is higher than the ADMDG SOI MOSFET. Therefore, the average electric field along the channel is high for SDMDG SOI MOSFET. This results in better carrier transport efficiency along the channel.

IV. I-V CHARACTERSTICS

A. I_D-V_{GS} CHARACTERSTICS

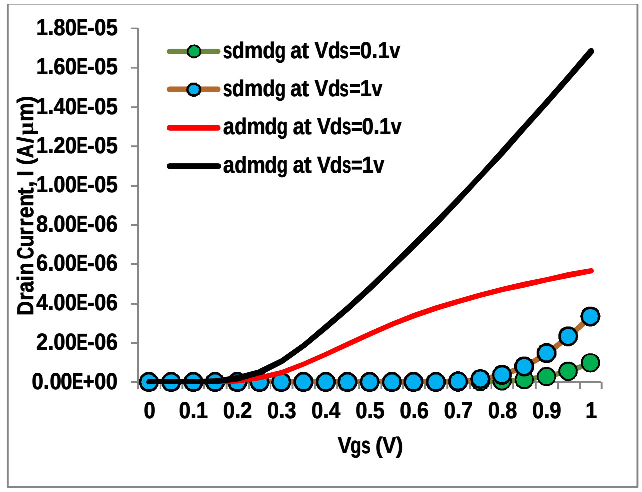


Fig.6. Drain current versus Gate voltage for SDMDG and ADMDG SOI MOSFET with *Vds* = 0.1 V and 1 V. Vgs = 0.1 V and 1 V. Channel length *L* = 20 nm, *L*1 = *L*2.

B. I_D -V_{DS} CHARACTERSTICS

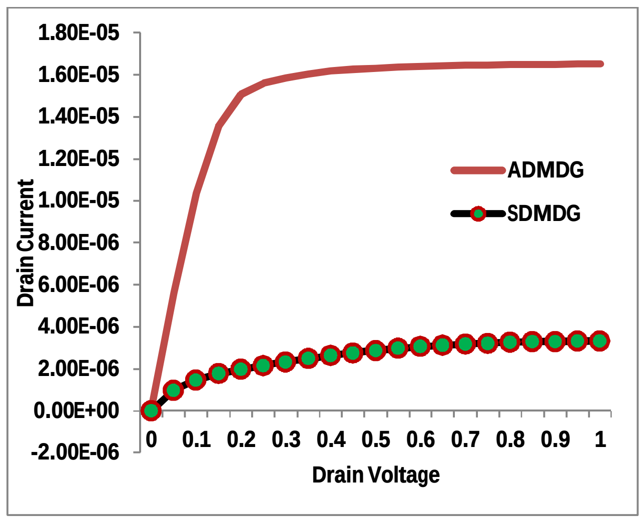
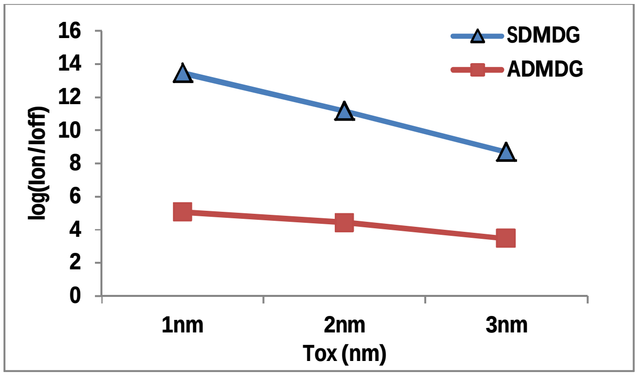


Fig.7. Drain current versus Drain voltage for SDMDG and ADMDG SOI MOSFET with *Vds* = 0V to 1 V and Vgs = 1 V. Channel length *L* = 20 nm, *L*1 = *L*2.

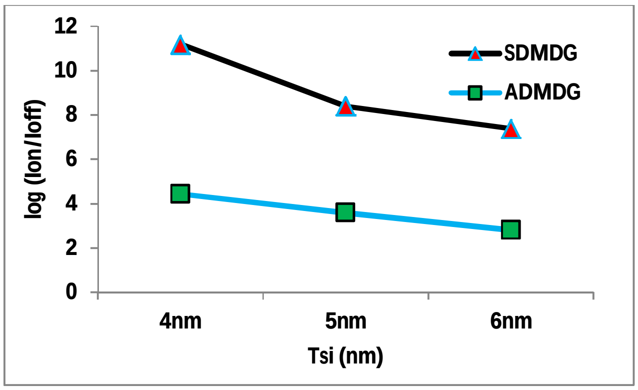
In fig.6 and fig.7, the comparison of current–voltage characteristics is shown for both the structures. We find that the drivability of SDMDG SOI MOSFET is not as good as that of ADMDG SOI MOSFET.

V. SIMULATION RESULTs

A. Ion/Ioff RATIO



(a)

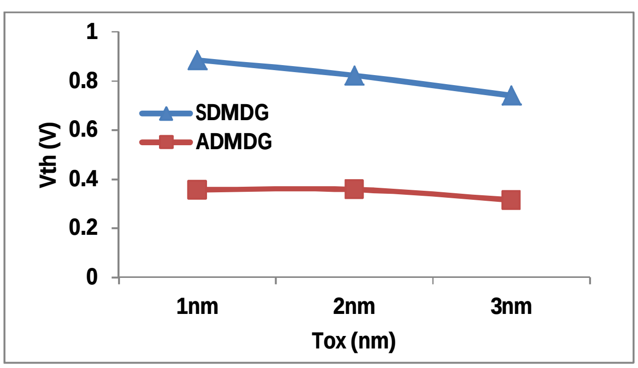


(b)

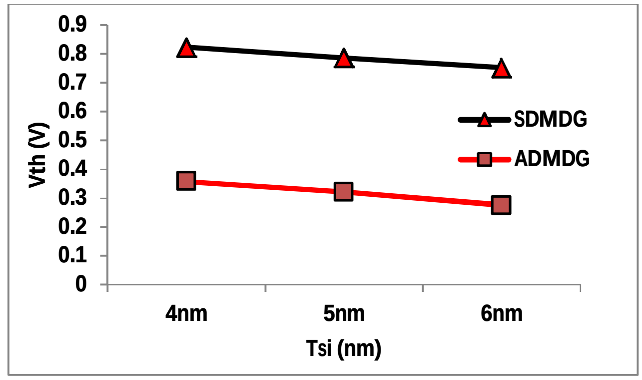
Fig.8. (a) log (Ion/Ioff) versus Gate oxide thickness. (b) log (Ion/Ioff) versus Silicon body thickness. (Vgs = 0V to 1V & Vds = 0.1V and 1V). Channel length L = 20 nm, $L1 = L2$.

Fig.8. shows that the I_{on}/I_{off} ratio of SDMDG is far better than the ADMDG SOI MOSFET. As the body thickness decreases, both I_{on} and I_{off} decreases but the I_{off} current decreases to a great extent. That results in an increase in the I_{on}/I_{off} ratio.

B. THRESHOLD VOLTAGE (V_{th})



(a)



(b)

Fig.9. (a) Threshold voltage versus Gate oxide thickness. (b) Threshold voltage versus Silicon body thickness. (Vgs = 0V to 1V & Vds = 0.1V and 1V). Channel length L = 20 nm, $L1 = L2$.

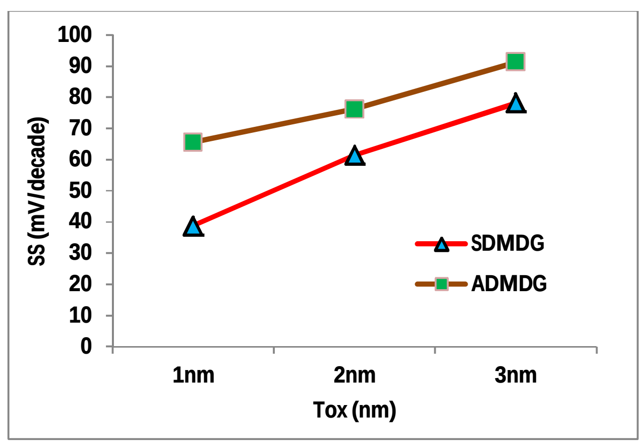
Fig.9. shows that as we increase the body thickness *(Tsi)* the threshold voltage *(Vth)* of both the device increases but *Vth* is higher in case of SDMDG SOI MOSFET. That results in a decrease in leakage current.

C. SUBTHRESHOLD SLOPE (SS)

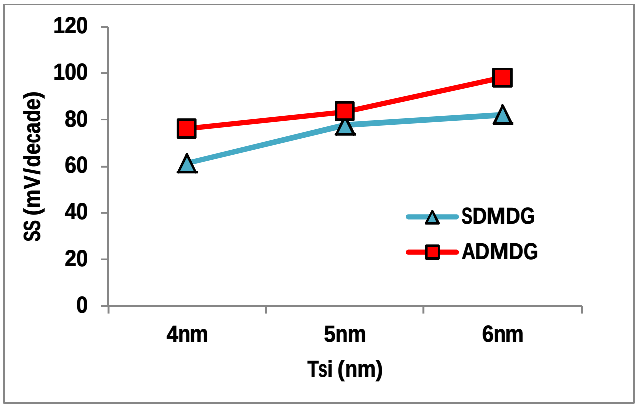
The Sub threshold Slope (SS) is the major parameter for calculating the off state current. Furthermore, SS is calculated as:

$$SS = \frac{1}{\frac{\partial(\log(I_d))}{\partial V_{gs}}} \qquad \textbf{(1)}$$

The SS value is extracted by calculating the inverse of maximum slope of Vgs versus $\log(I_d)$ curve.



(a)



(b)

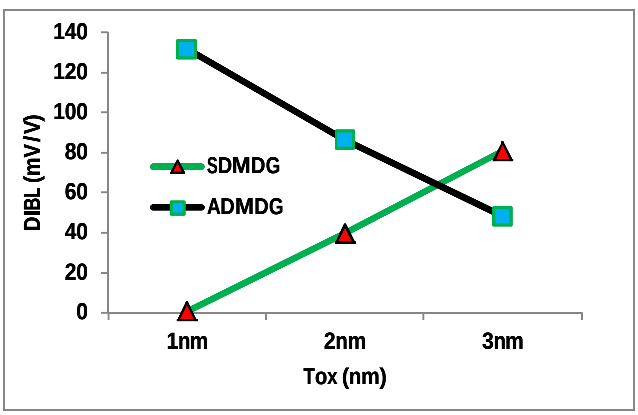
Fig.10. (a) Subthreshold slope versus Gate oxide thickness. (b) Subthreshold slope versus Silicon body thickness. (Vgs = 0V to 1V & Vds = 0.1V and 1V). Channel length *L* = 20 nm, *L*1 = *L*2.

Fig.10. shows that for Tsi=4nm and Tox=2nm we got near ideal value of subthreshold slope in case of SDMDG SOI MOSFET. As Tsi decreases, SS will also decreases. We got better SS for SDMDG SOI MOSFET.

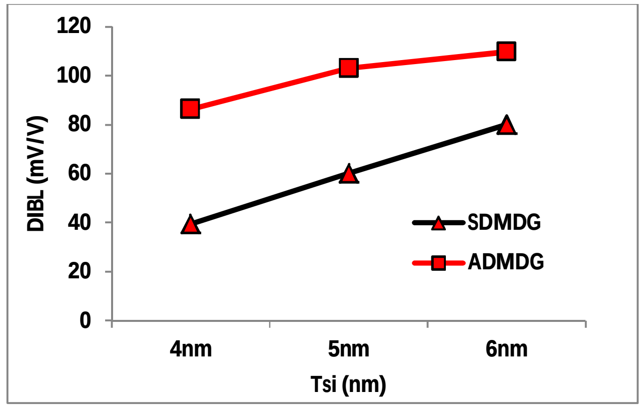
D. DRAIN INDUCED BARRIER LOWERING (DIBL)

The value of DIBL is calculated as per the relation:

$$DIBL = \frac{V_{th2}-V_{th1}}{V_{ds2}-V_{ds1}} \tag{2}$$



(a)



(b)

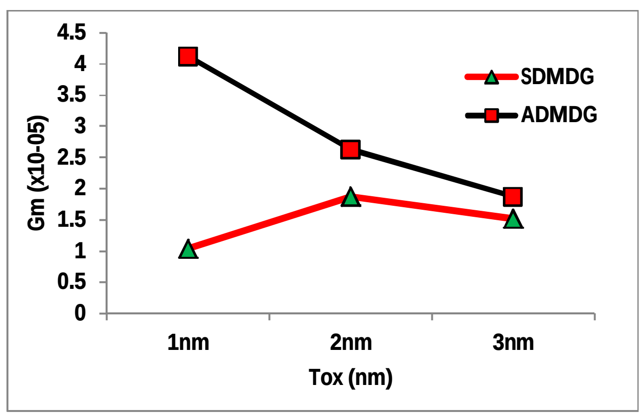
Fig.11. (a) DIBL versus Gate oxide thickness. (b) DIBL versus Silicon body thickness. (Vgs = 0V to 1V & Vds = 0.1V and 1V). Channel length *L* = 20 nm, *L*1 = *L*2.

Fig.11. shows that the DIBL effect is low in case of SDMDG SOI MOSFET. This is because of the symmetry in the gate electrode material used. The n+ poly will screened the source. Hence there is very less effect of drain voltage variation on surface potential near source.

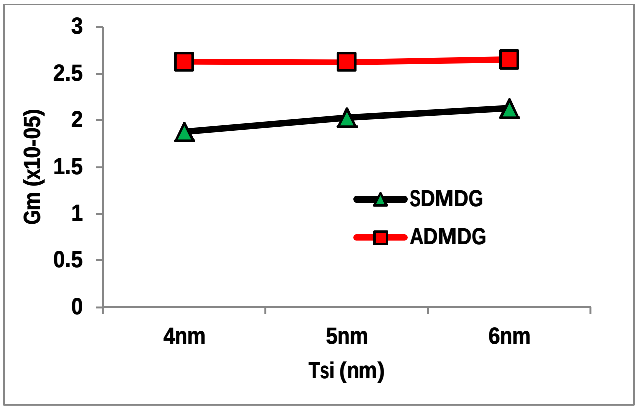
E. TRANSCONDUCTANCE (g_m)

As we know:

$$g_m = \frac{\partial(I_d)}{\partial(V_{gs})} \tag{3}$$



(a)



(b)

Fig.12. (a) Trans-conductance versus Gate oxide thickness. (b) Trans conductance versus Silicon body thickness. (Vgs = 0V to 1V & Vds = 0.1V and 1V). Channel length *L* = 20 nm, *L*1 = *L*2.

Fig.12. shows that as Gm is lower in case of SDMDG SOI MOSFET. Because of the high threshold voltage the drive current doesn't attain its saturation value for Gate voltage, Vgs=0V to 1V.

TABLE II
OPTIMIZED SIMULATION RESULT
For a Channel length, L=20nm and T_{ox}=2nm & T_{si}=4nm

S.No.	DMDG SOI MOSFETs		
	Parameters	***ADMDG***	***SDMDG***
1.	V_{t1} (at V_{ds}=0.1V)	0.280006	0.858033
2.	V_{t2} (at V_{ds}=1.0V)	0.357699	0.822379
3.	Subthreshold Slope (mV/dec)	76.2044	61.473
4.	g_m (S)	$2.62\text{x}10^{-05}$	$1.88\text{x}10^{-05}$
5.	I_{on}/I_{off}	$2.72\text{x}10^{4}$	$1.51\text{x}10^{11}$
6.	I_{on} (A/um)	$1.69\text{x}10^{-05}$	$3.34\text{x}10^{-06}$
7.	I_{off} (A/um)	$6.19\text{x}10^{-10}$	$2.21\text{x}10^{-17}$
8.	DIBL (mV/V)	86.3256	39.6156

III ANALOG PERFORMANCES

Transconductance *(Gm)* and output conductance *(Gd)* are the parameters mainly analyses the Analog performance of any Device. Other two derived parameters intrinsic gain *(Gm/Gd)* and trans conductance generation factor *(Gm/Id)* also helps the analysis of Analog response of the Device of the device.

A. TRANSCONDUCTANCE (g_m)

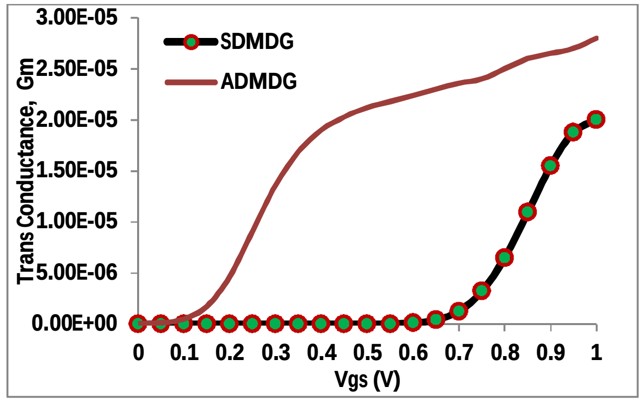


Fig.13. Transconductance versus Gate voltage. (Vgs = 0V to 1V & Vds = 1V). Channel length *L* = 20 nm, *L*1 = *L*2.

Fig.13. demonstrates the variation in the transconductance *(Gm)* with respect to applied gate voltage *(Vgs)* for both the structures. It can be observed that due to higher threshold voltage trans conductance *(Gm)* has been reduced for the SDMDG structure than ADMDG SOI MOSFETs. The lower trans-conductance is an advantage instead of a drawback, because it stands for smaller sub-threshold swing or faster current turning off.

B. OUTPUT CONDUCTANCE (Gd)

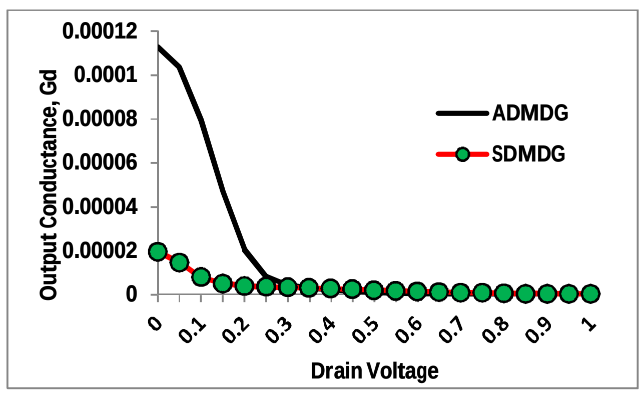


Fig.14. Output Conductance versus Drain voltage. (Vds = 0V to 1V & Vgs = 1V). Channel length *L* = 20 nm, *L*1 = *L*2.

Fig.14. demonstrates the variation in the output conductance *(Gd)* with respect to applied drain voltage *(Vds)* for both the structures. It can be observed that the value of output conductance *(Gd)* decreased in case of SDMDG structure over ADMDG SOI MOSFETs.

C. INTRINSIC GAIN, (Gm/Gd)

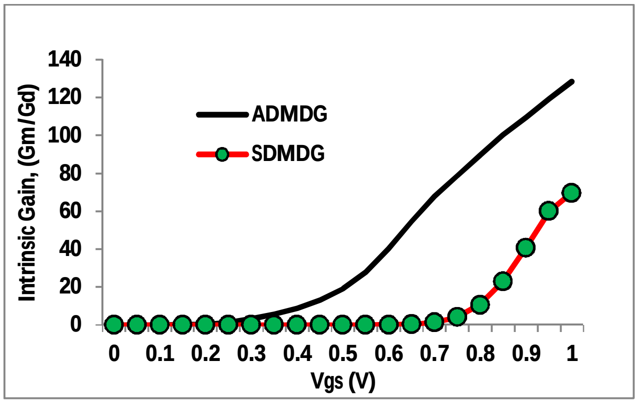


Fig.15. Intrinsic Gain versus applied gate voltage (at Vds=1V). Channel length L = 20 nm, $L1 = L2$.

Fig.15. demonstrates the variation in the intrinsic gain *(Gm/Gd)* with respect to applied gate voltage *(Vgs)* for both the structures. Because of a decrease in the Trans conductance and a decrease in the drain conductance, the voltage gain of the SDMDG structure is lower when compared with that of the ADMDG structure.

D. TRANSCONDUCTANCE GENERATION FACTOR, TGF (g_m/I_d)

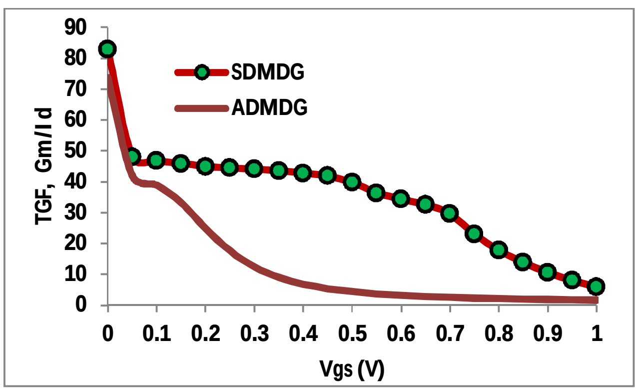


Fig.16. Trans-conductance generation factor versus Gate voltage. (Vgs = 0V to 1V & Vds = 1V). Channel length L = 20 nm, $L1 = L2$.

Fig.16. shows that the trans-conductance generation factor (TGF) or G_m/I_d ratio is viewed as the available gain per unit value of power dissipation. We got better G_m/I_d ratio for SDMDG SOI MOSFET.

CONCLUSIONS

The SDMDG SOI MOSFET shows better suppression of SCE's than ADMDG SOI MOSFET. We got improved I_{on}/I_{off} ratio, DIBL, reduced leakage current, I_{off} and near ideal sub-threshold slope. The drivability, I_d and trans conductance, G_m of the SDMDG device are not as good as that of the ADMDG device. But the Transconductance Generation Factor, TGF is high in case of SDMDG device.

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Study and Analysis of Environmental Issues for Scaled Version of Si-Ge Heterojunction Bipolar Transistor

Publisher: IEEE

Alok Kumar Pandey ; Arun Kumar ; Sheetal Singh **All Authors**

Abstract: Nowadays Si-Ge HBTs are playing an important role in the field of RF and microwave applications. Also Scaling of a device is an advance fashion in the innovation. In this... **View more**

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Abstract:
Nowadays Si-Ge HBTs are playing an important role in the field of RF and microwave applications. Also Scaling of a device is an advance fashion in the innovation. In this paper, we have scaled the Si-Ge HBT using scaling techniques and studied the behavior of the RF performance parameters of the DUT before scaling and after scaling with Ge content in base region.

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Contents

I. Introduction

VLSI plays an important role in RF electronics and RF & Microwave communication. The choice of material and semiconductor device is key factor in the field of VLSI. Which material and semiconductor device we have use is totally depends on the Figure of Merit (FOM). A detailed comprehensive study has been done for the selection of semiconductor device. In the study we have found that HBTs have intrinsic high-power density, linearity and efficiency compared to field effect devices in the RF and Microwave communication [2]–[4].

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A Qualitative Analysis of Secured Handover Management Schemes for Mobile IPv6 Enabled Networks

Publisher: IEEE Cite This PDF

Arun Kumar Tripathi ; Surendra Kumar Tripathi **All Authors**

Abstract: Development in wireless technologies permits IPv6 enabled handheld mobile devices to access the Internet ubiquitously. An IP-address is required to identify the mobile ho... **View more**

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Abstract:
Development in wireless technologies permits IPv6 enabled handheld mobile devices to access the Internet ubiquitously. An IP-address is required to identify the mobile host on the Internet. Mobile IPv6 (MIPv6) scheme enables a mobile host to migrate from one subnet to another without changing its exiting IP-address. For IPv6 based mobility, Internet Engineering Task Force (IETF) proposed standard Mobile IPv6 as first mobility management scheme. It provides a powerful and flexible way to handle handover management. Standard MIPv6 is a host-based global mobility management scheme and endure from basic issues such as signaling overhead, handover latency and packet loss. Subsequently, IETF has standardized localized network-based Mobility Management schemes to overcome problems associated with global host-based

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mobility management schemes named as Proxy Mobile IPv6 (PMIPv6). It reduces handover latency and packet loss compared to host-based mobility management schemes considerably, yet, suffers from security issues. Later on, researchers proposed secured-PMIPv6 protocols for authentication of mobile as well as network devices within LMD. The paper reviews various handover management schemes for secure handover management. The performance of various schemes qualitatively investigated on vital parameters such as authentication cost, signaling cost, packetloss etc.

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Contents

I. Introduction

Advancement in the field of mobile and wireless technology has affected our lives significantly and compelled us to shift from a fixed wired network to the wireless and mobile network. In the last decade, wireless technologies have increased 1000 fold in data rate approximately. Nowadays, wireless multifunctional terminals such as smart phones, laptops, personal digital assistants, navigation systems etc. have become part of our daily lives. These mobile terminals support a large number of multimedia applications such as social media applications, live video streaming, online games etc. To provide uninterrupted services to these devices, the volume is increasing exponentially day by day. Analysis by Computer Information System Company (CISCO), reveals that the mobile data traffic may grow up to 49 Exabytes per month by the year 2021, which is approximately seven times of the data traffic in 2016. In addition to this, the mobile data traffic may increase at a Compound Annual Growth Rate (CAGR) of 47% from year 2016 to year 2021 [1].

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Design of Multi-band Antenna

Ms. Swati, Department of Electronics & Communication Engineering (IGDTUW Delhi)/ Department of Electrical & Eletronics Engineering (KIET Group of Institutions Ghaziabad) India

Abstract:--

A new method for designing the multiband antenna is presented in this paper. In this method, two split ring slots with opposite gap facing is mounted on circular patch antenna. This configuration uses probe feeding technique along with RT duroid 5880 substrate. To create different short circuits along the slots the electric field is manipulated The resonance frequencies are chosen to increase the number of bands at which antenna can operate. Advance Design system 2011-10 is used for the simulation of this design. Results verify its multiband operation.

Keywords:--

Multiband, probe feed, patch antenna, resonant frequencies.

Space based solar power-a review

JyotiSrivastava ***Swati Singhal*** ***D.Blandina Miracle*** ***Swati***

[1,2,3,4]Department of Electrical Engineering, KIET Group of Institutions, Ghaziabad-201206, India.

Abstract

In the recent decades, there has been a huge energy demand due to the exponential increase of the human population and consequently, the depletion of non-renewable energy sources. This creates the need to explore alternate routes for renewable energy resources. The solar energy was the best alternative of the conventional energy system in last few decades, but because of intermittent energy and huge land area requirement it is the need of the hour to look for an alternate solar energy system. ***Space-based solar power (SBSP)*** *is a step towards this technology to overcome the limitation of intermittent supply as solar energy is always available in the space. SBSP is the concept of collecting* solar power *in* outer space *and distributing it to* Earth*. Potential advantages of collecting solar energy in space include a higher collection rate and a longer collection period due to the lack of a diffusing* atmosphere*, and the possibility of placing a solar collector in an orbiting location where there is no night.*

1. Introduction

Energy generation to meet the demand is a very big issue, and almost 10-15% of the total economic expenditures in the world are used for meeting this supply and demand [1]. The total resources which can be used for energy generation in the world can be broadly categorized into fossil fuels, renewable sources and nuclear resources. The fossil fuels and nuclear sources comes under the category of non-renewable sources further[2]out of these three sources of energy, fossil fuels are the conventional sources which are used to meet the major portion of the energy requirements in the world but they are depleting with time and also have adverse consequences such as global warming. Nuclear sources are also harmful for the living beings. This lead to shift towards renewable sources which is the best promising alternative of energy generation as compared with the above two categories of energy sources. The renewable energy source includes solar energy, wind energy, and hydel energy. Out of these solar energy was used and researched in last few decades, but because of its intermittent supply, it is not a very efficient energy generation system. So, the researchers thought to overcome this limitation by generating the energy directly in space where the availability of sunlight is always there using satellite and then transmit it to the earth. SBSP is an effort related to this initiative. Although the proposed system is in research state and not in use anywhere till now, but the researchers are targeting to achieve it till the end of 2025. In the present system which converts solar energy in to electrical energy, a considerable fraction of incoming solar energy (55–60%) is lost on its way through the Earth's atmosphere by the effects of reflection and absorption. But in Space-based solar power, the system convert sunlight to microwaves outside the atmosphere, avoiding these losses and the downtime due to the Earth's rotation, but at great cost due to the expense of launching material into orbit. SBSP is considered a form of sustainable or green energy, renewable energy, and is occasionally considered among climate engineering proposals. It is attractive to those seeking large-scale solutions to anthropogenic climate change or fossil fuel depletion (such as peak oil).

1.1 History

In 1941, science fiction writer Isaac Asimov published the science fiction short story "Reason", in which a space station transmits energy collected from the Sun to various planets using microwave beams. The SBSP concept, originally known as satellite solar-power system (SSPS), was first described in November 1968[6]. In 1973 Peter Glaser was granted U.S. patent number 3,781,647 for his method of transmitting power over long distances (e.g. from an SPS to Earth's surface) using microwaves from a very large antenna (up to one square kilometer) on the satellite to a much larger one, now known as a rectenna, on the ground[7]. Glaser then was a vice president at Arthur D. Little, Inc. NASA signed a contract with ADL to lead four other companies in a broader study in 1974. They found that, while the concept had several major problems – chiefly the expense of putting the required materials in orbit and the lack of experience on projects of this scale in space – it showed enough promise to merit further investigation and research[8]. Between 1978 and 1986, the Congress authorized the Department of Energy (DoE) and NASA to jointly investigate the concept. They organized the Satellite Power System Concept Development and Evaluation Program[9][10]. The project was not continued with the change in administrations after the 1980 US Federal elections. In 1997 NASA conducted its "Fresh Look" study to examine the modern state of SBSP feasibility. In assessing "What has changed" since the DOE study, NASA asserted that the "US National Space Policy now calls for NASA to make significant investments in technology (not a particular vehicle) to drive the costs of ETO [Earth to Orbit] transportation down dramatically. This is, of course, an absolute requirement of space solar power"[30]. On Nov 2, 2012, China proposed space collaboration with India that mentioned SBSP is a Space-based Solar Power initiative so that both India and China can work for long term association with proper funding along with other willing space faring nations to bring space solar power to earth[32].

2. Space Solar Power Exploratory Research and Technology program

In 1999, NASA's Space Solar Power Exploratory Research and Technology program (SERT) was initiated for the following purposes:

- Perform design studies of selected flight demonstration concepts.
- Evaluate studies of the general feasibility, design, and requirements.
- Create conceptual designs of subsystems that make use of advanced SSP technologies to benefit future space or terrestrial applications.
- Formulate a preliminary plan of action for the U.S. (working with international partners) to undertake an aggressive technology initiative.
- Construct technology development and demonstration roadmaps for critical Space Solar Power (SSP) elements.

SERT went about developing a solar power satellite (SPS) concept for a future Gigawatt space power system, to provide electrical power by converting the Sun's energy and beaming it to Earth's surface, and provided a conceptual development path that would utilize current technologies. SERT proposed an inflatable photovoltaic gossamer structure with concentrator lenses or solar heat engines to convert sunlight into electricity. The program looked both at systems in sun-synchronous orbit and geosynchronous orbit. Some of SERT's conclusions:

- The increasing global energy demand is likely to continue for many decades resulting in new power plants of all sizes being built.
- The environmental impact of those plants and their impact on world energy supplies and geopolitical relationships can be problematic.
- Renewable energy is a compelling approach, both philosophically and in engineering terms.
- Many renewable energy sources are limited in their ability to affordably provide the base load power required for global industrial development and prosperity, because of inherent land and water requirements.
- Based on their Concept Definition Study, space solar power concepts may be ready to reenter the discussion.
- Solar power satellites should no longer be envisioned as requiring unimaginably large initial investments in fixed infrastructure before the emplacement of productive power plants can begin.
- Space solar power systems appear to possess many significant environmental advantages when compared to alternative approaches.
- The economic viability of space solar power systems depends on many factors and the successful development of various new technologies (not least of which is the availability of much lower cost access to space than has been available); however, the same can be said of many other advanced power technologies options.

- Space solar power may well emerge as a serious candidate among the options for meeting the energy demands of the 21st century. Space Solar Power Satellite Technology Development at the Glenn Research Center—An Overview. James E. Dudenhoefer and Patrick J. George, NASA Glenn Research Center, Cleveland, Ohio.
- Launch costs in the range of $100–$200 per kilogram of payload to low Earth orbit are needed if SPS are to be economically viable[11].

3. Japan Aerospace Exploration Agency

The May 2014 IEEE Spectrum magazine carried a lengthy article "It's Always Sunny in Space" by Dr. Susumu Sasaki[33]. The article stated, "It's been the subject of many previous studies and the stuff of sci-fi for decades, but space-based solar power could at last become a reality—and within 25 years, according to a proposal from researchers at the Tokyo-based Japan Aerospace Exploration Agency (JAXA)."

JAXA announced on 12 March 2015 that they wirelessly beamed 1.8 kilowatts 50 meters to a small receiver by converting electricity to microwaves and then back to electricity. This is the standard plan for this type of power.[34][35] On 12 March 2015 Mitsubishi Heavy Industries demonstrated transmission of 10 kilowatts (kW) of power to a receiver unit located at a distance of 500 meters (m) away[36].

4. Design

Space-based solar power essentially consists of three elements[2]:

(1) Collecting solar energy in space with reflectors or inflatable mirrors onto solar cells

(2) Wireless power transmission to Earth via microwave or laser

(3) Receiving power on Earth via a rectenna, a microwave antenna

The space-based portion of collecting solar energy will not need to support itself against gravity (other than relatively weak tidal stresses). It needs no protection from terrestrial wind or weather, but will have to cope with space hazards such as micrometeors and solar flares. Two basic methods of conversion have been studied: photovoltaic (PV) and solar dynamic (SD). Most analyses of SBSP have focused on photovoltaic conversion using solar cells that directly convert sunlight into electricity. Solar dynamic technology uses mirrors to concentrate light on a boiler which is not suitable to use in the space. The orbital location also matters a lot for placing a satellite in the space. According to the researchers, the SBSP satellite should be place in the geostationary orbit. The main advantage of locating a space power station in geostationary orbit is that the antenna geometry stays constant, and so keeping the antennas lined up is simpler. Another advantage is that nearly continuous power transmission is immediately available as soon as the first space power station is placed in orbit; other space-based power stations have much longer start-up times before they are producing nearly continuous power.

Wireless power transmission was proposed early on as a means to transfer energy from collection to the Earth's surface, using either microwave or laser radiation at a variety of frequencies.The wireless power transmission via Microwave is based on the conclusion of demonstration done by William C. Brown demonstrated in 1964, during Walter Cronkite's CBS News program, a microwave-powered model helicopter that received all the power it needed for flight from a microwave beam. Between 1969 and 1975, Bill Brown was technical director of a JPLRaytheon program that beamed 30 kW of power over a distance of 1 mile (1.6 km) at 84% efficiency[43].

Microwave power transmission of tens of kilowatts has been well proven by existing tests at Goldstone in California (1975)[43][44][45] and Grand Bassin on Reunion Island (1997)[46].

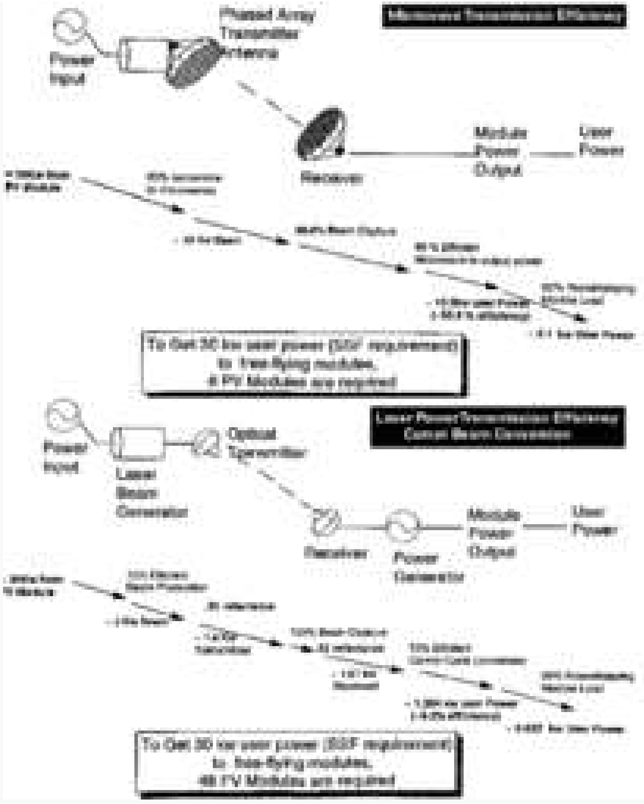

Figure 1.

Comparison of laser and microwave power transmission. NASA diagram

More recently, microwave power transmission has been demonstrated, in conjunction with solar energy capture, between a mountain top in Maui and the island of Hawaii (92 miles away), by a team under John C. Mankins[47][48]. Technological challenges in terms of array layout, single radiation element design, and overall efficiency, as well as the associated theoretical limits are presently a subject of research, as it is demonstrated by the Special Session on "Analysis of Electromagnetic Wireless Systems for Solar Power Transmission" to be held in the 2010 IEEE Symposium on Antennas and Propagation[49]. In 2013, a useful overview was published, covering technologies and issues associated with microwave power transmission from space to ground. It includes an introduction to SPS, current research and future prospects[50]. Moreover, a review of current methodologies and technologies for the design of antenna arrays for microwave power transmission appeared in the Proceedings of the IEEE [51]

Laser power beaming can also be used for the transmission of electricity generated from the space to the earth. It was envisioned by some at NASA as a stepping stone to further industrialization of space. In the 1980s, researchers at NASA worked on the potential use of lasers for space-to-space power beaming, focusing primarily on the development of a solar-powered laser. In 1989 it was suggested that power could also be usefully beamed by laser from Earth to space. In 1991 the SELENE project (Space Laser Energy) had begun, which included the study of laser power beaming for supplying power to a lunar base. The SELENE program was a two-year research effort, but the cost of taking the concept to operational status was too high, and the official project ended in 1993 before reaching a space-based demonstration[52].

In 1988 the use of an Earth-based laser to power an electric thruster for space propulsion was proposed by Grant Logan, with technical details worked out in 1989. He proposed using diamond solar cells operating at 600 degrees to convert ultraviolet laser light.

The designing receiver for receiveing the electricity generated in the space on the earth is one of the major hurdle in this project. Such receivers are called Rectennas on the earth. The Earth-based rectenna would likely consist of many short dipole antennas connected via diodes. Microwave broadcasts from the satellite would be received in the dipoles with about 85% efficiency[54]. With a conventional microwave antenna, the reception efficiency is better, but its cost and complexity are also considerably greater. Rectennas would likely be several kilometers across.

5. Launching costs

One problem for the SBSP concept is the cost of space launches and the amount of material that would need to be launched.

Much of the material launched need not be delivered to its eventual orbit immediately, which raises the possibility that high efficiency (but slower) engines could move SPS material from LEO to GEO at an acceptable cost. Examples include ion thrusters or nuclear propulsion. Power beaming from geostationary orbit by microwaves carries the difficulty that the required 'optical aperture' sizes are very large. For example, the 1978 NASA SPS study required a 1-km diameter transmitting antenna, and a 10 km diameter receiving rectenna, for a microwave beam at 2.45 GHz. These sizes can be somewhat decreased by using shorter wavelengths, although they have increased atmospheric absorption and even potential beam blockage by rain or water droplets. Because of the thinned array curse, it is not possible to make a narrower beam by combining the beams of several smaller satellites. The large size of the transmitting and receiving antennas means that the minimum practical power level for an SPS will necessarily be high; small SPS systems will be possible, but uneconomic. To give an idea of the scale of the problem, assuming a solar panel mass of 20 kg per kilowatt (without considering the mass of the supporting structure, antenna, or any significant mass reduction of any focusing mirrors) a 4 GW power station would weigh about 80,000 metric tons[58], all of which would, in current circumstances, be launched from the Earth. Very lightweight designs could likely achieve 1 kg/kW[59], meaning 4,000 metric tons for the solar panels for the same 4 GW capacity station. This would be the equivalent of between 40 and 150 heavy-lift launch vehicle (HLLV) launches to send the material to low earth orbit, where it would likely be converted into subassembly solar arrays, which then could use high-efficiency ion-engine style rockets to (slowly) reach GEO (Geostationary orbit). With an estimated serial launch cost for shuttle-based HLLVs of $500 million to $800 million, and launch costs for alternative HLLVs at $78 million, total launch costs would range between $11 billion (low cost HLLV, low weight panels) and $320 billion ('expensive' HLLV, heavier panels. To these costs must be added the environmental impact of heavy space launch missions, if such costs are to be used in comparison to earth-based energy production. For comparison, the direct cost of a new coal[60]or nuclear power plant ranges from $3 billion to $6 billion per GW (not including the full cost to the environment from CO2 emissions or storage of spent nuclear fuel, respectively); another example is the Apollo missions to the Moon cost a grand total of $24 billion (1970s dollars), taking inflation into account, would cost $140 billion today, more expensive than the construction of the International Space Station.

6. Potential and Drawbacks

Potential

The SBSP concept is attractive because space has several major advantages over the Earth's surface for the collection of solar power:

- It is always solar noon in space and full sun.
- Collecting surfaces could receive much more intense sunlight, owing to the lack of obstructions such as atmospheric gasses, clouds, dust and other weather events. Consequently, the intensity in orbit is approximately 144% of the maximum attainable intensity on Earth's surface.
- A satellite could be illuminated over 99% of the time, and be in Earth's shadow a maximum of only 72 minutes per night at the spring and fall equinoxes at local midnight[37]. Orbiting

satellites can be exposed to a consistently high degree of solar radiation, generally for 24 hours per day, whereas earth surface solar panels currently collect power for an average of 29% of the day[38].

- Power could be relatively quickly redirected directly to areas that need it most. A collecting satellite could possibly direct power on demand to different surface locations based on geographical baseload or peak load power needs. Typical contracts would be for baseload, continuous power, since peaking power is ephemeral.
- Elimination of plant and wildlife interference.
- With very large scale implementations, especially at lower altitudes, it potentially can reduce incoming solar radiation reaching earth's surface. This would be desirable for counteracting the effects of global warming.

Drawbacks

The SBSP concept also has a number of problems:

- The large cost of launching a satellite into space
- The thinned-array curse preventing efficient transmission of power from space to the Earth's surface
- Inaccessibility: Maintenance of an earth-based solar panel is relatively simple, but construction and maintenance on a solar panel in space would typically be done telerobotically. In addition to cost, astronauts working in GEO (geosynchronous Earth orbit) are exposed to unacceptably high radiation dangers and risk and cost about one thousand times more than the same task done telerobotically.
- The space environment is hostile; panels suffer about 8 times the degradation they would on Earth (except at orbits that are protected by the magnetosphere)[39].
- Space debris is a major hazard to large objects in space, and all large structures such as SBSP systems have been mentioned as potential sources of orbital debris[40].
- The broadcast frequency of the microwave downlink (if used) would require isolating the SBSP systems away from other satellites. GEO space is already well used and it is considered unlikely the ITU would allow an SPS to be launched[41].
- The large size and corresponding cost of the receiving station on the ground.
- Energy losses during several phases of conversion from photons to electrons to photons back to electrons[42].

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A Study on Green Energy Powered Cognitive Radio Network for Communication Network Architecture of Smart Grid

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Abstract–High information rate applications in smart grid can incredibly increase energy consumption, which has incited to an emerging trend of addressing the *energy efficiency* aspect of communication technology. Green energy powered cognitive radio (Green-CR) network is important technology to meet the high information rate prerequisites as well as to improve spectrum and energy efficiency. However, designing Green-CR networks for smart grid is challenging as it requires not only the optimization of dynamic spectrum access but also the optimal utilization of green energy sources. In this paper, spectrum aware and energy efficient Green-CR network model is introduced to overcome spatio-temporally varying spectrum characteristics and harsh environmental conditions for smart grid applications. Subsequent to presenting fundamental outline standards potential advantages and network architecture of Green-CR, a multi layered approach with small cells for efficient design methodology is proposed to provide energy efficient CR network at the smart grid utility.

Keywords–green cognitive radio network, smart grid, energy harvesting, green communication.

I. Introduction

Wireless communication plays an imperative part in realizing all essential features of smart grid such as, efficiency, reliability, resilience, sustainability and security [1], as it can offer smart grid a much greater degree of freedoms for information accumulation, dissemination, and processing than wired communication infrastructure. With the unique features of dynamic spectrum access technique, CR networks have the potential to make best utilization of scarce spectrum and support increasing demand for wireless applications including smart grid.

CR networks are context-aware reconfigurable wireless networks consisting two frameworks: the primary user (PU) framework and the secondary user (SU) framework. PUs are licensed users i.e. the have selected benefit to get to the licensed bandwidth, while the SUs are the unlicensed users in cognitive radio, which can just get to the bandwidth that is not utilized by the PUs [2]. Proposed CR framework based communications infrastructure guarantees to use possibly all spectrum resources efficiently in the smart grid. The idea of applying CR technology to smart grid was first proposed by A. Ghassemi *et al.* [3] in which the authors proposed to utilize CR based IEEE 802.22 standard in wireless regional area networks (WRANs) for smart grid backhaul data streams.

Different from current CR systems powered by the reliable on-grid energy source, continuous advances in green energy motivated us to concentrate on green energy powered networks. On the off chance that the green energy source is ample and stable in the sense of accessibility, CR system can be powered to opportunistically exploit the underutilized spectrum by harnessing free energy without requiring energy supplement from external power grid or battery [4]. As the smart grid advances and develops, green power farms that harvest energy from green sources can substantially reduce carbon footprints. The need for adopting green communication has been realized worldwide. There is a focus on following holistic approach for power optimization. The next generation architectures focus on developing new technology, cell deployment strategies and resource allocation policies to improve the energy efficiency of a wireless communication network. Akshita et al [5] surveyed various techniques for power optimization of the next generation wireless networks. Further, [6] developed green communication model for next generation wireless networks, which considers both the access and backhaul network elements. So far, a green communication architecture for smart grid communication architecture has not been premeditated.

The aim of this paper is to offer a comprehensive review on the recent works on the applications of CR network technology in smart grid, based on which we want to show an evolutional path of smart grid development based on spectrum aware and energy efficient Green-CR networks.

The rest of this paper is outlined as takes after Section II expounds energy challenges in cognitive radio. Section III presents the Green-CR network technology in the smart grid communication infrastructure. In the same segment, energy efficient CR systems with small cells are additionally talked about. Step by step instructions to green energy utilization in the smart grid environment, is examined first, in which only the energy dynamics is considered. This will provide some insights for the information transmissions in the CR system. At that point, with the introduction of spectrum dynamics, the energy utilization is discussed in Green-CR networks. Section IV discusses system model for smart grid communication infrastructure, followed by the conclusion drawn in Section V.

II. Cognitive Radio Energy Challenges

A CR system must make real-time decisions on continuous choices about which spectrum hole to sense, when, and for what surviving. The detected range data must be adequately sufficient to achieve exact conclusions with respect to the radio environment. Besides, spectrum sensing must be quick so as to track the transient varieties of the radio environment. Such

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prerequisite of spectrum sensing does not put CR energy challenges stringent prerequisites on the equipment usage of CRs as far as the detecting data transfer capacity, the handling speed, and the RF hardware, additionally speak to the fundamental energy-hungry segment of a CR. In what tails, the energy consumption challenges in CR transceivers and CRNs are examined, which are outlined in Fig 1.

A. CR Hardware High Energy Consumption

There exist various factors that altogether adds to the energy utilization of spectrum sensing in CR system. In any case, the CR transceiver hardware is required to accomplish adequately high affectability for a wide range (e.g., various GHz) while precisely identifying assorted and frequency-dependent primary signals at various received power levels. These spots serve necessities on the affectability, linearity, and element scope of the hardware in the RF front-end, and all the more particularly, the receiving wires, power enhancers and the analogue-to-digital transformation units [5], [6].

Moreover, preparing powers necessities of the signal processing units that investigate the detected range are high all together for the subjective radio to settle on a choice with generally low defer. Note that the environment is dynamic and the obstruction is adjusted both by the bursty traffic of primary clients and channel fading. Such stringent execution and preparing prerequisites require the CR transceiver hardware be power-hungry, and consequently, not green.

For example, the energy consumption of the High Power Amplifier (HPA) of a radio handset is ordinarily 70% of the aggregate energy utilized amid transmission - in any case the communication standard [1]. On the off chance that the energy utilization of the HPA in CR terminal can be proficiently overseen, e.g., by means of Peak to Average Power Ratio (PAPR) sensor, it can fundamentally lessen the energy utilization of the CR. This requires the configuration of adaptive HPA that can be tuned on the fly to increase distinctive signs that have a place with various communication benchmarks [1].

B. Listen-Before-Talk Idle Sensing

Talk Idle Sensing Existing range detecting systems rely upon identifying the exercises of the primary transmitters. Primary transmitter recognition plans are divided into matched filter detection, energy detection, feature detection, and interference temperature estimation. Right now, there does not exist any feasible way that permits CR terminals to estimate the interference at primary network receivers [5], [6] since primary clients are uninvolved and do not offer data with the CRN terminals. Despite the fact that there exists spectrum detecting procedures that adventure the bidirectional behavior of some primary systems or the weak leakage power of primary recipient RF circuits to surmise the presence or the non-attendance of a neighboring primary collector [7], such plans do not give an approach to quantify the cumulative interference at the primary recipient.

The basic component of all above spectrum detecting strategies is that they just think of one form or another of the conventional Listen-before-talk (LBT) methodology to identify primary transmitters. LBT procedures normally has the CR consistently listening to the distinctive range groups keeping in mind the end goal to get to the accessibility of spectral opportunities. While the CR is not really accepting information amid the unmoving listening process, regardless it still utilizes power that is comparable to the power consumed amid data reception. Since idle listening used as a part of LBT plans is constantly run by the CR over the spectrum bands of interest, it altogether adds to the energy utilization of the CR. Broad estimations in [8] have demonstrated that 60% of the energy utilized in real-world wireless innovations that utilize LBT is utilized in idle listening, even with the use of power saving modes. So as to diminish the energy utilization of CRs, LBT should be visited again to permit the CR to recognize the spectral opportunities taking into account the liminal measure of non-gainful idle listening.

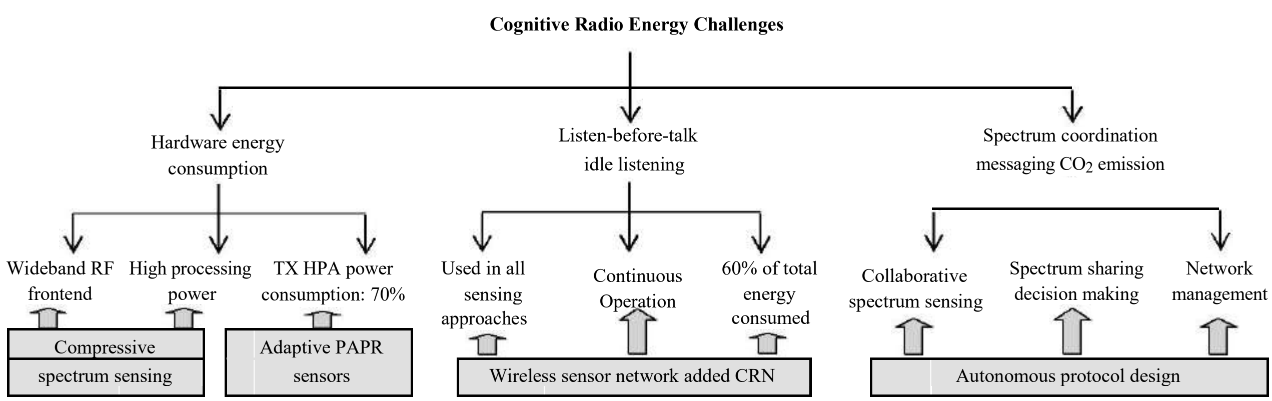

Fig.1 Energy challenges of CR sytem. The CR hardware and the LTB idle listening are the key energy consumption sources in CRNs. In the interim, the incessant range coordination message trade is the primary donor to the CO_2 outflow.

It merits saying that the limited detecting length of CR likewise restrains the precision of spectrum detection. Given a constrained detecting period, just a specific detecting precision can be ensured. As the sensing span expands, the dependability of the sensing data may increment. In any case, longer spectrum sensing windows are not as a matter of course helpful since the environment is dynamic and the energy on a given channel is regulated both by the bursty traffic, asynchronous initiation and end of packet transmissions, and channel fading.

C. Spectrum Coordination Messaging CO_2 Emission

In multi user CR systems, the coordination between numerous CR clients is a noteworthy challenge from networking perspective as well as from energy utilization viewpoint. In the event that legacy Medium Access Control (MAC) protocols intended for traditional networks were to be used as a part of CRNs, all CR clients that construe spectral opportunity will greedily endeavor to exploit the sensed opportunity. Review that legacy MACs frequently receive greedy procedures that attempt to best use a channel access (e.g., by using the most astounding transmission rate or picking the best channel). Such greedy methodologies disintegrate the good put of the CRN as the quantity of CR clients increment because of expanded blocking probability [4]. Moreover, such greedy MACs known to suffer from unfairness issues that may bring about some cognitive sender-receiver pairs sets to dominate different sets. A few centralized and distributed helpful MAC approaches have been as of late created for CR systems [9]-[11].

In any case, such plans depend on the explicit coordination between various transmissions which is a principle challenge in CRNs as it requires assembling and circulating spectrum information over the CRN and/or synchronizing the exercises of various flows. The use of a typical control channel for between stream coordination (and additionally for the coordination between a sender and its individual recipient) makes it the bottleneck of a CRN and the single point of failure for the whole framework [4].

Besides, the trading of spectrum coordination messages essentially adds to the CO2 outflow of CRNs. This is because of the gigantic number of messages exchanged so as to gather the spectrum information from various CR terminals and after that to disseminate the joint spectrum access discussion among them. With a specific end goal to diminish the measure of CO2 outflow of CRNs, spectrum sharing and access algorithms ought to minimize the explicit information sharing by either depending on local choices as much as possible or exploiting, learning and forecast techniques.

III. Green-CR Networks With Small Cells

As opposed to depending on cautious arrangement of ordinary CR systems, heterogeneous systems (HetNet's), which are comprise of a macrocell network overlaid by small cells, are proposed to determine the capacity demand issue. The small cells prompt higher spatial frequency reuse and lower power consumption. Furthermore, proposed green energy powered CR network is capable of liberating the wireless access networks from spectral and energy constraints. The limitation of the spectrum is alleviated by exploiting CR technology and dependence on the traditional unsustainable energy is assuaged by adopting energy harvesting (EH).

Green-CR network imposes more challenges than a regular CR system because the nodes with available spectrum, the nodes with sufficient power and the ones with data traffic to serve may all be different [5]. As compared with cellular networks powered by distributed green generators or green power farms, the operation of Green-CR network is more perplexing, because various framework architectures require different energy distribution within the network, *e.g.*, the centralized controller needs more energy in the spectrum sensing phase while secondary systems demand more energy in the information transmission phase. Besides, Cognitive functionality relies on upon the energy availability while spectrum availability in turn affects the energy consumption. In our proposed model energy harvesting is applied to address the problem of tapping energy from readily available ambient sources that are free for users, including wind, solar, biomass, hydro, geothermal, tides, and even radio frequency signals.

Contingent upon whether there is a storage capability for the power output of the harvesting system, the generic system model is ordered into:

- *Harvest-use modeling*: Mandates that the instantaneous energy harvesting rate should always be no less than the energy consumption rate.
- *Harvest-store-use modeling*: Provides a storage component, *e.g.* rechargeable batteries, to hoard the harvested energy for future utilization.

The energy harvesting procedure and energy consuming procedure *i.e.*, sensing, transmission, reception, etc, can be scheduled simultaneously, or in a time switching manner.

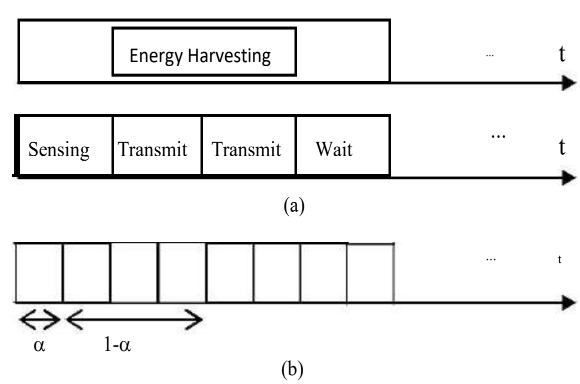

Fig. 2. The harvest-store-use mechanism of cognitive device
(a) Simultaneous energy harvesting and consuming (b) Time switching between energy harvesting and consuming

The unified model of the energy collecting method of these structures is given in Eq. (1).

$$E_h = \alpha\eta E \quad (1)$$

where E_h represents the energy harvested, E is the green power source. $0 < \alpha \leq 1$ is the time switching ratio that is consumed for energy harvested, and $0 < \eta < 1$ is the energy conversion efficiency.

Except for the isolated energy harvester and information recipient like Fig. 2(a), helped to establish energy harvester and information beneficiary can grasp two valuable designs: power splitting and time switching. As delineated in Fig. 3(a), when the RF signal achieves the recipient, some portion of it is used for power extraction and the rest for the concurrent data detection. Note that Fig. 2(b), which requires just one arrangement of antenna for both energy and information, is a special example of Fig. 1(b). The unified model of the RF energy harvesting process of these structures is given below in Eq. 2.

$$E_h = \alpha\, \eta\, |h^2| E \quad (2)$$

where h is the channel condition between the RF energy harvester and the RF energy source. $|h^2|E$ gives the energy of the recipient RF signals.

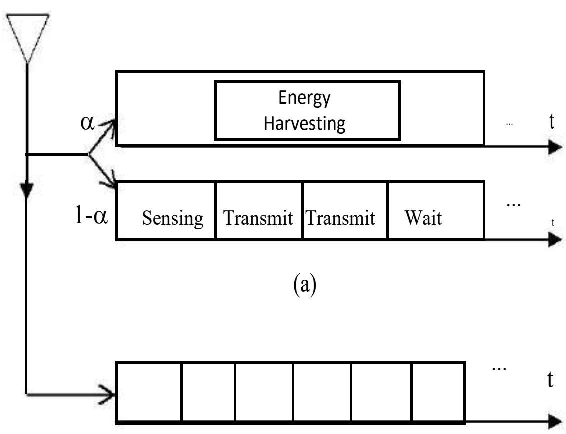

Fig. 3. The RF energy harvesting mechanism (a) Power splitting in the receiver (b) Time switching in the receiver

Energy harvested in the current time slot can only be utilized in subsequent time slots, inferable to the energy half-duplex constraint as indicated in Fig. 2(a) and Fig 3(a). Thus, before performing the cognitive functionality, the available residual energy is observable in all of the architectures. Proposed Green-CR is different in the sense of the dynamic nature of energy supply, i.e., opportunistic energy harvesting makes the energy-arrival rate no longer constant [6].

IV. Green-CR Based Smart Grid System Model

The communication architecture based on Green-CR for smart grid is comprised of three tired hierarchical structure counting Home Area Network (HAN), Neighborhood Area Network (NAN), and Wide Area Network (WAN) [7].

A. Cognitive Home Area Networks

HAN is basically a heterogeneous system with small cognitive cells, to give energy efficiency administration and demand reaction. In cognitive HAN, there is a key segment called cognitive home gateway (HGW) which can be coordinated into smart devices to provide two-way communications for smart grid by establishing a contact with various devices within the HAN to collect power-related data occasionally.

B. Cognitive Neighborhood Area Networks

As indicated in Fig. 4, a cognitive gateway in a NAN unites several HGWs together. The cognitive neighborhood gateway (NGW) is an information combination point, which is by and large a utility pole-mounted gadget, a power substation, or a communication tower. To inadequate the expense of obtaining spectrum bands, the NGW and the HGWs bestow in approved bands using CR innovation. The NGW circulated available spectrum bands to each HGW as indicated by the transmission request. The circulated generation frameworks offer advantages to electricity transmission since they are nearer to clients than traditional centralized power frameworks and facilitate demand response management in a NAN.

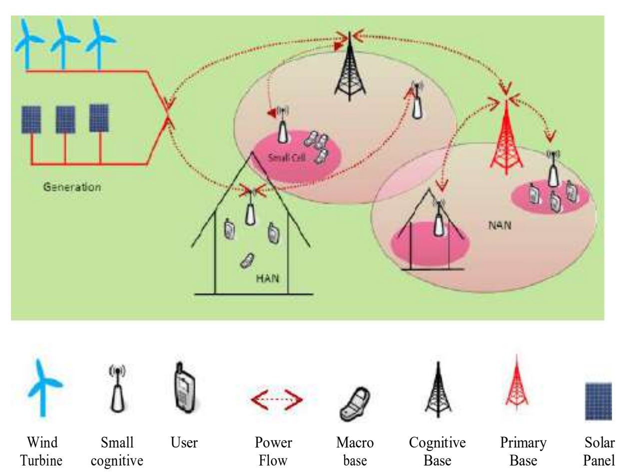

Fig. 4 Heterogeneous CR networks powered by Green energy

C. Cognitive Backhaul Networks in Wide Area Networks

WAN comprises of two interconnected systems, *i.e*., the center systems and backhaul systems. The center systems provide connection to the control center and commonly use fiber optics or cell systems to guarantee high information rates and low latency. The backhaul systems handle the broadband connection to NANs and monitoring devices. Applying CR technology in backhaul systems contributes to reducing the expanse for investment and enhancing the flexibility, capacity, and coverage. Each NGW is considered as a cognitive hub rather than an access point. The NGW has the capability of communicating with the cognitive base station distributed over a wide area through authorized bands unused by primary systems.

On one side, Green-CR communication frameworks that work in the unapproved bands are connected in the HAN to facilitate the heterogeneous wireless technologies; on the other hand, Green-CR communication frameworks that work in the approved band are connected in the NAN and WAN to powerfully get to the unoccupied spectrum opportunities. In this design, just nearby detecting information in the regions where the CR frameworks are found is acquired. From now on, the detecting precision increments with the number of CR frameworks.

The way of controlling a conventional generation facility is not suitable for a distributed renewable energy generation framework. Likewise, it is important that renewable energy sources tend to be variable and in like manner the working schedules of such power frameworks are property of dynamic variation. Assorted renewable energy sources have diverse active period amid a day. Amid the active period of renewable energy sources, higher information rate and more reliable services are needed for the data communication in distributed generation systems.

V. CONCLUSION

This paper discussed a diagram of the paradigm shift towards Green-CR system for communication network design of savvy grid. Not at all like the conventional CR systems, Green-CR systems know about maintainable advancement, and enhance the spectrum usage proficiency by means of spectrum awareness at low energy utilization and lessened CO_2 release to environment. We presented a system that can provoke move towards the green vision for smart grid by significantly reducing operational expenditure and CO_2 emissions.

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Contingency Analysis and Security Constraint based Optimal Power Flow in Power Network

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Deepak Yadav ; Aditya Singh Chauhan ; Brijesh Singh All Authors

Abstract

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Abstract: The objective of the present work is to observe the application of security constraint optimal power flow (SCOPF) technique in contingency management of power system. The... **View more**

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Abstract:
The objective of the present work is to observe the application of security constraint optimal power flow (SCOPF) technique in contingency management of power system. The contingency situations in power networks such as line outages and generation outages have been managed by using SCOPF solutions. The generation levels of various generators have been optimally rescheduled during contingent situation using SCOPF based load dispatch technique. In SCOPF, various other system constraints such as congestion, voltage deviation, and loss minimization have also been taken into account to achieve economic performance in the system. The interior point method (IPM) technique has been used to obtain the test results. The IPM based SCOPF methodology has been tested on an IEEE-9 bus system. The obtained test results show

that the IPM based SCOPF technique provides efficient solutions for economic load dispatch in power network during normal and contingent situation of line and generation outages.

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Contents

I. Introduction

The Power system is one of the leading fields where various operational activities have been involved, such as operational problems of a power system, security, reliability, and cost-effective load dispatch. One of the most challenging issues of modern power system infrastructure is analysis of contingency and optimal management methods. To insure a continuous power flow in power networks for meeting consumers' demand during contingency situations have also been a challenging task among the operators. The term, contingency analysis, is one of the most essential issue for establishing Power Management Systems (PMS) in power networks. The establishment of PMS in power networks is required advance analytical tools and algorithms for contingency analysis [1]. The objective is to provide a cost effective solution for power system operators. Mostly, the contingency situations raised because of generation and line outages [2]-[3]. In this situation, it is assumed that the system having capability to fulfill the power demands of the consumers through reserve capacities of the generators in the system. The rescheduling of generation is one of the usual practice adopted by the system operator [4]. Sometimes, the rescheduling decision making will be complex for the operators. Thus the optimal power flow (OPF) based system operation provide good solutions, especially during contingency [5]-[7].

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Study and Analysis of Environmental Issues for Scaled Version of Si-Ge Heterojunction Bipolar Transistor

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Alok Kumar Pandey ; Arun Kumar ; Sheetal Singh **All Authors**

Abstract: Nowadays Si-Ge HBTs are playing an important role in the field of RF and microwave applications. Also Scaling of a device is an advance fashion in the innovation. In this... **View more**

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Nowadays Si-Ge HBTs are playing an important role in the field of RF and microwave applications. Also Scaling of a device is an advance fashion in the innovation. In this paper, we have scaled the Si-Ge HBT using scaling techniques and studied the behavior of the RF performance parameters of the DUT before scaling and after scaling with Ge content in base region.

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Contents

I. Introduction

VLSI plays an important role in RF electronics and RF & Microwave communication. The choice of material and semiconductor device is key factor in the field of VLSI. Which material and semiconductor device we have use is totally depends on the Figure of Merit (FOM). A detailed comprehensive study has been done for the selection of semiconductor device. In the study we have found that HBTs have intrinsic high-power density, linearity and efficiency compared to field effect devices in the RF and Microwave communication [2]–[4].

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Disturbance Observer Based Robust Control Design of Variable Speed Wind Turbine

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Alok Kumar Pandey ; Bhanu Pratap ; Akhilesh Swarup **All Authors**

Abstract: This paper investigates the design of a robust control for two mass model (2-MM) of a variable speed wind turbine (VSWT). The VSWT is a class of nonlinear system with a h... **View more**

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Abstract:
This paper investigates the design of a robust control for two mass model (2-MM) of a variable speed wind turbine (VSWT). The VSWT is a class of nonlinear system with a high degree of uncertainty of irregular wind speed. The uncertain behaviour of wind speed is directly unmeasurable due to the high cost of sensors. Thus, the proposed control strategy is designed on the basis of disturbance observer which avoids the construction of inverse operator leads to the problem of singularity. The closed-loop 2-MM VSWT system stability is established as asymptotically stable. The simulation results reveal the performance and robustness of the proposed control algorithm for 2-MM VSWT system.

Figures

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Keywords

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Contents

I. Introduction

Among various renewable energy sources, wind energy considers as the most promising source. It is supplying 3.7 % of global energy production and can be increased to 15%-18 % by 2050 as suggested by the international energy agency. Annual growth production of wind energy is 22 % from 2000 to 2015 [1], [2]. For maximum extraction of wind energy, it is necessary to maintain a constant rotational speed of the rotor. A control strategy is required to maintain rotor speed of variable speed wind turbine (VSWT) due to continuous change in the wind speed. However, a lot of challenges are still there like control of its dynamics, effective harvesting of energy and to maintain its robustness during irregularities that include velocity and direction of the wind so that it is infeasible to extract total power [3].

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Figures

Energy Conservation: Analysis & Improvement through Energy Audit

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***Abstract*— Energy generated from either conventional or non-conventional resources are generally not fully utilized in efficient way results in overconsumption, reduced energy efficiency & increased cost. Effective energy scheduling through energy audit results in smart & efficient energy consumption. Energy auditing had been conducted based on one year KWH consumption in KIET Group of Institutions Ghaziabad and various recommendations through this paper will be necessarily helpful for all educational buildings to minimize energy consumption & improving energy conservation.**

***Keywords*-- Energy audit, energy scheduling, energy consumption**

I. INTRODUCTION

Krishna Institute of Engineering and Technology (**KIET**) is a private engineering institute affiliated to Dr. A.P.J. Abdul Kalam Technical University, situated in Ghaziabad in the National Capital Region of India 30 km from Delhi. The institute is ISO certified and NBA accredited. The institute was started in 1998 under the aegis of the Krishna Charitable Trust. The institute has 8 academic departments, 3 boys hostels, 3 girls hostel, Auditorium, TBI, Central Library, a Multi-Purpose Complex with a focus on education in engineering, sciences, pharmacy and management. As on the date, the student strength of the institute is about **5341** with total faculty plus staff strength of about **529** and over an area of about **21** acre. The institute connected load is **1112 KVA** and annual electricity bill keeps up in several (**Cr**). This huge electricity bill attracts the attention naturally. Making the institute energy efficient will not only concern with reduction in electricity expenses but also helps us to remind our moral responsibilities of not wasting this precious resource which may be used by people of the country in need.

A. Objective of the work

The objective of Energy Audit is to promote the idea of Energy Conservation in the Campus of KIET Ghaziabad. The purpose of the energy audit is to identify, quantify, describe and prioritize cost saving measures relating to energy use in the Hostels, Departments and Institute Central Facilities [3].

The work eligible for Energy Audit Study should be directed towards:

•Identification of areas of energy wastage and estimation of energy saving potential in Hostels, Departments and Central Facilities.

• Suggesting cost-effective measures to improve the efficiency of energy use.

• Estimation of implementation costs and payback periods for each recommended action.

• Documenting results & vital information generated through these activities.

•Identification of possible usages of co-generation, renewable sources of energy (say Solar Energy) and recommendations for implementation, wherever possible, with cost benefit analysis, and to reduce environmental effects.

B. Audit Methodology

The methodology adopted for this audit was a three step process comprising of:

1. Load Calculation & Testing of measuring devices In preliminary load calculation phase, exhaustive data collection was performed using different tools such as observation, interviewing key persons, and measurements. Power analyzer, lux meter used for this purpose is well tested by Lamp Load methods [14].

Following steps were taken for Load collection:

- The team walk through each department, center, hostel etc.
- Information about the general electrical appliances was collected by observation and interviewing.
- The power consumption of appliances was measured using power clamp meter.
- The details of usage of the appliances were collected by interviewing key persons e.g. Warden (in case of hostels), caretaker (in case of departments) etc.
- Light intensity was measured using lux meters at

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the places where light intensity was either very low or very high.

- Approximations and generalizations were done at places with lack of information.

Fig.1. Testing of power clamp meter

2. Load Analysis & interpretation-- is divided into two parts-

- **Time Schedule**-Working hours in each block and rooms with reference to time table provided.
- **Load Analysis-** it is basically energy utilized in KWH for whole year is tabulated.
- In data analysis, the data collected is processed to draw significant conclusions to pinpoint loopholes and identify the areas to focus upon. Analysis of the power consumption observations obtained was used to obtain the power consumption pattern and also to get the information about the points where electric power is wasted.

2.1-Time Schedule-

- Working hours of each room in every block of the institute, hostels, central library, multipurpose complex, laboratories, auditorium, TBI, streets etc. were observed.

2.2-Load Analysis-

- Load of each electrical equipment like tube lights, CFL, Air Conditioners, Refrigerators, Microwave Ovens, Fans, Projectors, Computers, Laboratory equipments, etc. were calculated of each room in each block and the power consumption was analyzed and then compared with total energy consumption of last year.

3. Recommendation –

On the basis of results of Load calculations and observations, some steps for reducing power consumption without affecting the comfort and satisfaction were recommended along with their cost analysis and finally payback period is calculated.

Following will be the steps involved in this process:

- The capital cost involved in replacing an appliance and/or process will be estimated.
- The energy saving by the move will be calculated in terms of price of energy per year.
- These two costs were compared to calculate the capital cost recovery time which defined as the total time by which the saving in energy bill balances the capital cost involved.

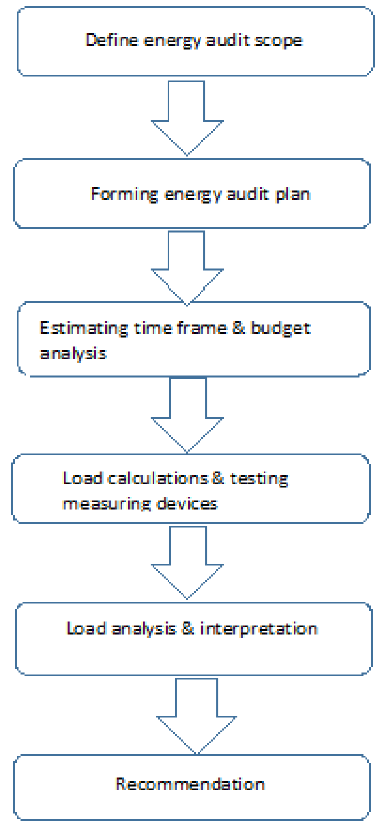

Fig.2. Flow chart of the proposed work

II. POWER CONSUMPTION ANALYSIS

A. The power consumption by each block per year is shown in Fig. 3.

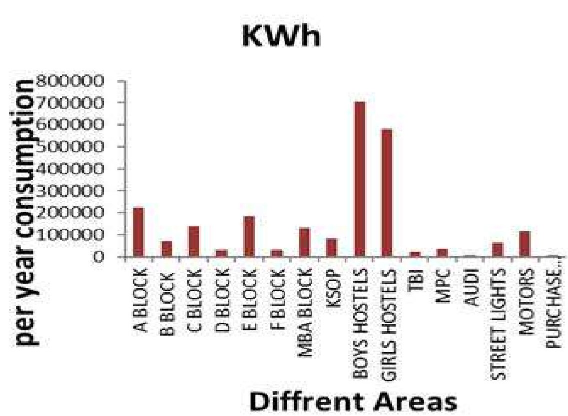

Fig.3 comparative analysis of different blocks

B. Overall campus consumption analysis:

In the above chart maximum consumption is observed in Boys and Girls Hostels because there are 6 hostels altogether. Second largest consumption was seen in Block A because it is the Administrative block and works continuously carried throughout the year. It was observed that huge amounts of Air conditioners (split and windows) together with centralized one consumes power significantly. E Block was third highest consumption area as it has 4 departments including CSE, CIVIL, IT, MCA. The reason was clear that more numbers of Fans, FTLs with more time duration of use, also blocks open for 5 days generally but it was not the case of Hostels which were open all over the week.

C. Equipment wise consumption:

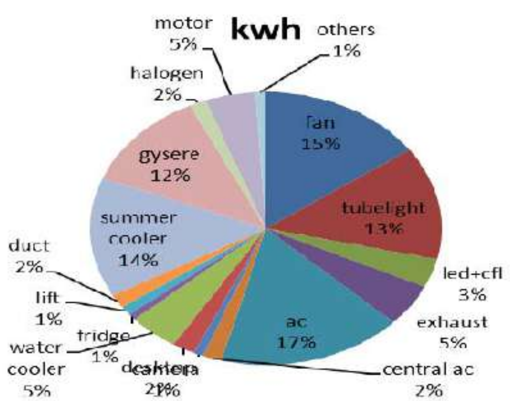

Fig.4 Percentage consumption of different equipment

It was observed from above pie chart that maximum consumption of energy per year due to AC which was 17% and it might be due to the large numbers of AC in A Block classes and in all the faculty cabins of various departments. Fans, tube lights, summer coolers and geysers share about equal energy per year and that is about 12-15% each. 5% energy is consumed by water coolers and exhaust Fans due to high wattage consumption, mainly in toilets, and also by motors that are used in Sewage plants, Fountains, etc. Rest of loads are very negligible as seen in figure 4.

D. Overall Energy Consumption of Hostels:

There are 3 boys' hostel and 3 girls' hostel in KIET with separate Mess for each. Most of rooms are triple seater with three Tube lights, two Fans and single seated with one fan and two tube lights. In winter season warm water facility is available through electric geysers in each boys' hostel. In girls' hostel also electric geysers of 2KW in each washroom are provided. Here we compare per year electricity consumption of individual hostel. Girls' hostels together with mess load is compared with boys' hostel.

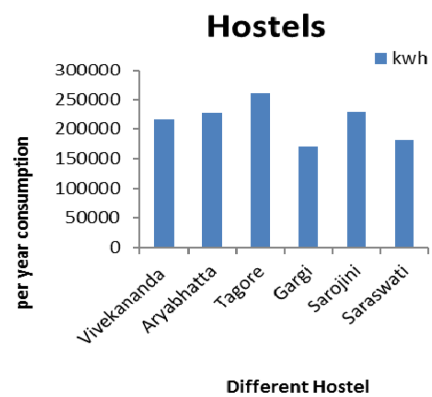

Fig.5. Comparative analysis of different hostels

E. Equipment wise hostel consumption:

As far as hostels are concerned, summer cooler loads were found to be 27% as almost all the room there is cooler and in operation during the summers. Second largest consumption was seen in heating elements which only used 120 days nearby but its wattage value is very high and attracts the attention to replace by some other mode of heating e.g. solar etc. Fans are in larger quantity with higher wattage value, however used only 200 days per year and it consumes third highest 20% of all hostels energy.

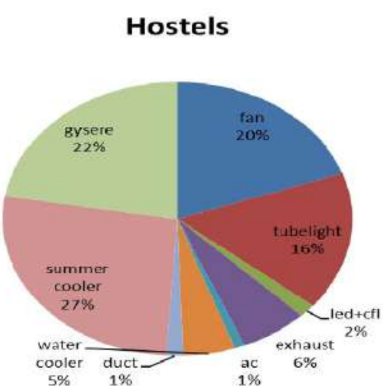

Fig.6. Equipment wise hostel consumption

F. Overall acedemic block energy consumption:

In KIET, there are 7 academic blocks and 1 academic cum administrative Block A. Block A consumes maximum energy per year and it is due to the fact that this block utilizes maximum number of Air conditioners (split & windows) along with centralized AC. Large quantities of Fans, FTLs and Water coolers. Second largest consumption was seen in Block E where CSE, CIVIL, MCA, IT departments classes run weekly along with Laboratories and Faculty cabins. Third highest consumption is of C Block as it takes the considerable share of energy consumption due to the college cafeteria, machine labs and mechanical workshop. Fourth largest is the MBA Block in which CRPC and Soft Skill departments are present including MBA classes.

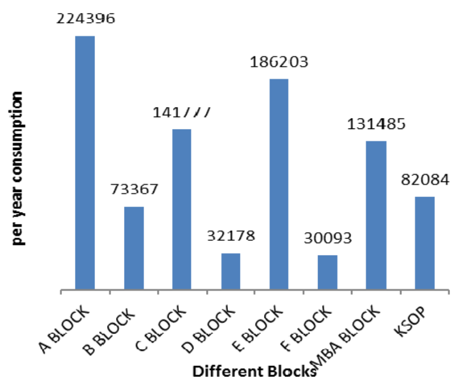

Fig. 7 Comparative analysis of academic blocks

G. Equipment wise acedemic block consumption:

Maximum energy consumption per year was found by Air conditioner and second largest by Fans and tube lights equally. However it is easily noticeable point that working period for Air conditioner is about 120 days and for Fans it is 140 days during summer days, of course it dominates Fan load due its high wattage consumption of AC's. Third largest consumption area was Desktops due to abundance of computer labs. Water cooler, Central AC, Exhaust Fans and LED and CFL were sharing the load equally with 4% each.

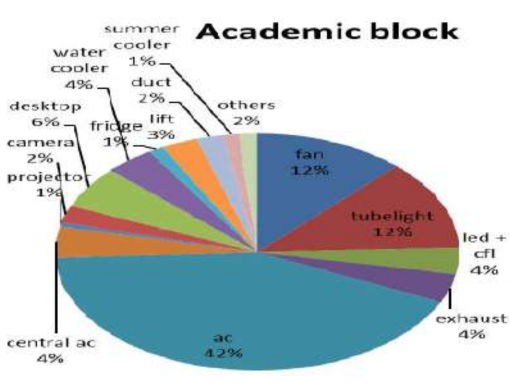

Fig. 8 Equipment wise academic blocks consumption

H. Other facilities consumption:

Motors take the highest amount of energy in the other facilities provided in the college campus in which the most prominent motor which take highest energy are Water Sewage Plant motors. It consumes huge electricity whole the year which is really the matter of discussion. In sewage plant, there are 11 motors of different HP ratings.

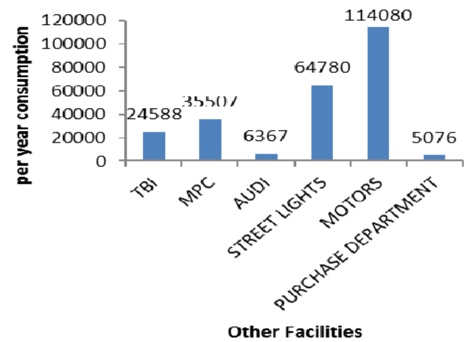

Fig.9. Power consumption by other equipments

SEWAGE PLANT MOTOR				
S.N	**Motors**	**Measured Power rating in watt**	**Quantity**	**hours /day**
1	3 HP	2138	2	12
2	5HP	3360	2	12
3	7.5HP	4600	1	12
4	7HP	4220	1	8
5	3HP	2138	2	8
6	10HP	5300	2	6
7	5HP	3360	1	6

Table 1. Power consumption by different facilities

I. Equipment wise consumption of other facilities:

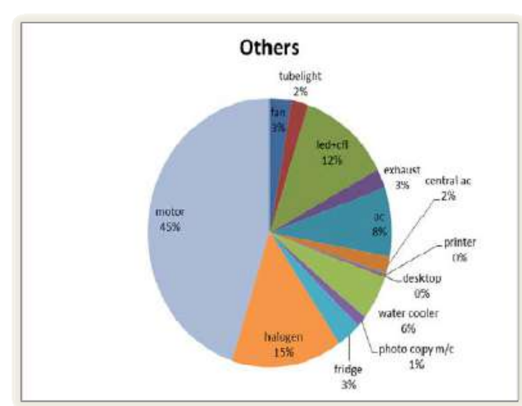

Fig.10. Equipment wise consumption

III. RECOMMENDATION

There are various ways of improving present situation. Based on previous analysis it is quite clear that as far as overall campus & hostels are concerned, if Fans of low rating is used it may be very useful in reducing the electricity bill. However during block wise load analysis it was found that UPS and Air conditioners cannot be underestimated as these areas seems to be having a lot of potential of improving energy efficiency.

A. Installation of bio gas plant:

Calorific value of biogas = 19.5 MJ/m^3
Calorific value of LPG = 46.1 MJ/m^3
Observed food wastage of 190 kg per day
Total LPG consumption in boys and girls hostel = 14 per day
Weight of one LPG (commercial cylinder) = 19 kg
Cost (varies time to time) of one LPG cylinder = 1200 Rs.
1 m3 biogas = 0.45 kg of LPG
40 kg food waste produces 20 m^3 biogas per day
190 kg food wastage produces 95 m^3 biogas per day
95 m3 biogas = 42.75 kg LPG or 2 LPG cylinder per day
Total cost of LPG per year (assume 280 days in a year working) = Rs.4704000
Cost of biogas produced per year = Rs. 756000 Per year
Installation cost = Rs. 600000
Annual saving = Rs. 756000
Payback period = 600000/ 756000 = 0.79 years (Approx.)

B. Lightning saving:

As per the Energy Conservation Building Code (ECBC) – 2006, published by the Bureau of Energy Efficiency (BEE), Govt. of India, and the recommended luminance are as given below in Table 2.

Table 2. Recommended Illuminance

Type of Interior Or Activity	Minimum Illuminance Required (Lux)
General	200
Reading room	200
Reading tables	200
Bathrooms	200
Computer workspace	300
Interior parking area	20
Music rooms	200
Sports hall	200
Corridors, cafeterias, mess	150
Food , cooking	300

Table 3. Observed Illuminance in campus (Lux meter reading)

Different areas	Measured Lux
Hostel rooms	250
Reading areas	300
Class room	250
Corridor	220

The lighting that is currently used in most of the hostels is T8 FTL with conventional ballast. It consumes 40 watt approximately measured by power meter. According to ECBC standard it was clearly observed that everywhere lighting standard violates and higher so first of all numbers of lighting elements are supposed to be reduced such that it may come within the specified region specially corridors.

B.1 FTL calculation

NO of T8 FTL in KIET = 2800
Observed working days = 250
Total KWH = 250*40*2800 = 28000
Total energy consumption cost per year = Rs. 231000 per year
Recommended T5 LED e.g. **SYSKA 18 W LED** more lumens (1880 lumens) and more hours life (50000 Hrs.)
Cost of each LED after discount (purchase in large amount) = Rs 300.
Total installation cost =2800*300 = Rs. 840000
Total payback period = 840000/231000 = 3.6 years

B.2 Recommendation for Metal Hallide

Currently, 30 Metal halide are placed throughout the college premise and some additional halides are also used time to time and it consumes 32850 KWH per year which cost Rs. 261157 per annum. Recommendation is to use LED in place of halide. We recommend 180 Watt LED e.g. **Wipro LED 180 Watt** with Lux luminous near about this particular Halide. It reduces electricity charges about less than 50%.

C. Low wattage ceiling fans:

Audit Team found that more than thousand Fans in college consumes approximately 60-70 watt power depending upon their ages (old) and due to after some maintenance also some Fans in mess were found in the range of 90 watt also. One biggest bottleneck was seen in some academic class rooms was that all Fans run without speed regulator and further one switch starts 3 Fans simultaneously (similar case for FTL also) which consumes energy unnecessarily without need. First of all, audit team suggest that every fan should be operated with **electronic regulator** so that Fan would run at required speed and a saving of **8-10 W** per fan can be achieved and second for individual Fan separate switch is required.
One important point here must be discussed is that if all Fan is replaced by new one with 40-50 watt e.g **USHA 43 watt ceiling Fans**, large energy saving would be achieved per annum.
During data collection it was observed that old Fans are in the range of 90 Watt and some Fans consumes more than 75 which was undergone maintenance and winding replacement. Thus, efforts should be to minimize repair work and should be done, if needed, by expert worker only

D. Use of motion sensors in corridor:

Corridors and toilets have large potential of saving energy as we discussed earlier that these area crosses the ECBC standard lighting criteria and energy may be saved by use of automation tools. Motion sensors automatically switched on

the light when there is any movement appears and switch off if not. This work greatly reduce the consumption in corridors and toilets. According to IIT Roorkee report on Audit [16], total cost of installation will be 750 Rs. Only in single corridor and payback period approximately one year.
Hence, the capital cost recovery time for installing motion sensors in corridors is 0.95 years. Toilets are also having comparable capital cost recovery time. Hence, this is a highly recommended step to largely reduce the consumption in corridors and toilets.

E. Guidelines for better use of Air conditioner:

The institute has in total 212 window type ACs and 117 split type ACs which make a very large part of total energy consumption of the campus. But, at many places it was found that AC is not used with best recommended practices. Even simple things, such as insulation, are not taken care of. Window panes were found broken at many places. Also, at certain places ACs were found to be used without keeping curtains. These poor practices account for increase in AC load and thus consumption [14].
Summarized below are some guidelines for most efficient use of ACs:
Proper Insulation – Good quality insulation must be maintained in the air conditioned rooms by keeping all doors and windows closed properly so as to prevent cool air go out and hot air come in.
Curtains – Always keep curtains on windows to prevent direct sunlight inside the room to avoid heating of cooled air. This reduces AC load significantly.
Maintenance – Proper maintenance and cleaning of ACs is required at regular intervals to make it work at highest efficiency. Any dirt in filter may reduce efficiency of ACs very significantly.
Operating – The ACs should be switched on 15 minutes before actual use and should be switched off before leaving the room.

F. Use of master switch outside the room:

Installation of Master switch outside a room is essential [14] especially Hostel rooms where students generally forget to switch off while leaving the room. Second, it was observed in faculty cabins that unnecessarily all FTLs and Fans switched on whole day irrespective of presence of faculty in their cabin. Implementation of Master switch is not feasible in faculty cabin as in most of the places there is no individual seating arrangement and improvement can only be achieved by proper awareness and instructions.

G. Installation of Solar Water Heating System:

Calculation for all the boys and girls hostels was done and payback period was calculated. According to Department of Renewable energy and ministry of New & Renewable Energy (MNRE) as well as Indian Renewable Energy Development Agency (IREDA) few important points regarding solar water heater and size and cost of Flat Plate Collector (FPC) was collected and summarized below.
A typical 100 liters insulated tank with 2 m2collector area will supply water at a temperature of 60-80°C.

Litre	**Area (m^2)**
100	2
200	4
300	6
500	8
1000	16

Table 3 Typical standard data (MNRE)

There is also some incentive schemes provided by government of India for SWHS users.

1) Capital subsidy@3300 per m^2FPC

2) Soft loan @5% per annum from IREDA, New Delhi

3) For 100 litre 2m^2 FPC area is required

4) Cost of FPC = 22000 Rs. and subsidy 3300*2 = 6600 Rs.

5) Cost of FPC after subsidy = 22000-6600 = 15400 Rs

Let us calculate payback period for all the hostels combined-

- Total no. of users (students) = 1450
- Total amount of hot water used per user = 14 litres / day
- Total amount of water used per day in Hostel = 20300 litre
- 2 m2 FPC area provides 100 litres hot water per day
- FPC area required = 406 m2
- Cost of 2 m2 FPC after subsidy = 22000-6600 =Rs. 15400.
- Total capital cost required for installation of SWHS = Rs.3126200
- Total electricity bill due to heating elements =Rs.2426880 Per year
- Payback period = 3126200 /2426880 Per year = 1.29 Years

Results shown above are very optimistic and also beneficial for society as according to MNRE report SWH of 100 litre capacity can prevent 1.5 Ton CO2 emissions per year.

H. Formation of student community:

There has to be college level student community that keeps track record of all energy consumption parameters and wastages. Its duty should be to spread the awareness program to save the energy throughout the institute.

I. Some hidden Loads:

Audit team noticed that there are about 150 electric kettles used mainly in boys' hostel having high wattage value near to 1.5 KW, in some cases, which moves on here and there. Further about 50 electric iron of very high wattage is used in both boys and girls hostels. Girls are provided a separate kitchen with induction heater and it is recommended to provide the same in boys' hostel to save huge amount of wastages unnecessarily. There are about 550 laptops in boys hostels and 430 laptops in girls hostels along with 50 for faculty members used per day but it is not considered in load but it also consumes a lot of energy and mainly students are advised to use economically and avoid its usage whole night without shut down although Master switch installation reduce these wastages in large extent.

IV MEASURING TOOLS USED

A. Lux meter:

Digital Lux meters are the devices used to measure luminous level at different points. This device is really helpful for light intensity measurement due to its good portability, robustness and accuracy. For light intensity measurement placement of lux meter is very important which is always the point of interest e.g. in study room it is placed on reading table and similarly various measurements were recorded.

Fig. 11. Typical Lux meter

B. Three phase clamp meter:

It is used to measure all kind of power e.g. active, reactive and apparent power along with the voltage L-N & L-L, current in phase and power factor. In our project, we used three phase clamp type meter which is easy to handle and measure the power at very complex points also. Frequency range between 20Hz to 200 Hz and voltage range upto 600 V with current range of upto 100 ampere. Power upto 750 KVA or KW or KVAR can be measured.

Fig. 12. Typical clamp meter

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Simulation Modelling of DC-DC Converter for Grid Side Connected Inverter

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Abstract: With the increasing demand of electrical energy, it became the necessity of human being and due to this its generation and utilization become one of the important concern... **View more**

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Abstract:
With the increasing demand of electrical energy, it became the necessity of human being and due to this its generation and utilization become one of the important concerns of the researchers, developers as well as for the industrialist. Different methodologies are achieved to harvest energy and convert it into required form with efficient use. In this paper a boost converter is used for the conversion of low DC voltage into high DC voltage with remodeled inverter and then voltage source inverter (VSI) synchronization to the grid is done. This paper consists of modeling of DC-DC converter for grid side connected inverter and presented the related output waveforms. Proposed circuit is simulated in MATLAB/SIMULINK 2013 and simulation results are provided.

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Contents

I. Introduction

Due to the increasing demand of energy consumption, renewaule resources are used for the generation of electrical energy. But Tremendous use of energy leads to overload the grid system which creates problem like instability, degradation ofpower quality, security and many more.

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Simulation of Three Phase Voltage Source Inverter Based on SVPWM Technique

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Abstract

This paper presents simulation of two level voltage source inverter based on SVPWM (space vector pulse width modulation) technique. The concept of two level inverter is used to reduce the harmonic distortion in output voltage waveform without decreasing the inverter output power. Simulation results are presented to realize the validity of SVPWM technique.

Keywords

Voltage source inverter PWM SVPWM LCL filter with series damping resistor

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Improved Mathematical Modeling and Analysis of Photovoltaic Modules and Arrays

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***Abstract*—Solar Photovoltaic array is non-linear power source and under varying environmental conditions it is time consuming and extravagant to obtain operating characteristics. In order to overcome these restrictions an improved model of solar module/array has been proposed, this paper presents a step-by-step method for the simulation of SPV panels/arrays in MATLAB/Simulink. The governing curves of SPV array are also investigated for vast range of environmental conditions, substantial parameters and array configurations. The proposed method gives an exact decisive and easy to tune model of SPV array. Moreover, it provides an improved analysis of SPV array for various substantial parameters (series, parallel resistance, diode factor etc.) and environmental conditions (irradiance, temperature and partial shading) aspects.**

***Keyword*—photo-voltaic array, photo-generated current, solar irradiance, ambient temperature, single-diode model, series and parallel resistance**

I. INTRODUCTION

Solar power is a fast-growing industry in India and as of December 2016, the country's solar grid had a total capacity of 9 giga watts (GW). In January 2016, the Indian government expanded its solar plans to 100 GW of capacity, including 40 GW directly from solar rooftop, by 2022. The infinite, renewable, clean and noiseless nature of the solar energy makes it the most preferred sources of renewable energies which are increasingly finding application areas in today's human life [1]. However, despite of the mentioned advantages, this clean energy source has some disadvantages which should be overcome for an efficient use. High production costs of Photo Voltaic panels, less availability of efficient energy storage devices and dependency of energy production on the environmental conditions is some of the main issues which comes while production of solar energy[2,3,4].

The elemental entity responsible for the conversion of solar energy directly into electrical energy in a Solar Photo Voltaic (SPV) system is referred as SPV cell [6, 7]. The congregation of these SPV cells generally connected in series forms a SPV module. In order to get desired voltage level these modules are connected in series and to get desired current level modules are connected in parallel or surface area of each cell is increased. A SPV array can be a module or combination of modules in series and parallel configuration [8].

There are two ways to use output of SPV array 1) using DC output of array without any processing 2) using Power electronics converter for further processing of output power [16, 21]. The second method helps operates SPV array at optimal point by altering parameters at load side and controlling flow of power in grid connected system [4]. In order to study the performance of SPV system we require model that correctly stand for SPV cells, modules and arrays.

The main work in this paper is improved mathematical modeling of SPV cell/module/array and development of simulation model of module as well as array that correctly represents prevailing modules/array.

II. IDEAL PV CELL

When PV cell is exposed to light (photon), electrons are pushed out creating electron-hole pair in semiconductor material. If positive and negative terminals are connected to the conductors, having a closed electric network, constitutes photon generated current I_{Ph}. Therefore PV cell is PN junction diodes that operate as a current source which is compelled by solar irradiance. The PV cell is ineffective in darkness and it work as PN junction diode, it will generate current I_d when large supply voltage is connected across this diode during darkness that is reason why it is known as dark current(I_d). The Shockley diode equation represents this current as described by equation (1) [2].

$$I_d = I_S\left(e^{\frac{qVd}{kTc}} - 1\right) \tag{1}$$

Where, V_d is the voltage across the diode (D).For the ideal case, this voltage is equal to the cell voltage, V_C, k is Boltzmann constant (1.38 × 10-23 J/$^o{}_K$), q is electron charge (1.602 × 10^{-19} C), I_S is reverse saturation current of diode (0.000025 A), T_C is typical cell operating temperature (25 °C).

The simple (Ideal) equivalent circuit of PV cell is represented in figure.1. It consists of current source (I_{Ph}) and diode connected in antiparallel.

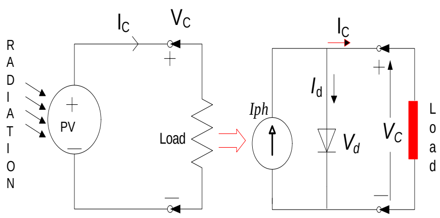

Figure 1 Ideal equivalent circuit of PV cell.

The Photon generated current flows in reverse direction of dark current and its value is independent of external voltage and this is reason why it is called as short circuit current(I_{SC} = I_{Ph}). This current is linear function of solar irradiance as increased irradiance causes incremented charge carriers. It can be seen from figure.1 that output cell current is the difference between photon generated current and dark current. As per standard convention photon generated current is reversed to represent the current from semiconductor theory. Mathematically Current-Voltage characteristics of a PV cell can be written as [9,10]:

$$I_C = I_{Ph} - I_d \tag{2}$$

III. MODELING OF PV CELL

Current-Voltage characteristics of a PV cell described by equation (2) are derived for ideal condition (internal resistance is zero and shunt resistance is infinite). However practically both have finite values that would change the characteristics. The equivalent considered is single diode model as shown in figure 2 of a PV cell includes a current source, diode, and series and shunt resistances.

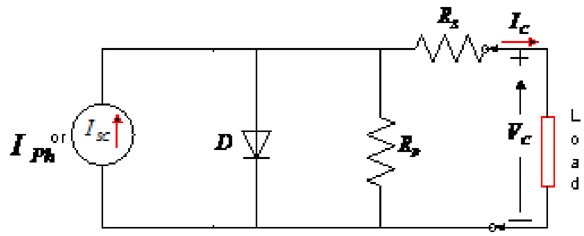

Figure 2 Single diode equivalent circuit of a Photovoltaic cell.

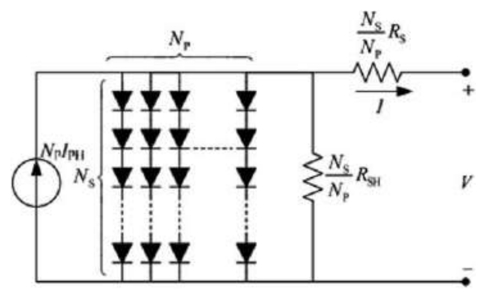

Figure 3 Equivalent circuit of a Photovoltaic array

Five parameters model of PV cell is represented by figure 2, The cell current can written as [1]:

$$I_C = I_{Ph} - I_d - I_{Sh} \tag{3}$$

$$I_C = I_{Ph} - I_S\left[e^{q\left(\frac{V_C + I_C R_S}{akT_c}\right)} - 1\right] - \left(\frac{V_C + I_C R_S}{R_P}\right) \tag{4}$$

Where: a is called as the "ideality factor of junction" ("a" is also represented as "n"). After rearranging the equation (4) we can write i-v equation as shown below.

$$V_C = \frac{akT_C}{q}\ln\left(\frac{I_{Ph} + I_S - I_C}{I_S}\right) - \left(\frac{V_C + I_C R_S}{I_S R_P}\right) - I_C R_S \tag{5}$$

In order to get practically utilizable power output, PV cells are connected together to form PV module and further series, parallel connection of modules form a PV array. PV module is obtained by connecting number of PV cells in series. The equation 1 gives relation of module current and voltage at given insolation S [21].

$$I_m = I_{Ph} - I_S\left[e^{q\left(\frac{V_{PV}+I_mR_S}{akT}\right)} - 1\right] - \left(\frac{V_{PV}+I_mR_S}{R_P}\right) \qquad (6)$$

PV module described by equation (6) is also known as five parameter model with parameters as I_{Ph}, I_S, q, a, $R_s$and R_p. Model parameters can be obtained either from manufacturer's data sheet or determined experimentally. These model parameters are variable and dependent with solar insolation and temperature. The photon generated module current is dependent on solar insolation and temperature given by equation (7).

$$I_{Ph=}I_{Ph,typ}(1 + C_I\Delta T)\frac{S}{S_{typ}} \qquad (7)$$

Where $I_{Ph,typ}$is typical photon generated module current at 1000 W/m^2 (S_{typ}) and 25 °C, ΔT is temperature difference between typical/standard temperature and module temperature, S is irradiance on the module and C_I is current coefficient.

The temperature dependence of diode saturation current is represented by equation 8 [11-13]:

$$I_S = I_{S,typ}\left(\frac{T_{typ}}{T}\right)^3 exp\left[\frac{qE_g}{ak}\left(\frac{1}{T_{typ}} - \frac{1}{T}\right)\right] \qquad (8)$$

Such that E_g being energy gap of the semiconductor (for Si, which has energy gap of 1.1eV at 25 °C and $I_{S,typ}$ is the typical saturation current:

$$I_{S,typ} = \frac{I_{sc,typ}}{\exp\left(\frac{V_{oc,typ}}{aV_{t,typ}}\right) - 1} \qquad (9)$$

Where $V_{t,typ}$ is called as the voltage equivalent of temperature at standard temperature T_{typ}.

The PV cell's saturation current I_S has dependence on cell's active area and the density of saturation current of semiconductors that forms device (J_o, [A/cm^2]). The saturation current density (J_o) further depends on various intrinsic parameter of semiconductors. This set of data is mostly unavailable for commercial PV modules. From the available experimental data, we indirectly acquired the typical saturation current $I_{S,typ}$ (9) and that is accessed by examining equation (6) at standard open circuit of PV module, having V= $V_{oc,typ}$, I=0 and I_{Pv}= $I_{SC,typ}$. The initial value of diode ideality constant "a" can be arbitrarily selected. Various researchers addressed methods to estimate the accurate value of this constant.[2,16]. Generally 1 ≤ a≤ 1.5 and choice rely upon the other parameters of the I-V model. An empirical analysis (R) may be used to get certain values of "a". "a" is completely empirical since represents ideality of diode. Some initial value of constant may be taken which can further modified based on curve fitting and its alteration improve model accuracy as represented by equation 10.

$$a = \frac{T}{T_{typ}}a_{typ} \qquad (10)$$

IV. UPGRADING THE MODEL

The reverse saturation current follows complex relation given by equation 8. Last section presents a PV model, which can be upgraded if equation (8) is changed by:

$$I_S = \frac{Isc,typ + C_I\Delta T}{\exp\left(\frac{Voc,typ + C_V\Delta T}{aVt}\right) - 1} \qquad (11)$$

Where $I_{sc,typ}$[A] is typical short circuit current, $V_{oc,n}$is typical open circuit voltage at the standard condition (usually 25 ◦C and 1000 W/m2),C_V is the voltage coefficient.

The purpose of correction is to co-relate with experimental results of V_{OC} (open-circuit voltage) for very wide range of temperature. The current coefficient (C_I) and voltage coefficient (C_V) is taken into account to get equation (11) from equation (8). The temperature surely effects the reverse saturation current and there is unlike way suggested by equation (11) to represent the dependence of I_S on the temperature. The above equation facilitate the PV model and wipes out model error around the open-circuit voltage and following different domains of the I-V curve.

The validity of upgraded model has been verified from computer simulation and from resemblance with experimental results. The voltage coefficient C_V incorporated in equation (11) can be obtained from the manufacturer's data sheet. For the temperatures different from the standard values it is now possible to get excellent I-V curve fitting by including voltage coefficient (C_V).

If one urge to use conventional equation (8) [14, 15, 16], rather than equation (11), it is likely to get the correct value of band gap E_g for the model such that V_{OC} obtained by model and V_{OC} of actual PV array must be similar in the extent T_{typ}≤T ≤ $T_{max.}$.

TABLE – 1

Parameters of PV module at standard conditions (1000W/m^2, 25°C)[23]

Maximum power output	200.143 W
Current at maximum power	7.61 A
Open circuit voltage	32.9 V
Voltage at maximum power	26.3 V
Short circuit current	8.21 A
Number of cell connected in series	54

V. STEPWISE METHOD FOR MODELING OF PV MODULE/ARRAY WITH TAGS

PV array's mathematical model containing basic elements as current source, diode, parallel and series resistors is modeled with tags in Simulink. The PV module is simulated on the basis of equations presented in previous section and accomplished in the trailing steps.

Step1

Specify input parameters for modeling:

$I_{SC,typ}$ is short circuit current of the PV module at 1000W/m^2 and 25°C= 8.21 A; $V_{OC,typ}$ is open circuit voltage of the PV module at 1000W/m^2 and 25°C = 32.9 V; R_S is series resistance, generally it has a small value = 0.221Ω; R_p is shunt resistance, generally it has a large value = 414.405Ω; T_{typ} represent standard temperature = 298 K; A represents diode ideality factor = 1.3; K represent Boltzmann constant =1.38*10^-23.

Step2

The Photon generated module current is expressed by equation (7) and simulated as figure 4.

Step3

Module Saturation current is expressed by equation (11) and simulated as figure. 5

Step 4

Modeled current is expressed by equation (6) and simulated as figure. 6

Step 5

Modeled circuit for PV array subsystem is as expressed by equation (6) as figure.7

Step 6

The PV module/array simulation process is presented from figure 4 to 7. The PV simulation presented in this section can be used for a single PV module or a PV array having N_{SS} number of modules connected in series and N_{pp} number of parallel strings of modules as shown in Figure7.

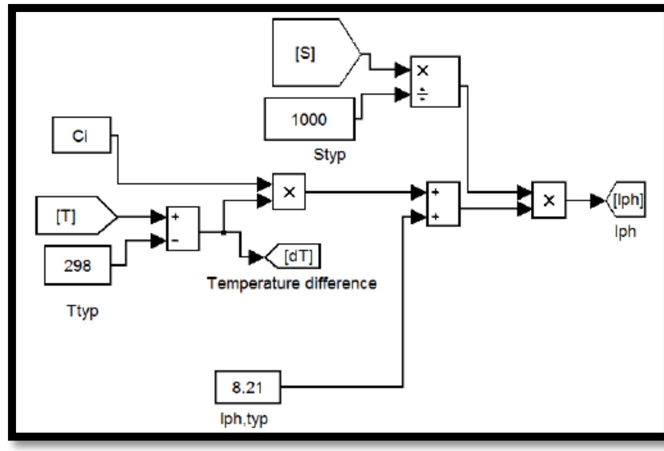

Figure.4. Simulation of Photon generated module current.

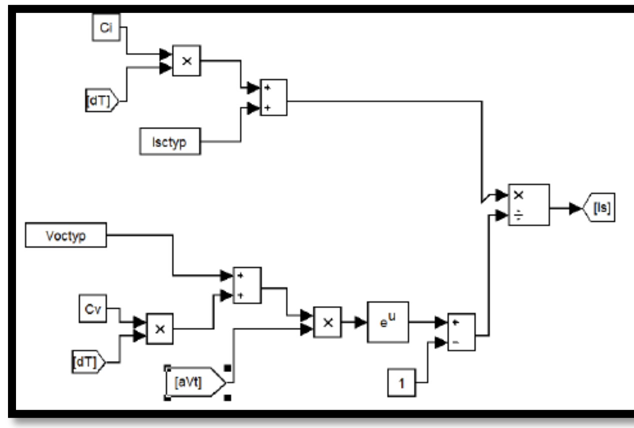

Figure.5. Simulation of saturation current.

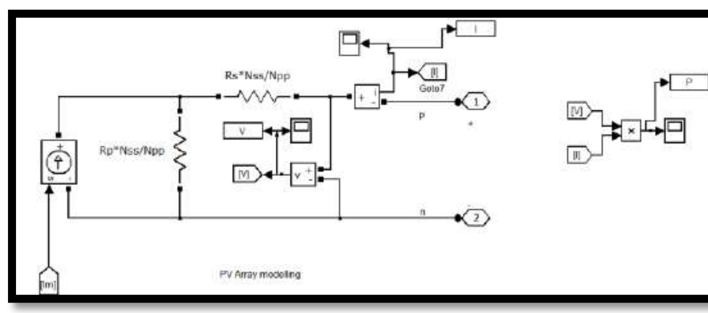

Figure 6 Simulation of PV array.

VI. RESULTS AND DISCUSSION

The array characteristics of presented PV model are assessed as:

1. With changing solar insolation and fixed temperature I-V and P-V characteristics as shown in figure 10 and11. Available insolation varies from 400 to 600 to 800 and 1000 W/m^2 whereas temperature remains fixed at 25°C. I-V and P-V characteristics indicates with increase in

solar insolation, there is increment in output current, voltage which finally results boost in power output.

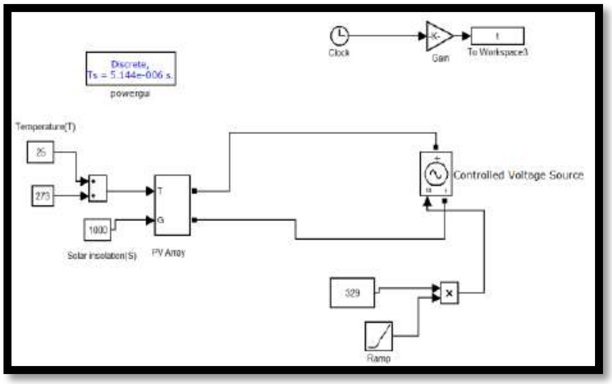

Figure .7. Simulation of PV array having Solar Insolation(S) and Temperature (T) as input parameter

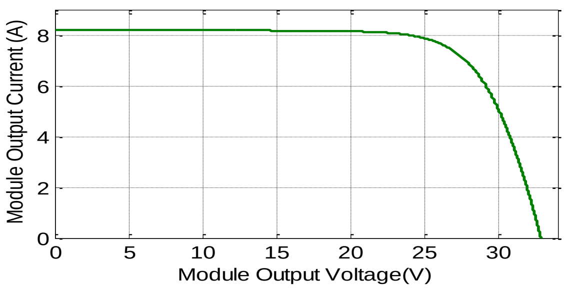

Figure.8. I-V characteristics at standard condition

2. With changing temperature and fixed solar insolation, I-V and P-V characteristics are plotted as shown in figure 12 and 13. Available temperature changes with values of 25°C, 35°C, 45°C and 55°C while insolation level remains fixed at 1000W/m^2. I-V and P-V characteristics indicate with increase in temperature, there is insignificant increment in output current whereas the output voltage reduces greatly. This results in decrement of output power with increase in temperature.

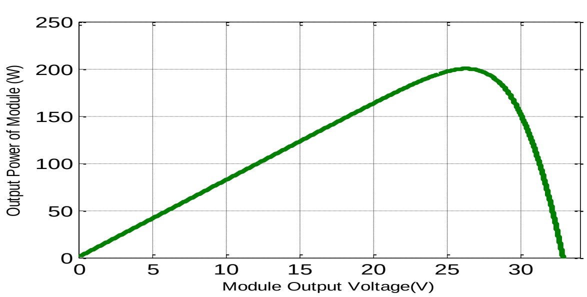

Figure.9. P-V characteristics at standard condition.

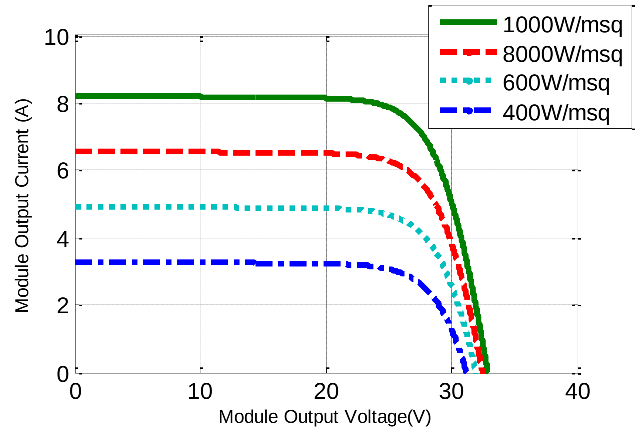

Figure.10. I-V characteristics at variable Sx.

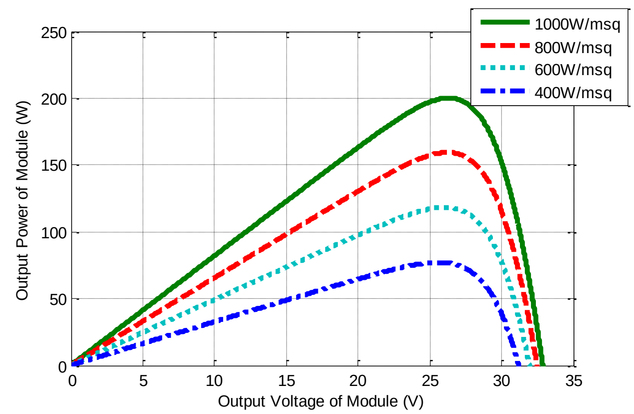

Figure.11. P-V characteristics at variable Sx.

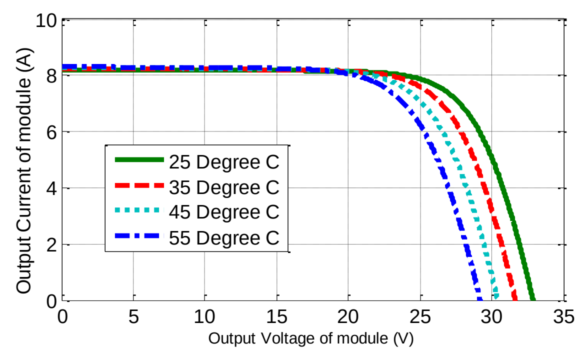

Figure.12.I-V characteristics at variable temperature.

3. I-V and P-V characteristics are plotted for variable R_S (Series resistance) and constant R_P (Parallel resistance), insolation, temperature as shown in figure.14 and 15. Available R_S changes with values 0.055, 0.110, 0.221, 0.442 and 0.884Ω respectively.

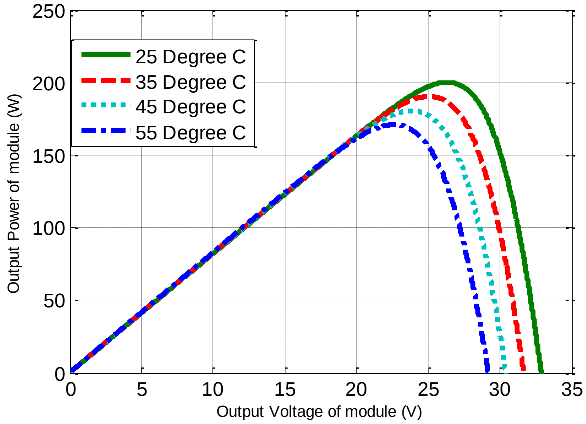

Figure.13. P-V characteristics at variable temperature.

It can be seen from I-V and P-V characteristics as value of series resistance increases from standard value (at which experimental maximum power output is equal to maximum power output evaluated from equation 6) maximum power output decreases whereas when value of R_S decreases from standard value then there is increment in maximum power output.

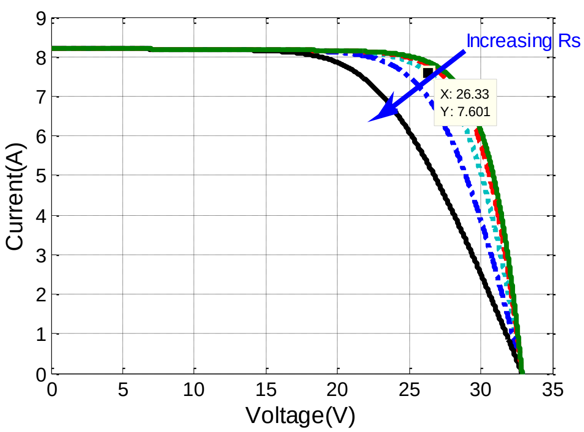

Figure.14. I-V characteristics of module at variable series resistance R_S.

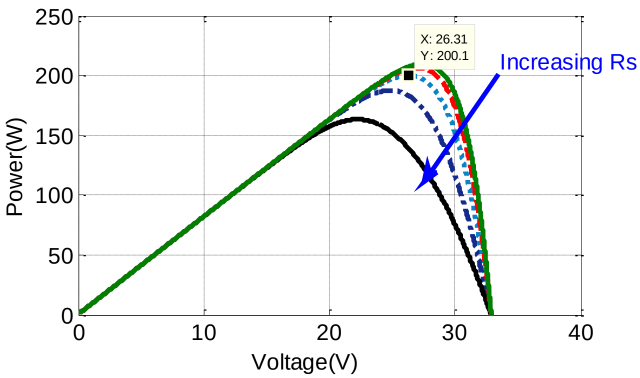

Figure.15. P-V characteristics of module at variable series resistance R_S.

Table: 3.2

Response of R_S on maximum power output, Voltage at maximum power and Current maximum power.

R_S (Ω)	P_{MAX}(W)	V_{MP}(V)	I_{MP}(A)
0.055	**209.7**	27.44	7.64
0.110	**206.5**	26.98	7.65
0.221	**200.1**	26.31	7.61
0.442	**187.6**	25	7.5
0.884	**163.34**	22.41	7.284

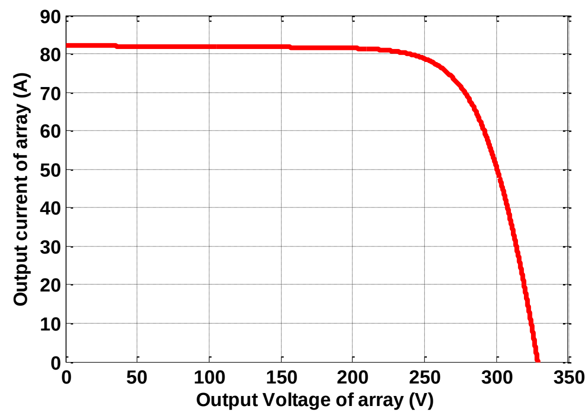

Figure.16. I-V characteristics of array at standard condition.

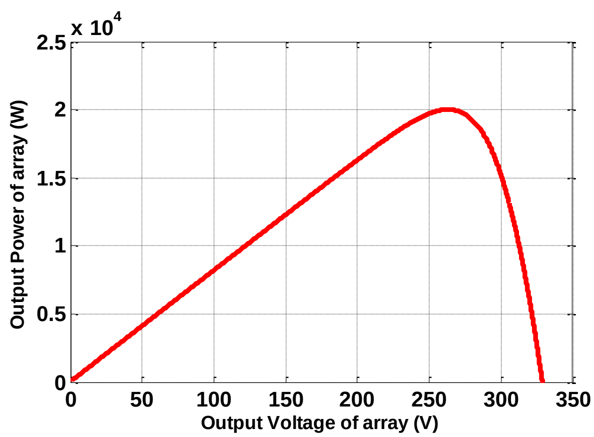

Figure.17. P-V characteristics of array at standard condition.

4. I-V and P-V curves for PV array having N_{SS} & N_{PP} = 10 are obtained as shown in figure 16 and 17. PV modules are connected in series to increase the voltage level of array and series strings of PV modules are connected in parallel to increase the current level of array. The module considered has 54 series connected cells. The PV array having 10 modules connected in series i.e. N_{SS}=10, the value of array voltage is 10 times that of single module and there are 10 such series strings connected in parallel so, the output current of

array is 10 times that of single string, so the output of array will be 100 times of single module.

VII. CONCLUSION

A step wise simulating procedure is presented for PV module/ array. The presented modeling technique helps to serve people in understanding I-V & P-V characteristics of PV modules. Further it can be used as powerful tool to anticipate the performance of SPV cells, panels and array under fluctuating environmental conditions (irradiance, temperature and partial shading) and substantial parameters (series, parallel resistance, diode factor etc.). The effect of change in solar irradiance and operating temperature are also presented. The typical value of series and shunt resistance (R_S and R_P) are also evaluated in iterative manner so that the MATLAB/Simulink model parameter matches with the practical PV array.

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Energy Conservation: Analysis & Improvement through Energy Audit

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Abstract: Energy generated from either conventional or non-conventional resources are generally not fully utilized in efficient way results in overconsumption, reduced energy effic... **View more**

Metadata

Abstract:
Energy generated from either conventional or non-conventional resources are generally not fully utilized in efficient way results in overconsumption, reduced energy efficiency & increased cost. Effective energy scheduling through energy audit results in smart & efficient energy consumption. Energy auditing had been conducted based on one year KWH consumption in KIET Group of Institutions Ghaziabad and various recommendations through this paper will be necessarily helpful for all educational buildings to minimize energy consumption & improving energy conservation.

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Contents

I. INTRODUCTION

Krishna Institute of Engineering and Technology (KIET) is a private engineering institute affiliated to Dr. A.P.J. Abdul Kalam Technical University, situated in Ghaziabad in the National Capital Region of India 30 km from Delhi. The institute is ISO certified and NBA accredited. The institute was started in 1998 under the aegis of the Krishna Charitable Trust. The institute has 8 academic departments, 3 boys hostels, 3 girls hostel, Auditorium, TBI, Central Library, a Multi-Purpose Complex with a focus on education in engineering, sciences, pharmacy and management. As on the date, the student strength of the institute is about 5341 with total faculty plus staff strength of about 529 and over an area of about 21 acre. The institute connected load is 1112 KVA and annual electricity bill keeps up in several (Cr). This huge electricity bill attracts the attention naturally. Making the institute energy efficient will not only concern with reduction in electricity expenses but also helps us to remind our moral responsibilities of not wasting this precious resource which may be used by people of the country in need.

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Figures

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Keywords

Metrics

A Bibliographical View on Research and Developments of Photovoltaic and Thermal Technologies as a Combined System: PV/T System

Anmol Gupta, Sourav Diwania, Sanjay Agrawal, Anwar S. Siddiqui and Yash Pal

Abstract In this hybrid photovoltaic thermal (PV/T) system, air or water is utilized as a circulating fluid which helps in maintaining electrical efficiency as well as utilization of thermal energy (space heating, crop drying, etc.) at the output. In this article, a review of innovative work in the field of PV/T system and thermal modelling of PV/T collector is presented. The thermal model having different equations for PV-integrated flat plate collector, energy balance for air or water heating system stored thermal energy, the instantaneous energy efficiency and the instantaneous exergy efficiency has been presented. Analytical articulations for different thermal parameters and electrical parameters, considering energy balance for several segments or components of PV/T collector is obtained. Various optimization techniques used in the field of PV/T collector, in view of the exergy concept is also presented.

Keywords Exergy efficiency · Photovoltaic thermal · Optimization · Genetic algorithm

NOMENCLATURE

α_t	Absorptivity of glass
b	Width of PV/T collector (m)
L	Length of PV/T collector (m)
dx	Small length (m)

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A_c	Area of the solar cell (m^2)
I_{sl}	Solar radiation intensity (W m^{-2})
η_c	Efficiency of the solar cell (%)
$C_{a/w}$	Specific heat of air/water (J kg^{-1} K)
$m_{a/w}$	Mass flow rate of air/water in the channel (kg/s)
$Q_{U,N}$	Useful heat gain for N no. of channels (kWh)
h_{p1}	Penalty factor due to the presence of solar cell material, glass and EVA
T_a	Ambient temperature (°C)
T_c	Solar cell temperature (°C)
T_{bs}	Temperature of the back surface (°C)
T_{aw}	Temperature of air/water (°C)
α_c	Absorptivity of solar cell
β_c	Packing factor of solar cell
h_t	Heat transfer coefficient of tedlar (W/m^2K)
τ_g	Transmittivity of glass
U_{ca}	An overall heat transfer coefficient from the solar cell to ambient (W/m^2K)
U_t	Convective heat transfer coefficient through the tedlar (W/m^2K)
h_{p2}	Penalty factor due to the presence of an interface between tedlar and working fluid

1 Introduction

Hybrid PV/T technology is a combination of both solar thermal and solar photovoltaic technology. A solar photovoltaic system changes sunlight into electric power while solar thermal changes sunlight into heat yet a PV/T system converts sunlight into heat and electricity simultaneously. The temperature of the PV module increases tremendously when light radiations of certain intensity fall on it, causing reduction in electrical efficiency. It is found that for every 1 °C rise in temperature of PV surface, it will cause 0.4–0.5% decrement in its electrical efficiency.

PV/T system has gained greater attention in the last four decades because of its quality to generate both electric power/energy and thermal energy all the while and joins the electrical and thermal parts in one element over the conventional PV system and solar thermal system. The application areas of PV/T technology are space heating, water heating, drying, integration of photovoltaic thermal in buildings, etc. [1] (Fig. 1).

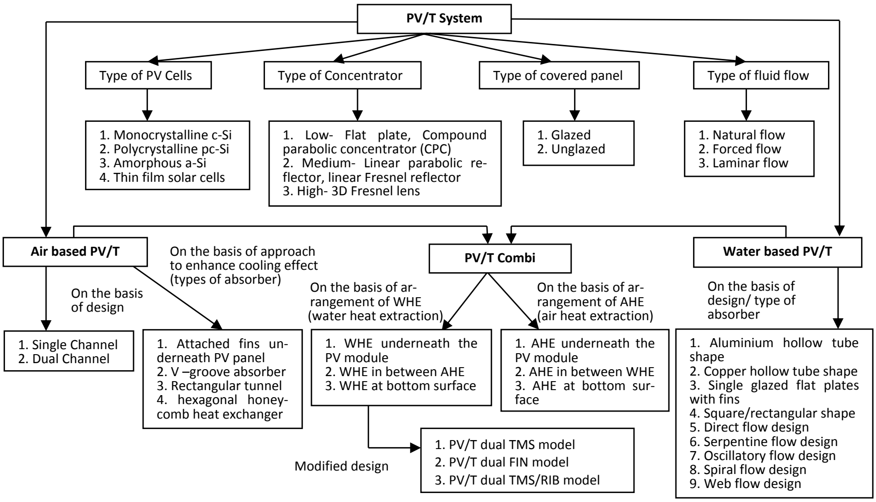

Fig. 1 Classification of PV/T system in view of various literatures

2 PV/T Air Collector

A considerable number of researches have been conducted in the designs of PV/T air collector because its performance is affected by several parameters such as position, dimensions of air duct, input temperature, velocity of flowing air into channel and surface roughness of air duct. A channel or duct is applied below the PV panel in which air is used to absorb the heat energy from the solar cell by conductive or convective process so as to improve the electrical efficiency of the system. The critical factor about the popularity of PV/T is the low efficiency of the cell that varies from 6% to 16% at the temperature of 25 °C but in some of the countries, the ambient temperature rises up to 35 °C. The rising of temperature decreases the module efficiency, hence heat removal from the module is necessary [2].

Hegazy [3] presented four different designs of PV/T collectors based on airflow and investigated the thermal, electrical and overall performance as shown in Fig. 2. The comparative study shows that system-(c) gives appropriate result as it converts solar energy in the form of high-grade electrical energy and low-grade thermal energy, and also it is simple to install in rural areas. Wolf [4] performed the analysis of PV/T system and individual solar PV and solar thermal system and concluded that exergy analysis is a valuable method for the evaluation and comparison of various solar systems.

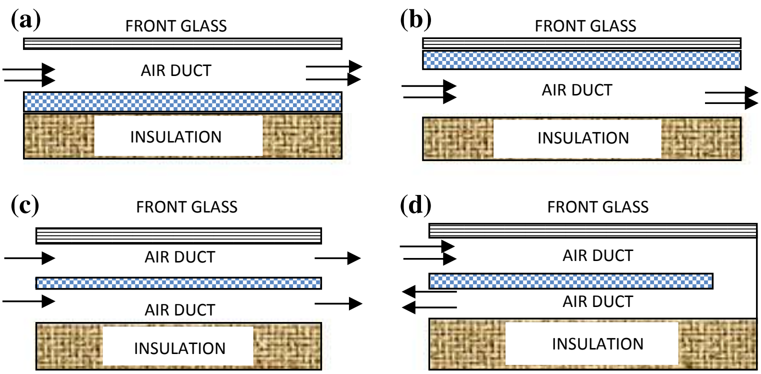

Fig. 2 Cross-sectional view of common designs of PV/T air collector

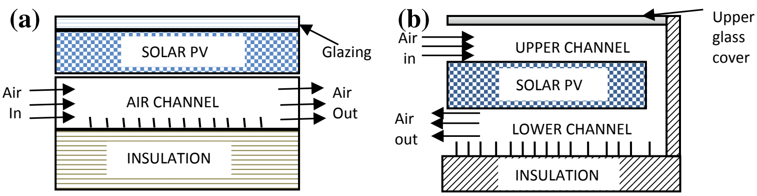

Fig. 3 Cross-sectional view of single-pass and double-pass PV/T air collector with fins

2.1 *Effect of Glazing*

The overall energy output or thermal energy output can be maximized by using glass cover above the PV surface to trap the extra heat energy which will increase the thermal energy output almost double that of unglazed PV/T, but decreases the electrical energy output [5] (Fig. 3).

2.2 *Effect of Adding Thin Metallic Sheets (TMS) and Fins*

Tripanagnostopoulos et al. [6] presented a study of PV/T air collectors and suggested that the surface roughness and thin metallic sheets (TMS) used in the air channel are the cost-effective and simple methods for heat removal from the PV panel. Mojumdera et al. [7] experimentally observed the electrical and thermal efficiencies of the system with TMS as 13.75 and 56.19%, respectively.

2.3 *Effect of Packing Factor*

Packing factor refers to the area of the module covered by the solar cell to the left blank and it affects the output power and operating temperature of the photovoltaic module. Vats et al. [8] found that with an increase in packing factor, the temperature at the output of the channel increases by absorbing the higher amount of thermal energy. Hence, the temperature of the PV module increases which causes a decrease in electrical efficiency. At lower packing factor, the absorber area is less, hence the electrical efficiency if further reduced.

3 PV/T Water

PV/T air has the main problem of temperature issue because an air-based system cannot work effectively at high-temperature areas as there are constraints of low heat capacity, low density, etc.; instead of air, water can carry maximum heat so researchers work in the field of PV/T water. In some areas, during summer season the ambient temperature is very high and for the PV/T air standard, operating is at 20 °C temperature so PV/T water is preferred due to its higher density [9] (Fig. 4).

Huang et al. [10] relate the performance of conventional solar water heater system with a new design which is a combination of the photovoltaic and thermal solar system and evaluated electrical efficiency of 9%. Ji et al. [11] fabricated a flat box aluminium alloy PV for large contact area with a circulation water heating system and the experimental results are obtained with its electrical efficiency of 10.15%, thermal efficiency of 45% and daily total energy of 52%. Chow et al. [12] designed and presented a PV/T system having aluminium alloy flat box collector. In this work, electrical efficiency of the system is 10% with a thermal efficiency of 45–48% for closed circuit and thermal efficiency of 49–52% for open circuit.

The logical articulation of PV/T water heater in steady flow rate of hot water is acquired by Tiwari et al. [13]. Ibrahim et al. [14] executed simulation on seven types of water absorbers. The spiral flow configuration indicates the best result, it has the highest thermal efficiency and parallel cell efficiency of 50.12% and 11.98%, respectively. Dupeyrat et al. [15] investigated the impact of water flow in a flat plate PV/T having single glazing and found thermal efficiency as 79%, electrical efficiency

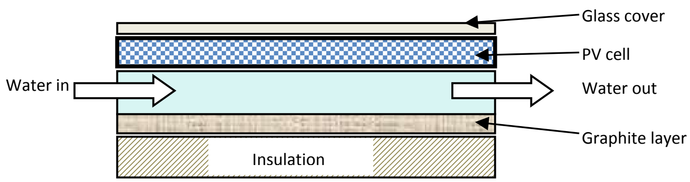

Fig. 4 Cross-sectional view of PV/T water system

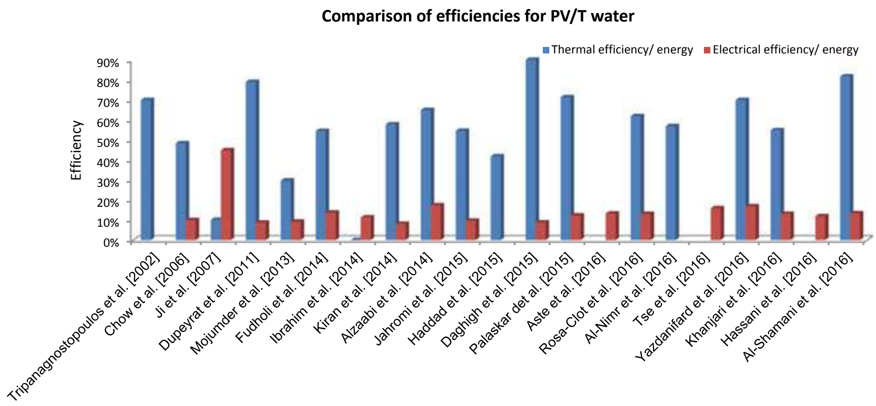

Fig. 5 Comparison of thermal and electrical efficiency for PV/T water system

as 8.8% and in totality, the efficiency is 88% for the propelled configuration. Liang et al. [16] composed a PV/T water collector combined with graphite; it produced the highest electrical efficiency of 7.2% and essential energy saving efficiency of 45%. Yazdanpanahi et al. [17] numerically estimated exergy efficiency of PV/T considering pressure drop in flow channels and maximum efficiency of 13.95% is observed experimentally. Yazdanifard et al. [18] presented mathematical modelling and simulation of flat plate PV/T water system with and without glass cover. It is found that PV/T system with glazing has better energy efficiency (Fig. 5).

4 PV/T Combi

To improve the absorption process on photovoltaic and to get maximum performance of the overall system, the combination of various types of coolant media are utilized (Fig. 6).

PV/T combi achieved better overall energy efficiency, particularly in the generation of electrical energy since heat is removed from the photovoltaic module by integrating both air and water media [19]. Six PV/T combi system designs based on

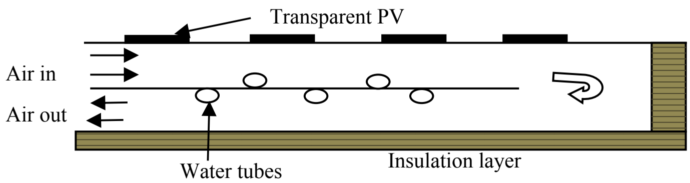

Fig. 6 Cross-sectional view of PV/T-combined system

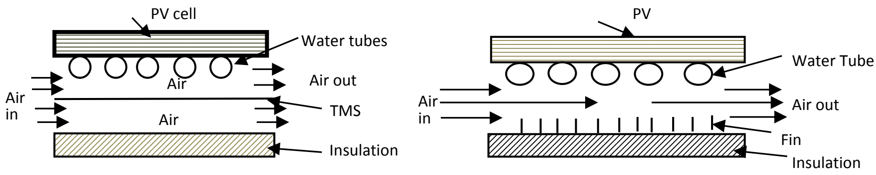

Fig. 7 Cross section of PV/T/dual solar system with TMS modification and with fins

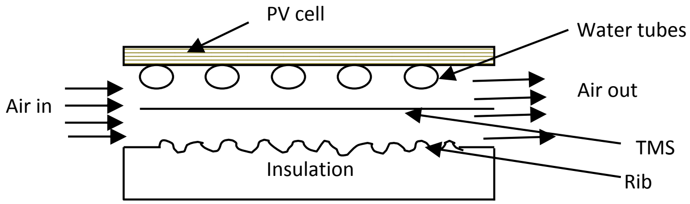

Fig. 8 Combination of TMS with ribs on opposite air channel

the arrangement of air-type and water-type absorber are presented and their performances are observed by Tripanagnostopoulos [20]. Tripanagnostopoulos et al. [21] worked on PV/T combi unit with slight modifications in the air heat extraction unit.

A thin metallic sheet (TMS) is placed between the air channel and the modification is named as PV/T/dual-TMS. This result in a temperature rise of TMS leads to an increase in temperature of the circulating air and hence the thermal efficiency improves (Fig. 7).

A fin plate element is used throughout the length of the air duct and the modification is named as PV/T/dual-fin. This results in increasing the temperature of the air at the output which will further help in improving the thermal efficiency. In the PV/T/dual-TMS/RIB model, ribs are used on opposite channel wall. This model combines the advantages of the above two models mentioned (Fig. 8).

5 Modelling of PV/T Collector

The transfer of heat can take place by means of three mechanisms: conduction, convection and radiation. Heat transfer coefficients of different modes are essential for analysis [22, 23].

Energy balance for solar cells of the PV module (for glass—tedlar PV module)—

$$\tau_g[\alpha_c\beta_c + \alpha_t(1 - \beta_c)]I_{sl}bdx = [U_{ca}(T_c - T_a) + U_t(T_c - T_{bs})]bdx + \eta_c\alpha_c\tau_g\beta_c I_{sl}bdx \tag{1}$$

Energy balance for the back surface of tedlar—

$$U_t(T_c - T_{bs})bdx = h_t(T_{bs} - T_{aw})bdx \quad (2)$$

Energy balance for air/water flowing below the tedlar—

$$\left[m_{a/w}C_{a/w}\frac{d}{dx}T_{aw}.dx\right] + [U_{wa}(T_{aw} - T_a) * bdx] = h_t(T_{bs} - T_{aw})bdx \quad (3)$$

Thermal efficiency of PV/T collector—

$$\eta_{th} = \frac{Q_{u,N}}{bLI_{sl}} \quad (4)$$

Electrical Efficiency of PV/T collector—

$$\eta_{el} = \eta_o[1 - \beta_0(T_c - T_o)] \quad (5)$$

where η_o—efficiency at standard test condition, β_0—temperature coefficient, T_o—outlet temperature

Overall thermal energy gain—

$$\sum Q_{overall,thermal} = \sum Q_{thermal} + \frac{\sum Q_{Electrical}}{\eta_{c,power}} \quad (6)$$

Overall Exergy gain—

$$\sum Exg_{thermal} = Q_{thermal}\left[1 - \frac{T_a + 273}{T_{awout} + 273}\right] \quad (7)$$

$$\text{Exergy Efficiency } \eta_{EXG} = \left(\frac{Exg_{outflow}}{Exg_{inflow}}\right) \times 100 \quad (8)$$

6 Optimization Using Soft Computing

Optimization using soft computing techniques is proved to be very efficient to evaluate the design parameters of PV/T air and water collector. Singh et al. [24] optimized the parameters of a single-channel hybrid photovoltaic thermal air collector using the genetic algorithm (GAs). The overall exergy efficiency of the system is found to be 16.88% at the optimized value of parameters. Singh and Agrawal [25] work on improving the results of GA approach by using the fuzzy-based rules. The overall exergy efficiency with GA–FS approach is observed as 15.82% which is much better than an optimized system with GAs and an unoptimized system. Singh et al. [26] used Evolutionary Algorithm (EA) for parameter optimization of glazed SCPV/T.

An annual carbon emission reduction of around 88% is observed than unoptimized system. Sobhnamayan et al. [27] presented an optimized PV/T water collector system in view of the exergy concept. To optimize exergy efficiency, genetic algorithm is utilized for the given PV/T water collector system. Maximum exergy efficiency of 11.36% is experimentally obtained with optimum inlet velocity and pipe diameter.

7 Conclusion

The PV/T system is in the emerging phase and at present, there is vast acceptability for facilitating development as well as advancement in the presently available PV/T system. Numerous researchers are in this field to enhance the performance of the ordinary air and water PV/T system; whereas, some researchers have presented a small number of innovative ideas in the field of PV/T as heat pipe, nanofluid and phase change materials. The purpose of the review of traditional PV/T systems, so that bibliophile will be assessed advancement in the field of PV/T. Summary of essential PV/T methods and additional attributes of thermal and electrical systems like efficiency, exergy and energy is obtained towards the finish of each section, in order to obtain real facts with respect to technical improvement in PV/T systems initially. Apart from the advantages, further research is required to optimize cost, improvement in efficiency and technological design development.

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Exergetic Analysis of Glazed Photovoltaic Thermal (Single-Channel) Module Using Whale Optimization Algorithm and Genetic Algorithm

Sourav Diwania, Anmol Gupta, Anwar S. Siddiqui and Sanjay Agrawal

Abstract Photovoltaic thermal (PV-T) system gains greater attention in the last four decades because of its quality to produce both electrical and thermal energy simultaneously and unites the electrical and thermal components in a single unit over the conventional photovoltaic system and solar thermal system which are capable of producing electricity and thermal energy, respectively. There are various parameters which affects the performance of the PV-T system such as dimensions of the channel (duct), depth of the tedlar, thickness of insulation layer, solar cell fabrication technology, velocity of fluid flowing through the channel, temperature of the fluid at the inlet and outlet of the channel ,and cell temperature but in this paper, only four of the above parameters have been considered for optimization study. But in the proposed work, only four parameters such as air channel length (L_M), depth of the air duct (d), fluid velocity through the duct (V_F), and temperature of the air at the inlet of duct (T_{in}) have been considered for optimization using two dissimilar optimization algorithms such as whale optimization algorithm (WOA) and genetic algorithm (GA). The outcomes show that an improvement around 31.147% in exergy efficiency and 41.29% in thermal efficiency of glazed PV-T (single-channel) module is observed using WOA technique when compared with GA. Furthermore, WOA is better in contrast to GA because of faster rate of convergence in identifying the parameters.

Keywords Exergy efficiency · Photovoltaic thermal (PV-T) · Whale optimization algorithm (WOA)

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1 Introduction

In today's scenario, the demand for renewable energy is increasing day by day because the energy generated from conventional energy sources is not pollution-free. Apart from all the renewable energy sources available, solar photovoltaic is most popular because of the availability of sunlight in most part of the globe. A PV system converts sunlight into electricity while solar thermal converts sunlight into heat, but a PV-T system converts sunlight into heat and electricity simultaneously. A channel or duct is used below the PV panel in which air/water is used as a circulating fluid or cooling medium to assimilate the heat energy from the PV panel by conductive or convective process in order to enhance the electrical efficiency of the system. It was reported in the literature that electrical efficiency of the solar cell decreases with increase in temperature of upper surface of solar cell. The crucial factor about the popularity of PV-T collector is the low efficiency of the solar cell that varies from 6 to 16% at the temperature of 25 °C but in some of the countries the ambient temperature rises up to 35 °C. The rising of temperature decreases the module efficiency therefore, the extraction of heat energy from the backend surface of PV module is necessary. Depending upon the type of cooling medium, PV-T system is classified as PV-T air collector, PV-T water collector, and PV-T combi system in which both air and water are used as cooling medium. From the last three decades, a lot of research and development is done in this field in order to reduce the cost and complexity of the PV-T system. In this direction, Wolf [1] performed the experimental investigation on PV-T system and individual solar PV and solar thermal system. The PV-T is installed in Boston, USA to supply a single family residence. The area of designed collector is 50 m^2 and the collector is of non-concentrating type as shown in Fig. 1.

Crystalline silicon technology is used in the fabrication of solar PV array. From the outcomes obtained from the experimental investigation, it was concluded that that PV-T system is technically feasible and cost-effective as compared to the individual system used for electricity and thermal production. An active cooling system was designed by Teo [2] in which parallel array of cooling ducts was attached with back side of PV panel. The results obtained from the experimental analysis show

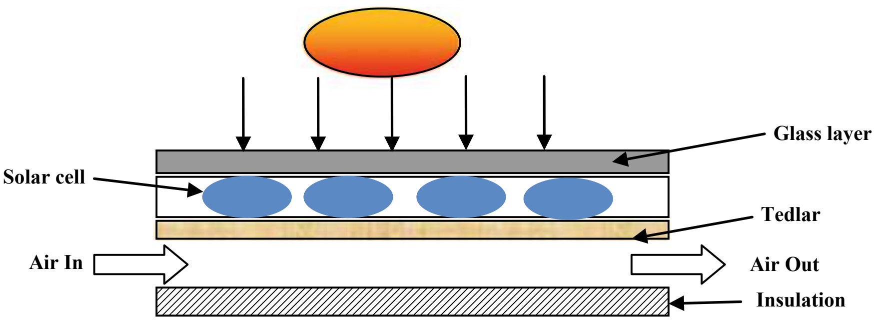

Fig. 1 PV-T air collector

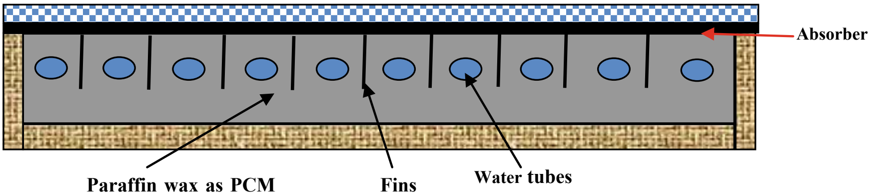

Fig. 2 PV-T water collector system with PCM

that the electrical efficiency of the system was enhanced by 4–5% with the active cooling system. Kalogirou et al. [3] reviewed the applications of various solar thermal collectors. The author discussed the latest advancement in the PV-T technology, i.e., application of phase changing materials (PCM) in the channel so that better thermal and electrical performance of the PV-T system is achieved. PCMs are used in the cooling medium due to its high latent heat of fusion, it increases the thermal absorbing capacity of cooling medium and keep the temperature fluctuations under the controlled range. Stropnik et al. [4] discussed the advantage of using PCM in the cooling medium as shown in Fig. 2. It was concluded that the average electricity production in the city of Ljubljana was enhanced by around 7.3% by mixing PCM in the cooling medium. Certain design modifications such as use of additional glass cover (upper glaze), use of thin metallic sheets and fins in the channel, etc., were also adopted by various researchers around the globe because these design modifications help in achieving the better the performance of the PV-T system. An additional glass cover (glaze) is used above the PV surface in order to trap more heat energy due to which thermal efficiency of the system improves significantly. It was reported that thermal output of the glazed PV-T system is almost double that of unglazed PV-T but decreases the electrical energy output [5]. Apart from this, there are certain disadvantages of the glazing such as edge shedding and increased temperature of the surface which leads to reduction in electrical output [6] and increases the sensitivity of photovoltaic module toward reflection losses and leads to the formation of hot spots.

The reflection losses are then reduced by using antireflective coating and hence improves the electrical efficiency of the system as compared to an ordinary glass cover [7]. Since there are a lot of design parameters which affect the performance of PV-T system. Therefore, optimization of parameters using soft computing techniques proved be very efficient in the designing of the system. In this direction, Singh et al. [8] use the genetic algorithm (GA) approach to optimize the parameters of single-channel photovoltaic thermal air collector. The outcomes demonstrate that the thermal and electrical performance of the system enhances significantly when the parameters were optimized using GA as compared to un-optimized system. In another study, the author [9] investigates the performance of the system with multi-objective function using genetic algorithm for the climatic conditions of New Delhi (India). Singh and Agrawal [10] implemented the hybrid GA-FS approach to the single-channel PV-T and the performance is compared with GA and un-optimized system. The objective function during the course of optimization is exergy efficiency. The conclusions drawn from the outcomes showed that the exergetic performance of the PV-T system is significantly enhanced using GA-FS approach as compared to GA and an un-optimized system. Singh et al. [11] worked upon evolutionary algorithm approach to optimize the parameters of glazed PV-T module and concludes that the performance of the system is improved when compared with un-optimized system.

2 System Description

In the proposed work, two different algorithms such as whale optimization algorithm (WOA) and genetic algorithm (GA) have been implemented on a single-channel glazed hybrid PV-T air collector system to find out the optimum value of parameters in order to maximize the exergetic performance of the system. There are various parameters which affect the performance of the PV-T system such as dimensions of the channel (duct) below the panel, depth of the tedlar, thickness of insulation layer, type of solar cell fabrication technology, velocity of fluid flowing through the channel, temperature of the fluid at the inlet and outlet of the channel, and temperature at the upper surface of the PV panel but in this paper, only four of the above parameters have been considered for optimization study. These four parameters were air channel length (L_M), depth of the air duct (d), fluid velocity through the duct (V_F), and temperature of the air at the inlet of duct (T_{in}). The overall exergy efficiency is considered as an objective function. The exergy efficiency, thermal efficiency, and electrical efficiency of the system are calculated according to the thermal modeling given by Agrawal and Tiwari [12].

3 Tool Used for Optimization

In this paper, two dissimilar optimization algorithms such as whale optimization algorithm (WOA) and genetic algorithm (GA) have been used to optimize the parameters of glazed PV-T (single-channel) module. WOA is a recently developed algorithm which was based upon the hunting behavior of humpback whales. WOA is introduced in 2016 by Mirjalili and Lewis [13]. For feeding themselves, humpback whale kills the little fishes close to the upper water surface. During this process, they formed a spiral or nine-like structure of bubbles in order to encircle its prey. They go down to 12 m and formed spirals of water bubbles to confuse the fishes and then swim up toward the surface as shown in Fig. 3.

This foraging behavior of humpback whales is called bubble-net feeding method. The movement of whale is classified in two ways, one in which whale goes down, make bubbles, and then goes up and second method includes different stages: coral loop, lobtail, and capture loop. When one of the whales updates its position to reach an optimal location, other whales are also attracted toward that and updated their

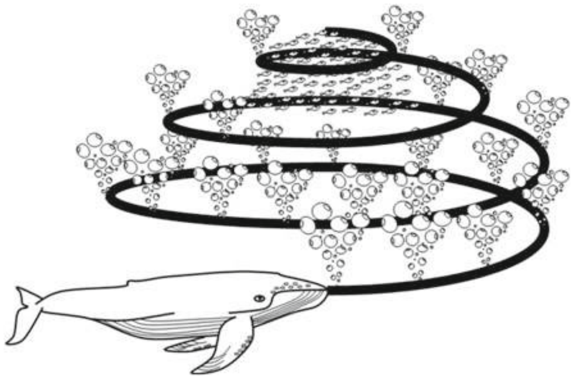

Fig. 3 Bubble-net feeding behavior of humpback whales [13]

positions according to Eq. 1.

$$\vec{D} = \left| \vec{P} \cdot \overrightarrow{Y^*}(t) - \vec{Y}(t) \right| \tag{1}$$

$$\overrightarrow{Y}(t+1) = \overrightarrow{Y^*}(t) - \vec{D} \cdot \vec{Q} \tag{2}$$

$\vec{P}$ and $\vec{Q}$ are coefficients, $\overrightarrow{Y^*}$ is the position vector of best position obtained so far, and $\vec{Y}$ is the position vector. The P and Q vectors are calculated as follows:

$$\vec{Q} = 2 \cdot \vec{a}\vec{r} - \vec{a} \tag{3}$$

$$\vec{P} = 2 \cdot \vec{r} \tag{4}$$

where $\vec{a}$ decreased from 2 to 0. The searching location dimension of whale is based upon the number of tuning variables. Since four design parameters have been considered for optimization, so a hypercube for searching space can be considered in which either optimal position or area around optimal position is the target of whale. The optimal location for whale will be that for which value of exergy the set of searching space parameters will be highest among nearby searching space positions. The flow chart which explains the proposed work is shown in Fig. 4.

4 Result and Discussion

The optimization is performed on the data for a day taken from Indian Meteorological Department, Pune for New Delhi India climatic conditions as shown in Table 1. We have compared the results obtained by optimizing the parameters with WOA with the results obtained when the parameters were optimized using genetic algorithm (GA) using the same input data.

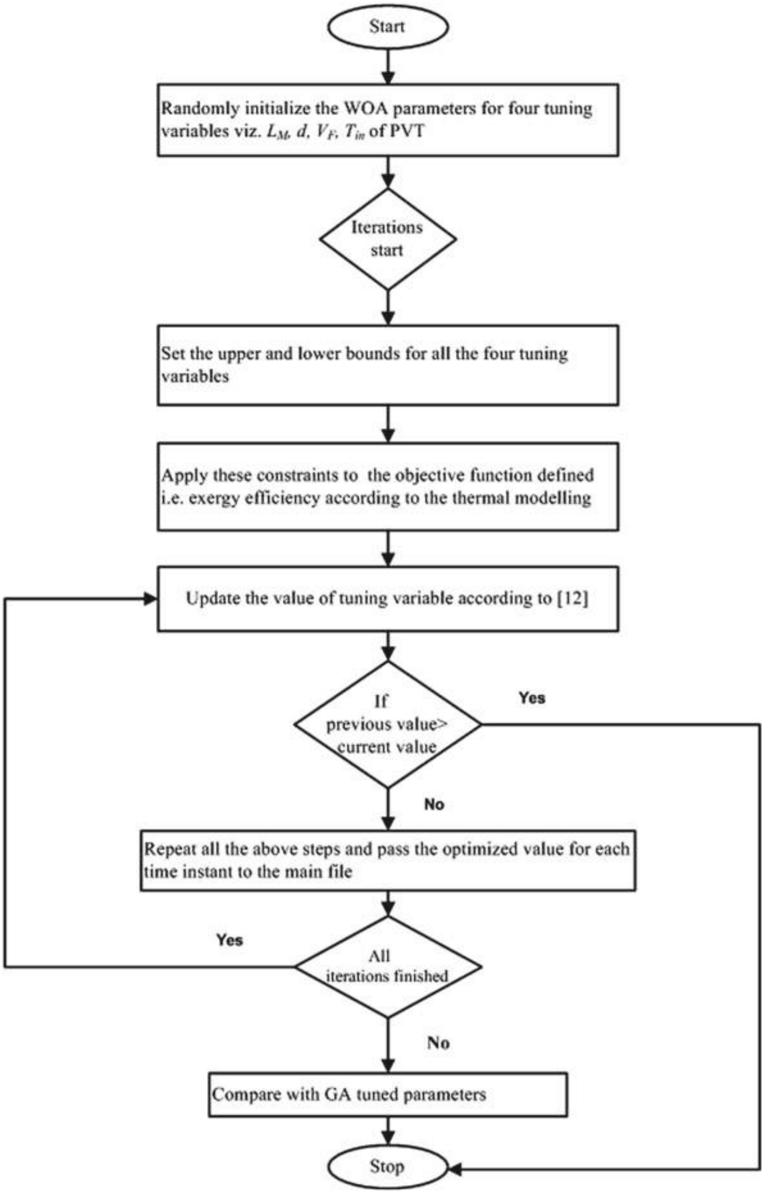

Fig. 4 Flow chart for WOA algorithm

Table 1 Input data taken from IMD, Pune

Daytime (h)	Intensity of sunlight (W/m^2)	Ambient temperature (°C)
08:00	132.99	7.90
09:00	355.56	7.90
10:00	554.69	7.90
11:00	680.73	6.60
12:00	726.74	6.40
13:00	733.85	7.70
14:00	656.08	10.60
15:00	500.00	13.00
16:00	311.46	15.00
17:00	106.42	16.50

The optimization techniques are used to solve nonlinear complex programming problems as in this work and good optimization is validated only if the iterations convergence reaches earlier and no further variation in the results is observed.

The results show that the iterations converge at a faster rate when WOA is used as an optimization technique and also it takes very less time for the identification of optimum value of design parameters for the Glazed PV-T module. The convergence curve is shown in Fig. 5. WOA optimization is best in terms of convergence rate when compared with GA. The optimization curve shows that the iteration is converging after 32 iterations in case of WOA whereas, in case of GA, it is converging after 60 iterations.

For the proposed study, exergy efficiency is considered as an objective function. Exergy efficiency is high-grade electrical energy obtained from the PV-T system. Figure 6 demonstrates that pattern for exergy efficiency is increasing from 08:00 to 13:00 h and maximum when the intensity is maximum. When the intensity of

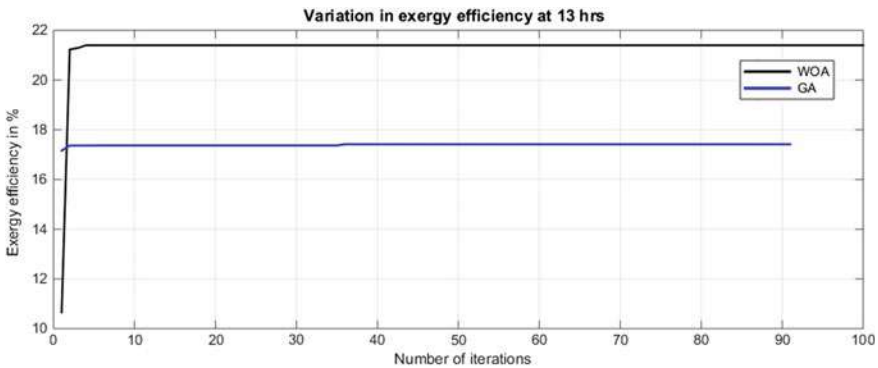

Fig. 5 Convergence curve of WOA and GA at 13 h

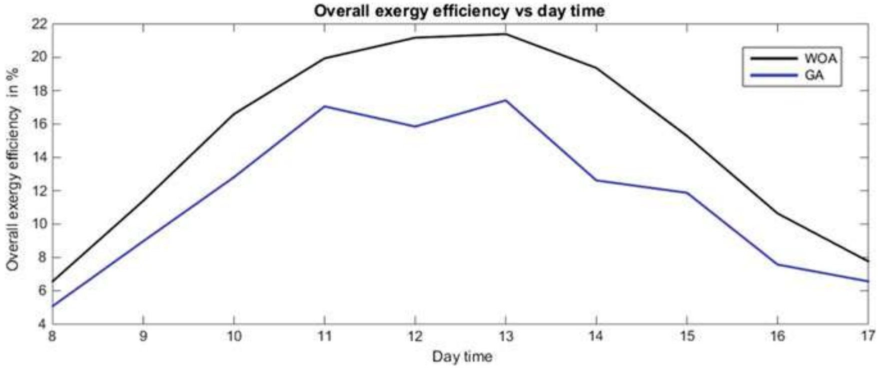

Fig. 6 Overall exergy efficiency of glazed PV-T module using WOA and GA

sunlight is decreasing, i.e., from 13:00 to 17:00 h, the exergy efficiency is decreasing. From the optimization curve, it is observed that exergy efficiency obtained when the parameters were optimized using WOA is 15.0119% and by using GA, the exergy efficiency is 11.58211%. Hence, from the results, significant improvements in the exergy efficiency of the system were observed using WOA.

The variation in thermal performance of the glazed PV-T system with time is shown in Fig. 7. The observations from the plot demonstrate that the thermal efficiency is maximum when the intensity of sunlight is maximum (i.e., around 12–13 pm) and thermal efficiency is minimum when the intensity of sunlight is minimum. The outcomes show that significant improvement in thermal efficiency was observed when the parameters were optimized using WOA.

The deviation in overall thermal efficiency with time is shown in Fig. 8. The outcomes demonstrate that the calculated value of overall thermal efficiency of the PV-T system is 43.67272% by using WOA while the calculated value of overall thermal efficiency is 33.30057% by using GA at the optimized values of parameters. The

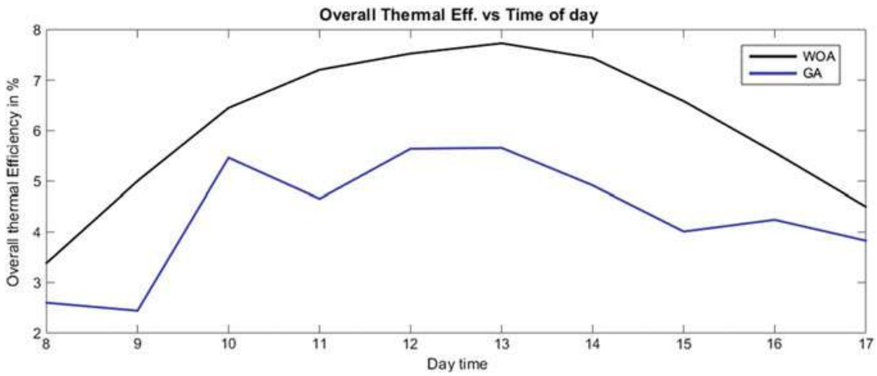

Fig. 7 Thermal efficiency of glazed PV-T module using WOA and GA

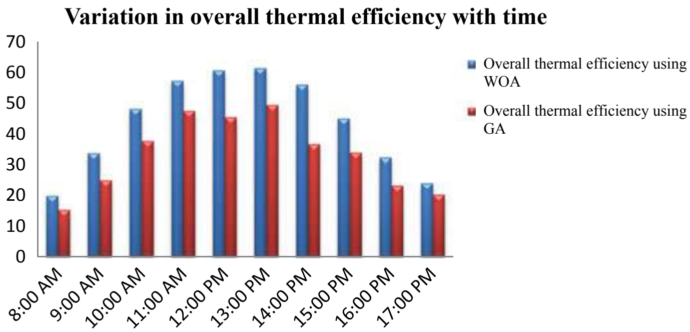

Fig. 8 Comparison of thermal efficiency using WOA and GA

outcomes demonstrate that an improvement of around 31.147% in overall thermal efficiency was observed when the parameters of glazed PV-T were optimized using WOA.

5 Conclusion

In this paper, two different optimization techniques have been implemented to glazed PV-T (single-channel) module to optimize its four variable parameters. For this purpose, the exergy efficiency of the system is considered as objective function. The outcomes of the proposed analysis demonstrate that exergy efficiency and thermal efficiency of the PV-T system were significantly enhanced by optimizing the parameters using WOA. The optimum value of exergy efficiency at the optimized value of parameters is shown in Appendix. The results show that an improvement of around 31.147% in overall thermal efficiency and 41.29% in exergy efficiency was observed when the parameters were optimized using WOA. The proposed work concludes that WOA is proved to be an efficient technique for optimizing the parameters of glazed PV-T (single-channel) module as its convergence rate is faster as compared to GA.

Appendix: Optimized Value of Parameters

Parameter to be optimized	WOA	GA
Length of the air channel, L_M (m)	0.3	0.27948
Air channel depth, d (m)	0.1	0.00092
Fluid velocity at the inlet, V_F (m/s)	1.5	1.37070

(continued)

(continued)

Parameter to be optimized	WOA	GA
Temperature of fluid at inlet, T_{in} (°C)	4.98	3.62050

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Effect of thermoelectric materials in electrical and thermal performance of photovoltaic thermal (PVT) collector

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Abstract. A photovoltaic integrated thermal (PVT) collector with thermoelectric material has been proposed in this communication, where a channel or duct has been used below the photovoltaic module in which air has been circulated to extract the heat taken by the photovoltaic module. Hence in PVT system, electrical energy from photovoltaic and thermal energy from duct are taken at the output. In this collector, thermoelectric (TE) is used to change the thermal energy by removing the waste heat of photovoltaic module into electric energy. In proposed PVT with thermoelectric system, TEs are generally appended at the back of the photovoltaic to improve the efficiency of PVT collectors. Thermal modelling has been presented for PVT collector with thermoelectric. The effect of thermoelectric material has been analysed for PVT collector. The electrical energy gain for photovoltaic collector and overall electrical energy gain with thermoelectric has been theoretically calculated. From the computed results, the overall electrical output is observed of PVT system with thermoelectric material; it is higher than only PVT system due to thermoelectric. As PVT system without thermoelectric generates only electrical energy due to PV and thermal energy but PVT system with thermoelectric generates electrical energy due to PV and thermoelectric both as well as thermal energy so overall exergy of PVT system with thermoelectric is higher than only PVT system. Hence PVT system with thermoelectric shows better results than only PVT system in respect of electrical, thermal and overall exergy gain.

Keywords: PVT collector, PVT collector with thermoelectric, thermal modelling, electrical gain, exergy gain

1. Introduction

Nowadays the renewable energy resources are very popular in terms of the energy generation process. As per the survey, the production of energy through the renewable sources was 9% in the year 2009 will be expected to grow 23% in 2035. Solar power plant is an important source of clean energy and generates a large amount of power in the present scenario. In solar photovoltaic, maximum of the incident sunlight is transformed into heat and only 15%-20% is changed into useful output electrical energy. The generated heat decreases its electrical efficiency as well as reduces the life time of PV module [1]. An integration of photovoltaic with thermal technology has been presented as photovoltaic thermal (PVT) system to use this waste heat. A channel or duct is applied below the PV panel in which air/water is applied to take the heat energy from the photovoltaic by conductive or convective process so as to improve the electrical performance of this hybrid system [2]. Hence both electrical and thermal energies are obtained at output of PVT system. A considerable number of researches have been conducted in the designs of photovoltaic air/water collector because its performance is affected by several parameters [3].

Mojumdera et al. [4] analyse single-pass PV/T air collector with thin rectangular fins throughout the length of air channel to dissipate heat. Kumar & Rosen et al. [5] presented the comparative study of double-pass PV/T air based collector with and without fins. Fins are used in this system at the base to improve the efficiency of given system by enhancing heat transfer rate. Vats et al. [6] discussed the effect of increasing packing factor on the overall annual energy of photovoltaic and found that increase in packing factor not always increase the overall output energy because with increase in packing factor, the temperature at the output of channel increases by absorbing the higher amount of thermal energy. Dubey and Tiwari [7] outlined and exhibited integrated PV/T solar based water collector. Some logical articulations were inferred as climatic conditions and design parameters, on the basis of absorber area observed that if coverage area of PV is reduced to one third than instantaneous efficiency rises from 33% to 64%.

Chow et al. [8] considered changes when coating on PV/T-thermosyphon system is used from exergy and thermodynamics perspective. From exergy perspective observed that expansions of packing factor, efficiency of cell, wind speed and proportion of water mass to collector region were ideal for system without glazing while surrounding solar radiation and temperature were positive for system with glazing. Mishra and Tiwari [9] examined water based PV/T-system based on constant collector temperature. It was found that fully covered PV was appropriate for generation of electricity as well as partially covered PV was reasonable for generation of heated water. Fudholi et al. [10] presented of spiral/web/direct flow absorber and observed that system's total efficiency was 68.4% for spiral absorber PV/T collector; it is found better than web and direct absorber. Dupeyrat et al. [11] created PV/T water system having better lamination of cell to get more heat exchange in between fluid and absorber. Hazi et al. [12] created a numerical model; it measured monetary markers and energy limits of PV/T water system and represented payback time was less for given system.

Thermoelectric (TE) are basically combination of many thermocouples and used to change the thermal energy by removing the waste heat of photovoltaic module into electric energy. The temperature of photovoltaic module can be reduce and control by using thermoelectric. In proposed PVT-TE hybrid module, TEs are generally appended to the back of the photovoltaic to improve the efficiency of PVT air/water based collectors [13].

A lot of research has been conducted in the field of PVT in last 30 years but there is very limited study in the literature of PVT with thermoelectric system. Lertsatitthanakorn et al. [14] designed an air based TE solar collector with double-pass in Thailand. It is reported that the overall efficiency of this hybrid TE system is increased. Yang and Yin [15] based on theoretical approach observed for a hybrid system comprising of photovoltaic, thermoelectric and hot water gives 30% more output electrical power contrasted with photovoltaic hot water thermal system and only PV system. Deng et al. [16] presented a hybrid design containing photovoltaic, thermoelectric generators with a heat collector. Also, it is exhibited that the overall efficiency of thermoelectric generators and photovoltaic are improved in this hybrid system. Onget. al. [17] assessed the execution of a PV based, evacuated tube heat pipe system for water heating and additionally, TE modules for generating electrical energy. Experimentally different temperatures are recorded by taking various water coolant flow rates and electrical efficiency is calculated as about 0.16%. Li et al. [18] experimentally considered a hybrid photovoltaic thermoelectric generator system in which TEG module is attached by a micro-channel heat pipe with PV to remove the heat. The electrical performance of this given hybrid PV/TEG is compared with a conventional PV system under different ambient conditions. It is found an improvement in overall electrical efficiency by 0.82% of this hybrid system over conventional PV system.

Dimri et al. [19, 20] presented thermal modelling of PVT-TE collector to observe the efficiency of this hybrid system. The designed PVT-TE collector is compared with only PV and PV-TE collector, and found that PVT-TE collector gives better overall electrical efficiency than PV-TE and PV collector by 4.7% and 7.3% respectively. Dimri et al. [21] considered a PVT-TE collector with different kinds of base materials of photovoltaic modules. It is found that for opaque base material, the overall electrical efficiency by 1.9 – 2.8% and thermal efficiency by 20.8 – 21.8% of PVT-TEC water collector is more than PVT-TEC air collector. The performance of all three types of base cover material (opaque, semitransparent and Aluminium) of PVT-TEC water collector is considered and on comparing it is found that the performance for PVT-TEC water collector with Aluminium base is much better than other. In literature, hybrid PV-TE generator system is found in many studies and many of them having heat sink in the TE generators cold side to make a large temperature gradient. However, the expelled heat for this situation is discharged to the environment so the overall efficiency of the system is reduced as this energy is lost. Lekbir et al.[22] proposed a nanofluid based hybrid PVT-TEG design. As nanofluid is having higher cooling potential than heat sink so in this design nanofluid is used in place of heat sink to increase both photovoltaic and TE generators performance, and also using waste heat as valuable energy.

2. System description

In this paper, a PVT collector with thermoelectric has been considered, where the thermoelectric material is used below the PV module to convert waste heat in to electrical energy as shown in Figure 1. In this given model, a channel has been used below the photovoltaic and thermoelectric material in which air is passed to absorb the heat of the panel. The electrical output of photovoltaic improves by placing a thermal system below the PV and thermoelectric. Additional electrical energy is also generated by using thermoelectric material. In this system, an insulation layer below the thermal channel has been used to trap the heat so that heat may not dissipate through the bottom part of the system. In this research work, analyse the electrical and thermal performance of the PVT system with thermoelectric.

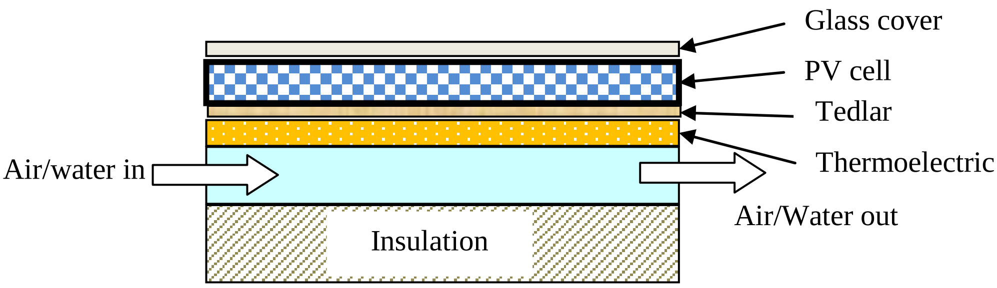

Figure 1. Proposed photovoltaic thermal system with thermoelectric material [18]

3. Thermal modelling

The energy balance equations have been developed for photovoltaic thermal air collector integrated with thermoelectric material [19-24], when taking an elemental area bdx. The following equations can be given for different part of the integrated PVT thermoelectric system:

a) For photovoltaic module-

$$\tau_g \alpha_{sc} I(t) bdx = U_{t,c-a}(T_{sc} - T_a) bdx + h_t (T_{sc} - T_{tec,top}) \beta_{tec} bdx + U_{b,c-a}(T_{sc} - T_f)(1 - \beta_{tec}) bdx + \eta_{sc} \tau_g I(t) bdx \quad (1)$$

b) For tedlar-

$$h_t (T_{sc} - T_{tec,top}) \beta_{tec} bdx = U_{tec}(T_{tec,top} - T_{tec,bottom}) \beta_{tec} bdx \quad (2)$$

c) For TE module-

$$U_{tec}(T_{tec,top} - T_{tec,bottom}) \beta_{tec} bdx = h_{tf}(T_{tec,bottom} - T_f) \beta_{tec} bdx + \eta_{tec} U_{tec}(T_{tec,top} - T_{tec,bottom}) \beta_{tec} bdx \quad (3)$$

d) For fluid flowing below TE module-

$$h_{tf}\left(T_{tec,bottom} - T_f\right)\beta_{tec} b dx + U_{b,c-a}\left(T_{sc} - T_f\right)(1 - \beta_{tec}) b dx = m_f C_f \frac{dT_f}{dx} dx + U_b\left(T_f - T_a\right) b dx \quad (4)$$

The expressions for T_{sc}, $T_{tec,top}$ and $T_{tec,bottom}$ are obtained, after solving Eqs. (1-3) and given as:

$$T_{sc} = \frac{(\alpha\tau)_{eff} I(t) + U_{t,c-a} T_a + h_t T_{tec,top} \beta_{tec} + U_{b,c-a}(1-\beta_{tec}) T_f}{U_{t,c-a} + h_t \beta_{tec} + U_{b,c-a}(1-\beta_{tec})} \quad (5)$$

$$T_{tec,top} = \frac{h_{p1}(\alpha\tau)_{eff} I(t) + U_{tec,top-a} T_a + U_{tec} T_{tec,bottom} \beta_{tec} + U_{tec,top-f} T_f}{U_{tec,top-a} + U_{tec}\beta_{tec} + U_{tec,top-f}} \quad (6)$$

$$T_{tec,bottom} = \frac{(\alpha\tau)'_{eff} I(t) + (1-\eta_{tec})\, U_{tec,bottom-a} T_a + h_{tf} T_f \beta_{tec} + (1-\eta_{tec}) U_{tec,bottom-f} T_f}{(1-\eta_{tec}) U_{tec,bottom-a} + h_{tf}\beta_{tec} + (1-\eta_{tec}) U_{tec,bottom-f}} \quad (7)$$

By taking the inlet and outlet boundary conditions, following expression for average fluid temperature is computed:

$$\bar{T}_f = \left[\frac{[h_{p3}(\alpha\tau)'_{eff} + h'_{p1}(\alpha\tau)_{eff} + h'_{p2} h_{p1}(\alpha\tau)_{eff} + h'_{p3}(\alpha\tau)'_{eff}] I(t)}{(U_{fa} + U_b)} + T_a\right]\left[1 - \frac{1 - exp\left(\frac{-(U_{fa}+U_b)bL}{m_f C_f}\right)}{\frac{(U_{fa}+U_b)bL}{m_f C_f}}\right] + T_{fi}\left[\frac{1 - exp\left(\frac{-(U_{fa}+U_b)bL}{m_f C_f}\right)}{\frac{(U_{fa}+U_b)bL}{m_f C_f}}\right] \quad (8)$$

After putting $\bar{T}_f$ from Eq. (8) in Eq. (7), the TE bottom end temperature, $T_{tec,bottom}$ is calculated. Further, putting $T_{tec,bottom}$ in Eq. (6), the expression for TE top end temperature, $T_{tec,top}$ is obtained. Finally, by putting $T_{tec,top}$ in Eq. (5), the expression for average solar cell temperature, T_{sc}can be computed.

4. Comparative results of PVT module with and without thermoelectric

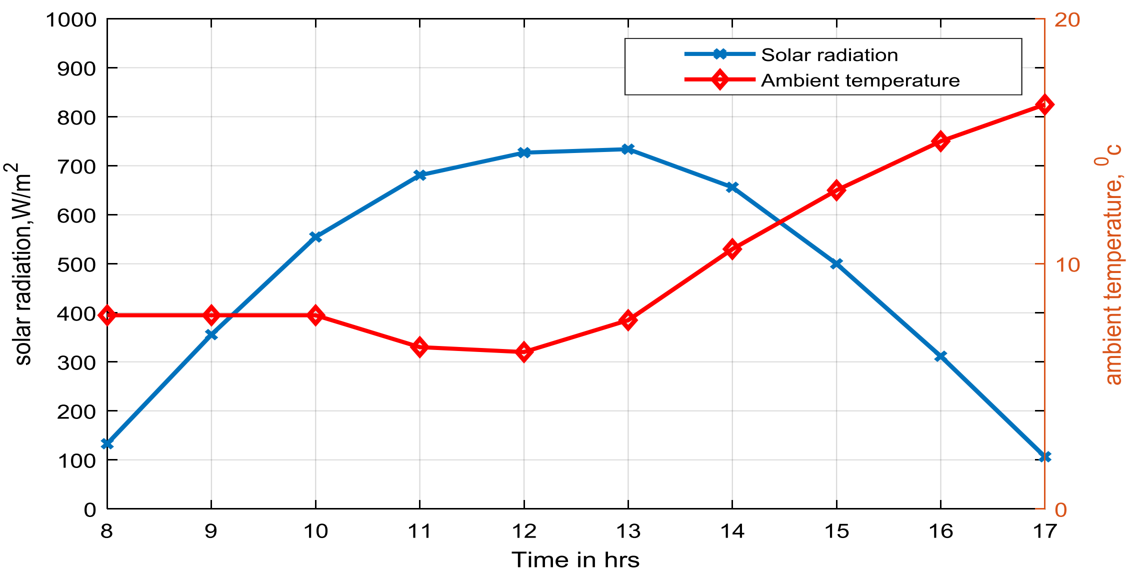

Figure 2. Variation of solar radiation and ambient temperature with time

In this module, a channel is used below the PV module and thermoelectric in this air is used for cooling and to absorb the heat from the photovoltaic and also to keep one terminal of thermoelectric as cool. In the given model, the electrical efficiency is considerably enhanced by using channel and thermoelectric material below the photovoltaic module. Fig. 2 shows the variation of the solar radiation (in W/m2) and ambient temperature (^{o}C) for New Delhi, India from 8:00 a.m. to 5:00 p.m. on a day of January, 2019. It is observed from the graph as shown in Fig. 2 that solar radiation is maximum at 1:00 p.m. and ambient temperature is in the range of 6–17 °C.

Fig. 3 indicates the variation of theoretically calculated electrical energy gain generated by photovoltaic, thermoelectric material and overall gain for the PVT system with thermoelectric material. The overall electrical energy of this hybrid system is the total electrical energy due to photovoltaic and thermoelectric material; it is higher than the electrical energy only due to the photovoltaic only. Hence the electrical energy of the given photovoltaic thermal collector with thermoelectric is better than only PVT collector.

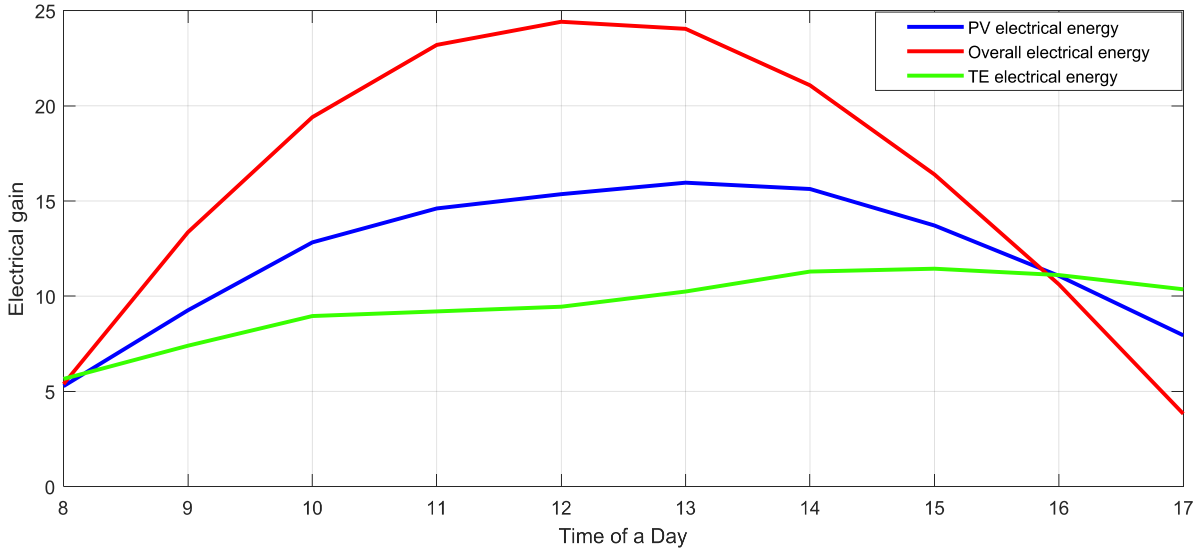

Figure 3. Variation of theoretically calculated electrical energy by PVT collector with thermoelectric material

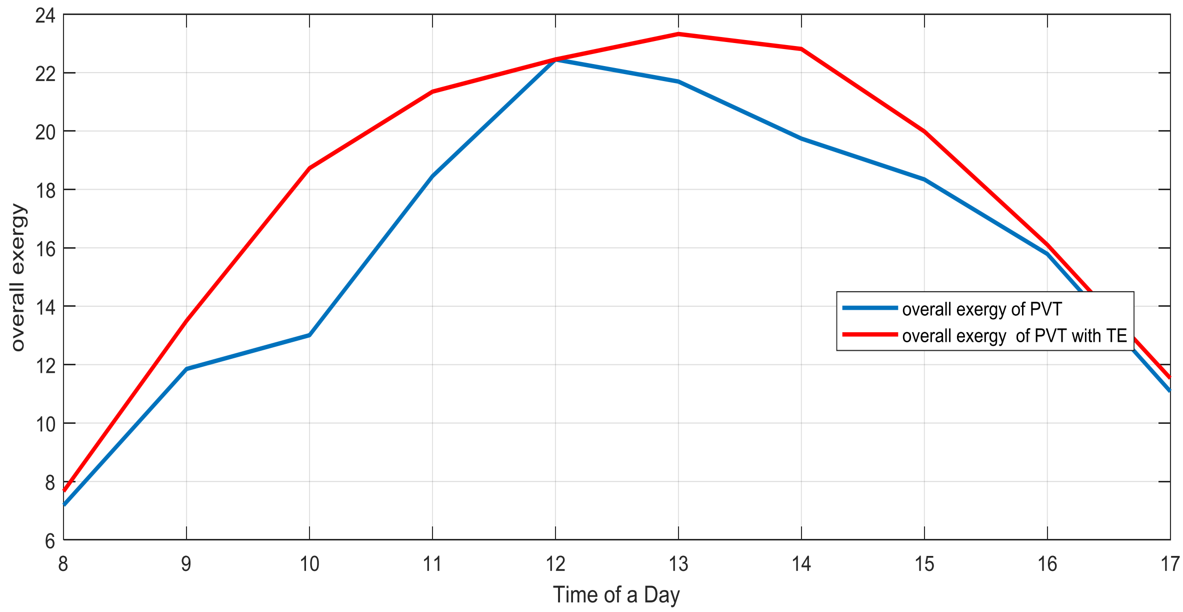

Figure 4. Variation of overall exergy of PVT collector with and without thermoelectric material

Variation of overall exergy of the PVT collector with and without thermoelectric material is shown in Fig. 4. It is observed that overall exergy of PVT collector with thermoelectric material having component of thermal energy along with electrical energy of photovoltaic and thermoelectric is higher than the overall exergy of PVT collector that is having component of thermal energy and electrical energy of photovoltaic only.

5. Conclusions

In the given work, theoretical modelling for PVT collector with thermoelectric material has been presented and compared with the PVT collector. TAs per the above study, the following points have been concluded:

• The overall electrical energy of PVT collector with thermoelectric is higher than the PVT collector only, as thermoelectric material is capable to generate electrical energy.

• In this proposed PVT module with thermoelectric material, TEs are appended to the back of the photovoltaic to attain the improved performance of PVT air collectors.

• This PVT collector with thermoelectric material shows better overall exergy, when compared with same type PVT collector.

6. Nomenclature

τ_g	Transmittivity of glass	α_{sc}	Absorptivity of solar cell
b	width of collector(m)	T_a	Ambient temperature(^{0}C)
L	length of collector(m)	T_{sc}	Solar cell temperature(^{0}C)
dx	Small length (m)	T_f	Temperature of air(^{0}C)
A_c	Area of solar cell(m^2)	β_{tec}	Packing factor of thermoelectric
$I(t)$	Solar radiation intensity(W m^{-2})	η_{tec}	Efficiency of thermoelectric (%)
η_{sc}	Efficiency of solar cell(%)	h_{p1}, h_{p2}, h_{p3}	Penalty factor due to glass, tedlar and thermoelectric respectively
C_f	specific heat of fluid or (J kg^{-1} K)		
m_f	Mass flow rate of fluid in channel(kg/s)	h_t , h_{tf}	heat transfer coefficients (W/m^{2}K)
$T_{tec,top}$, $T_{tec,bottom}$	Temperature of top and bottom surface of thermoelectric (^{0}C)	$U_{tec,top-a}$, $U_{tec,bottom-a}$, $U_{tec,top-f}$, $U_{tec,bottom-f}$, $U_{b,c-a}$, $U_{t,c-a}$, U_b, U_{fa},U_{tec} - overall heat transfer coefficients for different parts of hybrid system	

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Performance assessment of hybrid PVT air collector using GSA-CS algorithm

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Abstract. In the last few decades, enormous attention is drawn towards PV/T systems due to their advantages as compared to solar PV or solar thermal systems individually. In this proposed paper, hybrid Gravitational Search Algorithm (GSA)-Cuckoo Search (CS) has been implemented to optimize the parameters of glazed hybrid PVT air collector. Although there are various parameters which affects the thermal and electrical performance of PVT system but in this paper only four parameters namely Channel length below the PV panel, channel depth, velocity of fluid flowing through the channel and temperature of fluid at the inlet of the channel have been considered for optimization using the hybrid approach. The outcomes shows that GSA-CS algorithm is proved to be very efficient techniques to be used to optimized the parameters of hybrid PVT module. The result of the analysis shows that the average value of exergy efficiency is 14.8228% when the parameters are optimized using hybrid GSA-CS algorithm.

Key Words: Gravitational Search Algorithm; Cuckoo Search; PVT module

1. Introduction

The industrial reformation in the 18th century has tremendously hiked the energy demand globally. Around 14% of total energy consumption globally is provided by sustainable power sources [1]. Amongst all the available renewable energy sources, the solar PV has the highest capital cost, but due to its lower operational cost and maintenance [2], this technology is acknowledged around the world. Other advantages of solar PV are increased efficiency and pollution free energy [3]. The installed capacity of solar PV is increasing day by day worldwide due to its above-mentioned point of interests.

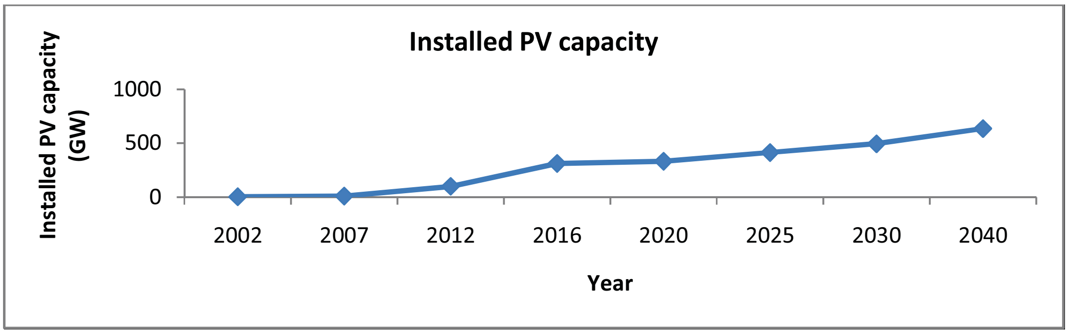

Figure 1. Worldwide installed capacity of PV

Banker & Pearce [4] discussed the development in PV technology over the last the two decades. The PV technology gained popularity due to decline in the price of a photovoltaic module. This reduction in cost is mainly due to competition among the manufacturers. Different governments in various parts of the world also show interest in emerging PV technology. Incentives had also been provided to the consumers in many parts of the world. Liou [5] discussed different silicon and non-silicon based technologies utilized for photovoltaic applications as depicted in Figure 2.

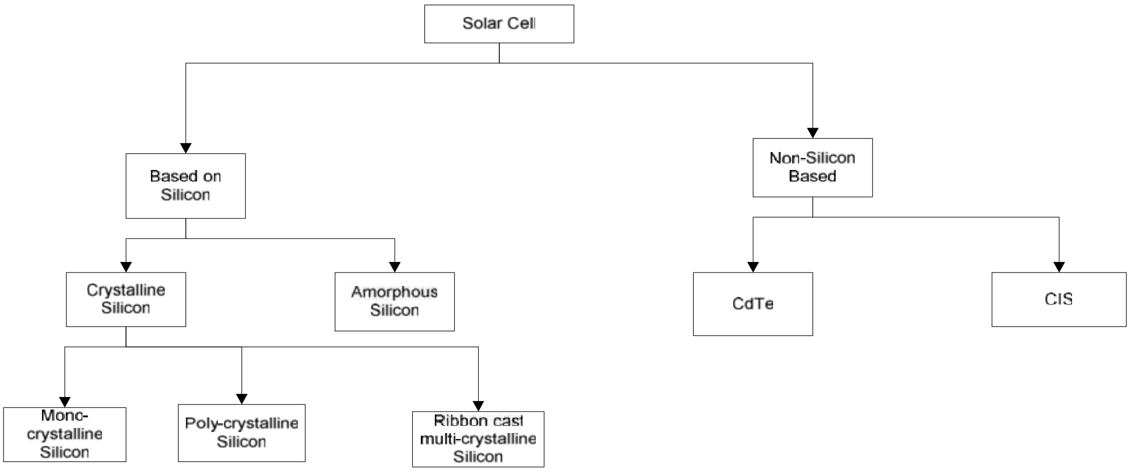

Figure 2. Classification of PV technologies [5]

The crystalline silicon technology is widely accepted as compared to other solar cell technologies because it exhibits higher efficiency as compared to other silicon based PV modules. In the most recent research, efficiency of multi-crystalline silicon technology up to 23% is reported in the literature [6]. But there are various hindrances such as easy availability of the sun energy, lesser efficiency and high payback time. Most of the incident sunlight is converted into heat and only a small portion (15%-19%) of it is converted into electrical energy. This heat energy not only reduces the life time of PV module but also decreases its electrical efficiency [7]. In order to utilize the wasted heat, the concept of PVT is introduced. The PVT system combines the solar PV technology and solar thermal technology. In PVT system, a duct/channel/tube is used below or above the module and circulating fluid is used in the channel to pull out the heat energy absorbed by the panel [8].

An experimental study is conducted by Ahn et al. [9] to examine the performance of PVT- air collector. The heated air exhausted from the channel was again passed through heat recovery ventilation (HRV) to preheat the heated air to improve the thermal efficiency (η_{th}) of the system. It has been observed from the experimental investigation that the thermal and electrical performance of the system has improved significantly. Slimani et al. [10] compared a single pass design of PVT-air collector with a glazed double pass PVT- air collector. The outcomes of the experiments show that the introduction of glazing (additional glass cover) caused an increase in temperature of all layers due to the greenhouse effect. The outlet temperature of double pass design reached up to 47 °C while in single pass design, the maximum temperature at the outlet was around 32 °C. The increase in temperature of upper PV module surface causes the decrease in electrical efficiency (η_{ele}). Thus, the double pass design has a lesser electrical efficiency compared to single pass design. Sarhaddi et al. [11] worked upon a mathematical expression of overall energy of flat plate PVT air collector. From the experimental evaluation, the electrical, thermal and overall efficiencies of the flat plate PVT system are found to be 10.01%, 17.18%, and 45%, respectively. From the experimental analysis, following inferences are drawn: 1.The η_{th} and $\eta_{overall}$ of PVT- air collector reduced with an increase in input temperature at the channel, 2. The η_{th} and $\eta_{overall}$ increases with increase in inlet air velocity, 3. The η_{th} and $\eta_{overall}$ initially increases with an increase in solar radiation intensity (up to 100 W/m2) but later the overall energy efficiency and electrical efficiency tend to reduce slightly.

Hegazy [12] experimentally investigated the effectiveness of the four different types of PVT-air collector depicted in Table 1. These PVT configurations are classified as model A, B, C and D based on the position of channel.

Table 1. Classification of PVT module based on position of air channel

Model	Air flow pattern
A	Above the PV panel
B	Below the PV panel
C	Single pass type with channel both sides of PV
D	Double pass type with channel both sides of PV

The effect of air velocity through the channel and selectivity of absorber plate has also been examined. From the experimental investigation, following inferences are drawn: 1. The electrical energy output and thermal output of model B and model D are almost similar and higher than that of model A, 2. The model C demands least fan power, hence its electrical efficiency is better than other three configurations discussed and 3. The thermal gain of any particular model increases with increase in fluid mass flow rate through the channel but at the same time, this requires more fan power hence has a slightly lower electrical efficiency. Qureshi et al. [13] discussed the impact of various environmental parameters viz. Air velocity, humidity, atmospheric temperature and temperature of solar cell on the performance of hybrid PVT- air collector.

PVT- system with upper glazing traps the heat from the sunlight and helps in improving the thermal efficiency when compared with unglazed system. Additional glass cover (glazing) is used above the PV surface to trap more heat energy which increases the thermal energy output almost double that of unglazed PVT but decreases the electrical energy output [14]. Other effects of glazing are edge shedding and increased temperature which may lead to reduction in electrical output [15] and increase the sensitivity of photovoltaic module towards reflection losses and lead to the formation of hot spots. The η_{ele} the PVT- air collector is inversely proportional to number of glass cover (glaze). As the number of glass cover over the PV module increased, the η_{th} of the system increases while the η_{ele} reduces [16].

Jin et al. [17] worked upon modified PV/T air collector by adding rectangular tunnel heat exchanger in the channel and compared its performance with conventional PV/T air collector. From the experimental investigation, it has been concluded that the thermal and electrical efficiencies for the modified system were 54.70% and 10.02% respectively which is significantly higher as compared to conventional PV/T air collector. Hussain et al. [18] uses honeycomb heat exchanger of hexagonal shape in the air channel. It has been concluded from the experimental investigation that the thermal efficiency of the system was improved significantly with the modification in the air channel. At a solar irradiance level of 828 W/m2 and mass flow rate of 0.11kg/s, the ɳth of the system was found to be 87%.

2. System description
In the proposed work, a single channel gazed PVT module is considered having 36 cells arranged in 9 rows as shown in Figure 3. The solar cells are arranged in series and in parallel to increase the voltage and current ratings respectively of the module. The objective of the proposed work is to analyze the exergetic performance of the PVT system using hybrid GSA-CS algorithm. In the proposed model, the extra glass cover is used above the PV module to trap the sunlight. Below the PV module, a channel is used in which air is circulated to absorb the heat energy of the panel. The layer of insulation is used below the channel so that the trapped heat in the channel may not dissipate through the bottom part of the system. Only four variable parameters i.e. Channel length, channel depth, velocity of air flowing through the channel and temperature of fluid at the input of channel have been considered for the analysis.

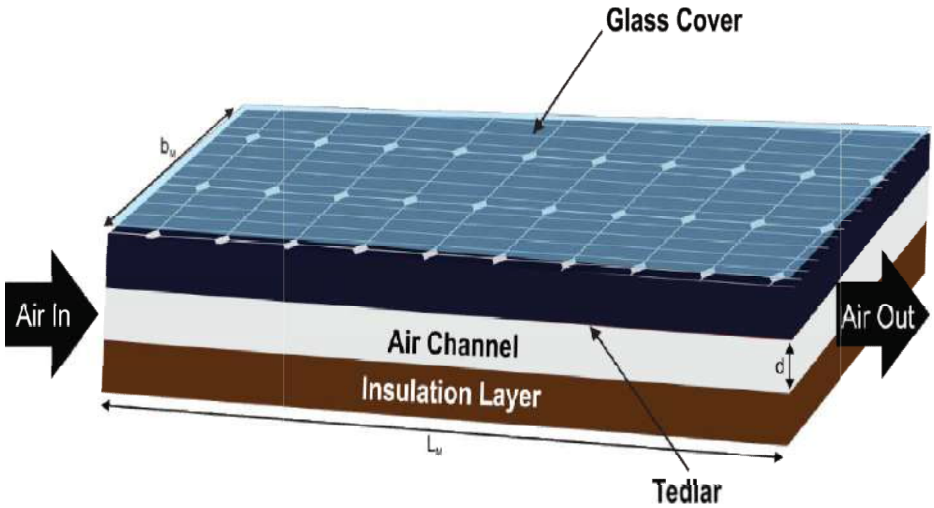

Figure 3. Proposed single channel photovoltaic thermal module [20]

3. Optimization of the system
In this paper, the hybrid GSA-CS algorithm is used to find out the optimum value of objective function (exergy efficiency) by considering the values of variable parameters within the specified limit (upper and lower bound). The hybrid GSA-CS algorithm combines the best properties of gravitational search algorithm and cuckoo search algorithm. In GSA, each search agent is categorized according to its position, gravitational mass, velocity and inertial mass. In cuckoo-search (CS) algorithm, the swarms were divided into various groups according to their identity (roosters, chickens and hens). The groups were decided on the basis of fitness function. The swarms with highest fitness value will be categorized as roosters while the swarms having lowest fitness value will be identified as chickens and rest will categorized as hens. Hens can choose a group for its survival haphazardly and the relation between the hens and chickens is resolved arbitrarily. In Cuckoo Search algorithm, the initialization of population is arbitrary. That's why it can't ensure success in every solution. The irregular arrangements of population cause the solution to be far away from the optimized solution. In each selected group, every chicken can be viewed as an answer, though a moved chicken is another arrangement. The optimal arrangement is held at last, which is the extreme objective of this calculation. The hybrid GSA-CS optimization technique is applied to the PVT module and the fitness value of each search agent is calculated according to gravitational search algorithm. The best fitness value so far is the optimal location of the search agent. The position of the search agent is updated in

the next iteration according to the cuckoo search algorithm [19]. The best updated solution is find out using the hybrid approach for t = t+1 iterations. The pseudo code for the hybrid GSA-CS algorithm is shown in figure 4.

```
1.  Initialize all the design parameters of PVT system
2.  load the solar irradiance and temperature data for a day
3.  for i=1:number of time instants
4.          randomly initialize the GSA-CS parameters for four tuning variables of solar cell
5.          for j=1:GSA-CS iterations
6.                  set the upper and lower bounds for all four variables parameters
7.                  pass these to objective function written to calculate the exergy efficiency
8.                  save this exergy value for first iteration.
9.                  If exergy (t+1)>exergy(t)
10.                         Best_sol(t+1)=current_position(t+1)
11.                 End if
12.                 Update the current positions as per GSA update equations
13.                 Pass the GSA updated to cuckoo search algorithm to inherit its local serach
                    property.
14.                 Update the GSA updated position by levy flight formulation by cuckoo
                    search.
15.                 Check for constraints
16.                 If constraints ==True
17.                         Accept the update position
18.                 Else
19.                         Randomly initialize the current positions
20.                 End if
21.                 Repeat the steps from 7-20
22.
23.         End for
24.         If iteration (t)==iteration (end)
25.                 Select the best solution
26.         End if
27. End for
28. pass the optimized value for each time instants to the main file
29. stop if all the time instants design variables are optimized
30. take the mean value of design parameters
```

Figure 4. Pseudo-code for hybrid GSA-CS algorithm

4. Optimization results and analysis

The exergetic performance of glazed PVT module has been evaluated by optimizing its four different variable parameters (length of the channel, depth of the channel, velocity of air flowing through the air duct and temperature at the input of the air channel) using hybrid GSA-CS algorithm. In glazed PVT module, a single channel is used below the PV module in which air is used as a cooling fluid to absorb the heat energy from the PV surface. By using channel/duct below the PV module, its electrical efficiency is enhanced significantly. Therefore, the removal of heat from the PV module is necessary. The hourly data for solar radiations and ambient air temperature used for the optimization has been taken from IMD, Pune for a day in the month of January for the climatic conditions of New Delhi, India as shown in Figure 5 [20]. There are various parameters which have an impact over the effectiveness of PVT module but in this proposed work, only four parameters have been considered. For the proposed module, the variation in temperature at the output of channel, exergy efficiency, electrical energy and thermal energy have been calculated according to thermal modeling presented by Agrwal and Tiwari [20].

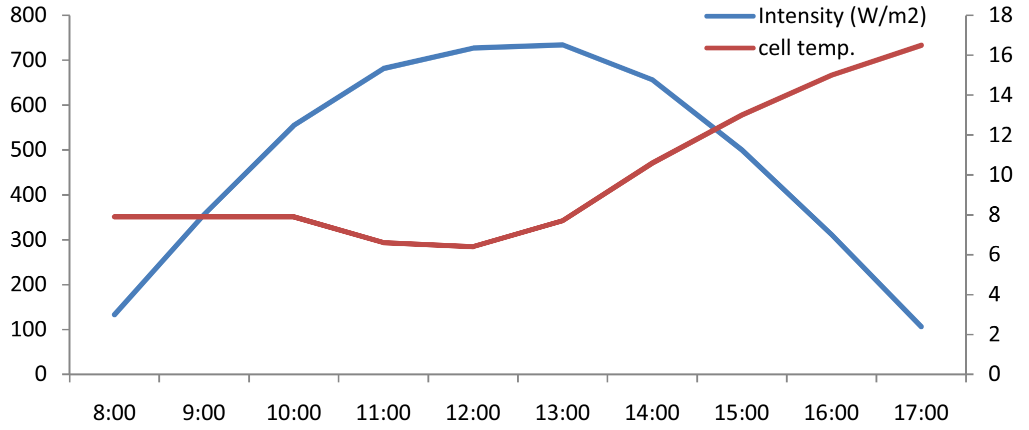

Figure 5. Variation in intensity and temperature with time

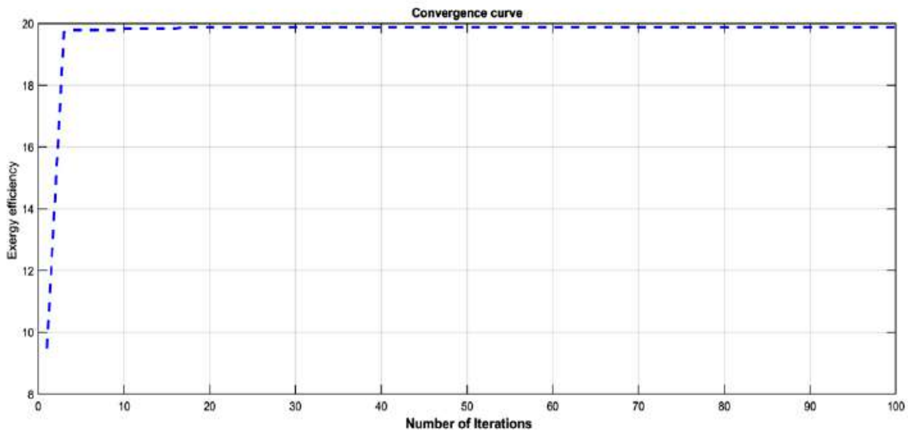

Figure 6. Convergence curve for PVT using GSA-CS algorithm

The convergence curve for the hybrid GSA-CS algorithm for the different time of a day shows that the iteration converges at a very fast rate and it takes less time in the recognition of optimized value of parameters. The curve showing the convergence rate is depicted in Figure 6 when the intensity of sunlight is maximum i.e. 1:00 PM. From the plot, it has been observed that the exergy efficiency (ɳEx) is highest when the intensity of sunlight is maximum.

The variation in ɳEx of the PVT module with time of a particular day is depicted in Figure 7. The Trend for exergy efficiency is increasing when the intensity of sunlight is increasing i.e. from morning 08:00 AM to 13:00 PM and it shows decreasing trend when the intensity of sunlight is decreasing i.e. from 13:00 PM to 17:00 PM. By using hybrid GSA-CS optimization algorithm, the solution converges with less than 10 iterations and also the convergence time is very less. The average value of ɳEx of the PVT system is 14.85228% at the optimized values of the parameters as shown in table 2.

Table 2. Optimized values of variable parameters

Exergy efficiency	Length of channel	Depth of the channel	Temperature of fluid at the input	Velocity of fluid at the input
14.85228	0.414538 m	0.3 m	2.3	1.5 m/s

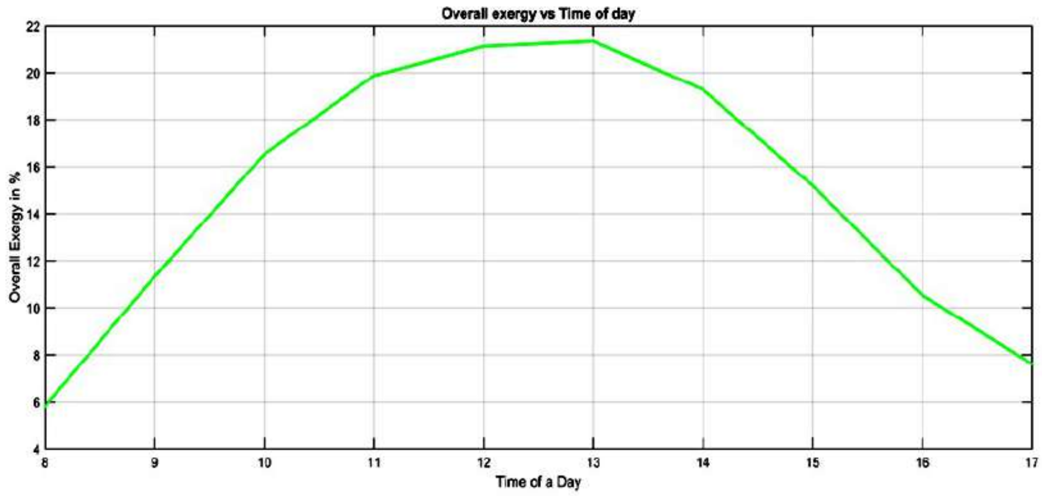

Figure 7. Variation in overall exergy efficiency of system with of a day

5. Conclusion

The following conclusions are drawn on the basis of above study:

• The convergence rate of hybrid GSA-CS algorithm is fast. The solution converges in less than 20 iterations.

• The average value of exergy efficiency (ɳEx) of the glazed PVT module is 14.85228% at the optimized value of parameters.

• The hybrid GSA-CS algorithm is proved to be an efficient technique for optimizing the parameters of PVT systems.

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Experimental Validation & Performance Analysis of 100kW Solar Photovoltaic System

Publisher: IEEE

Akhilesh Rai ; Anmol Soni ; Anmol Gupta ; Ashish Thombre **All Authors**

Document Sections

Abstract: This paper focused on modelling & simulation of 100kW Solar Power Plant. In today's world as the demand of supply is increasing, a technology is needed to meet requiremen... **View more**

Metadata

Abstract:

This paper focused on modelling & simulation of 100kW Solar Power Plant. In today's world as the demand of supply is increasing, a technology is needed to meet requirements using renewable resources. The application of renewable energy in electrical power system is growing fast. Solar energy is the most clean, ample and endless of all the renewable energy resources till date. In this system, sunlight is harvested by using a technique like maximum power point technique (MPPT) to meet requirements without affecting the environment. In this paper, the development of PV array model & Simulink implementation with a mathematical model is discussed on MATLAB R2015a. This system is also connected to the grid to transfer the produced surplus energy. The effectiveness of power plant analysed by various characteristics.

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Contents

I. INTRODUCTION

Solar power is the conversion of energy from the sun into electricity directly using photovoltaic (PV) system. Solar energy is intermittent due to day/night cycles and unpredictable weather conditions. To use this energy efficiently, an optimized system is introduced. As the output obtained from the system is dc in nature and cannot be used directly to run various loads but when dc power is converted into ac, the efficiency of a system gets reduced. In order to increase efficiency & the utilization of solar energy different models studied over the world on PV system [1]-[5].

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Figures

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Keywords

Metrics

A Five–Level PWM Inverter for Hybrid PV/Fuel Cell/Battery Standalone Power System

Publisher: IEEE

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Abstract: Renewable energy sources (RES) has found attention of power system researchers as alternate energy sources recently. On the other hand RES based generation has emerged as... **View more**

Metadata

Abstract:
Renewable energy sources (RES) has found attention of power system researchers as alternate energy sources recently. On the other hand RES based generation has emerged as one of the best option due to global environmental concerns, especially for off-grid load locations like islands, mountains, etc., where diesel generators are main source of power generation. This paper presents an efficient photovoltaic (PV) generation integrated with multilevel inverter to ensure regulated power at user end. In order to track the maximum power of PV applications Perturb and observe (PO) algorithm is used which is based on the maximum power point tracking (MPPT) principle. However in PV based power generation, control problems surfaces because of large variation in irradiance round the clock. This issue is controlled by hybrid PV

generation system which is application of secondary power source as battery and fuel cell integrated with PV generation unit. The DC output of standalone hybrid PV-SOFC-Battery generation system is inverted by a single-phase multilevel converter. This output of developed standalone hybrid PV-SOFC-Battery generation system is used to supply the single-phase load. The results have been verified with MATLAB/Simulink for different load applications.

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Contents

I. Introduction

The energy demands of human beings has increased exponentially over the course of time. Fossil fuels will be depleted in the coming years and the only answer to those needs will be fresh alternate energy which will in turn improve energy proficiency and force quality issues [1].

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R-peak based Arrhythmia Detection using Hilbert Transform and Principal Component Analysis

Publisher: IEEE

Varun Gupta ; Monika Mittal All Authors

Abstract

Abstract:
The analysis of Electrocardiogram (ECG) signal is very cumbersome due to its non-stationary nature. ECG signal is the combination of P-wave, QRS-wave and T-wave. R-peaks detection is very important for classifying heart diseases in QRS-wave. R-peaks detection is not easy task due to the involvement of various types of noises and large length of data sets. In this work, discrete wavelet transform (DWT) is considered for preprocessing step. Hilbert transform has been used for spectral estimation for the step of extracting features. Finally, principal component analysis (PCA) is adopted for reducing feature vectors. R-peaks have been detected from reduced features on the basis of calculating the variance of principal components (PCs). The detection sensitivity (SE), positive predictivity (PP), F-measure (F-m) and mean squared error(MSE) are estimated for evaluating the performance of the proposed technique. It gave 99.88% SE, 99.88% PP, 99.88 % F-m, and 0.0766 MSE.

The proton whistler wave energization by finite frequency kinetic Alfven wave: A numerical approach R. Goyal, R P Sharma, D N Gupta and N. Gaur Proc. Jangjeon Math. Soc. Vol. 21 (2018), No. 4, 733-743
On the different clusterization algorithms and role of cross-sections in forming complex multi bound structures using Monte-Carlo simulations R. Kumar and I. Puri Proc. Jangjeon Math. Soc. Vol. 21 (2018), No. 4, 745-758
(1,3) Solid burst-correcting optimal linear codes over GF(5) T. Lata Proc. Jangjeon Math. Soc. Vol. 21 (2018), No. 4, 759-763
Dimension reduction and classication in ECG signal interpretation using FA and PCA: A comparison V. Gupta and M. Mittal Proc. Jangjeon Math. Soc. Vol. 21 (2018), No. 4, 765-777
Continuity conditions for locally bounded finite-dimensional representations of almost connected locally compact groups A. I. Shtern Proc. Jangjeon Math. Soc. Vol. 21 (2018), No. 4, 779-782

Metamaterial Inspired Dual Band Patch Antenna Array

Publisher: IEEE

Chirag Arorak ; Shyam S. Pattnaik ; R. N. Baral All Authors

Abstract:
This paper presents a shorted-pin, dual-band, metamaterial-loaded microstrip patch antenna array. Under the unloaded conditions, the traditional patch antenna array resonates at 5.8 GHz with gain of 9.8 dBi and bandwidth of 540 MHz. However, when each patch of this traditional array is loaded with split ring resonator (SRR) and a metallic via hole is made on the patch, the same antenna array also produces an additional resonant frequency in 2.45 GHz Wi-Fi band with bandwidth and gain of 290 MHz and 5.6 dBi, respectively, while the initial resonant frequency (i.e. 5.8 GHz) gets shifted to 5 GHz Wi-Fi band, providing the gain and bandwidth of 11.4 dBi and 510 MHz, respectively. The prototype of this proposed antenna array has been fabricated.

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DOI: 10.1109/SPIN.2018.8474134

Publisher: IEEE

ECG Signal Analysis: Past, Present and Future

Publisher: IEEE

Varun Gupta ; Monika Mittal All Authors

Abstract:
Cardiovascular activity is a complicated process and the abnormality is directly represented in the ECG rhythm, heart rate, blood pressure and respiration signal. The Electrocardiogram (ECG) is an important tool for diagnosing the health status of the patient. It represents cardiac electrical activity of the patient. Analysis of this cardiac electrical signal is very challenging due to the involvement of various types of noise such as baseline wander noise, differences in the electrode impedances, power line interference, muscle artifact and the current flowing in the signal acquisition arrangement. For analyzing such cardiac electrical signal, it requires Computer aided diagnosis (CAD). Time domain techniques are suitable in the analysis of the clean ECG signal. Frequency domain techniques suffers due to spectral leakage. Hence, not suitable for analyzing nonlinear dynamics of the ECG signal. Nonlinear methods are used for analyzing such nonlinear and nonstationary features of the ECG signals. In this paper, different methods from time, frequency and nonlinear domains have been discussed.

Published in: 2018 IEEE 8th Power India International Conference (PIICON)

Date of Conference: 10-12 Dec. 2018

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Institutional Sign In

Smart Solar Energy Management to Power Computer Lab in Rural Areas

Publisher: IEEE

Neeraj Kumar Gupta ; Aditya Kumar Singh ; Ashish D. Thombre ; Kirti Pal **All Authors**

Abstract: An isolated solar PV system is a reliable solution to providing electricity in rural and remote locations. Such systems require an array of PV panels, charge controllers,... **View more**

Metadata

Abstract:
An isolated solar PV system is a reliable solution to providing electricity in rural and remote locations. Such systems require an array of PV panels, charge controllers, battery bank to compensate the supply & demand mismatch. The paper presents an evaluation of stand-alone photovoltaics (PV) system installed on the roof of EN Dept. building, KIET Group of Institutions, Ghaziabad. The experimental data was recorded for month of August 2018 through IoT. This project aims to encourage the use of small stand-alone solar PV system to supply power to laboratories in rural areas & remote locations. In this project we also develop a cost-effective energy management solution for data logging & monitoring is done by Wi-Fi based Internet of things (IoT) system that can be accessed from anywhere.

Keywords

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Contents

I. Introduction

Electricity plays a crucial role in the development of the society. It is a fundamental part of our life and one can't think of a world without electricity. Yet, over 1 billion people in the world do not have access to electricity. Of this, over 95% live in developing countries and over 84% reside in rural areas [1]. At the same time, we face the issue of depleting reserves & increasing cost of fossil fuels. Additionally, there is special focus on the major problem of Global Warming and pollution. These issues prompt us to reduce our dependence on fossil fuels as the primary source of energy. Due to this, the need of the hour is to develop and utilize renewable resources like solar, wind, geothermal, bioenergy& many more. Amongst these, solar energy is the one with the most potential. The approximate emission power from the sun is 1.8×10^{11} MW [2].

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Figures

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Volume. No. 5, Issue No. 2, July-December 2017, ISSN: 2320 - 8996

SMALL SCALE POWER GENERATION FOR RURAL HOUSEHOLDS

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Abtract: This paper includes details about a project to build a human powered generator with the help of a bicycle. This can be used for upto 120watts DC. This project will help to develop a clean way of generating electricity. It is intended to be both achievable and affordable.

Keywords: portable generator, clean electricity, low cost power generation

I. INTRODUCTION

The purpose of this project is to build a human powered generator with the help of a bicycle which is also portable and can be used to power small appliances such as dc fans, light bulbs etc. This project will help to develop a clean way of generating electricity. It is intended to be both achievable and affordable. By using principles of energy conversation a small amount of power source can be developed which can be used in rural and remote areas. The chemical energy in a person's body is converted into mechanical energy using a bicycle and then further into the electrical energy with the motor. This energy is stored in a battery for further use.

II. LITERATURE REVIEW

[10] A remote village has limited access to electrical power and, as a result, the village homes are lit with candles and kerosene lamps after dark. Narrow mountain paths limit the access to neighbouring villages and limits the supply of diesel for the village's generators. The task is to develop a small and sustainable source of electricity for the village. [7] The intention is to create a system that can be used to generate and store enough energy to light an LED or any other small appliance for about 10

minutes.It is intended to be both achievable and affordable. [1] The chemical energy in a person's body is converted into mechanical energy with the use of bicycle and then further into the electrical energy with the motor. By hand-cranking the bicycle pedal at different speeds we will discover that at higher speeds the lamp will get brighter. We shall also discover that the sound emitted by the speaker gets higher in frequency and amplitude (volume) as the pedaling speed is increased. If the speaker or lamp has weak output, we will connect one at a time. An oscilloscope can also be connected to the dynamo to show the sinusoidal waveform. The loads provided should be appropriately matched to the dynamo's output. This energy can be measured by using a microcontroller and LCD display to display instantaneous power.

III. PROPOSED ARCHITECTURE

The various components which are required to build this project are mentioned below [2] A bicycle which can be of any size, the dynamo will be fixed at the hub of its rear wheel, Dynamo, bridge rectifier, voltage regulator and a LED bulb. [8] Its working can be explained as follows. The AC from the dynamo(present at the hub of the rear wheel) passes through a full-wave rectifier and feeds the LED bulb through the connected circuit elements. The current in the LED is limited by the dynamo to about 0.5Amps - 0.6Amps.LED should be capable of handling this much amount of current without getting fuse. [6] The charge (q) stored in a capacitor is the product of its capacitance (C) value and the voltage (V) applied to it. Capacitors offer infinite reactance to zero frequency so they are used for blocking DC components or bypassing the AC signals. The capacitor undergoes through a recursive cycle of charging and discharging in AC circuits where the voltage and current across it depends on the RC time constant. For this reason, capacitors are used for smoothing power supply variations. The instantaneous voltage produced by pedaling at normal speed is about 14 volts when measured through a multi meter. The light flickers when pedaling is done at low speed. Hence a smoothing capacitor is used to reduce the flicker at low speed and also to increase a little bit of brightness. Capacitor C1 used has a high value so as to reduce the flickering caused at low speed. A small value of capacitor C1will increase the flickering at low speeds. The capacitor should withstand at least 4V.Its value is limited by the size & its cost hence these factors should be kept in mind while choosing a capacitor. LED should be disconnected from the circuit after the capacitor has charged to its full value otherwise it can charge to a higher voltage level. This could be dangerous to the operator as well as for the LED. A sudden very high peak current will most likely destroy the LED or change its color. [9] By revolving the bicycle pedal at different speeds, we will find that at higher speeds the lamp will get brighter. We will also discover that the sound emitted by the speaker will be higher in frequency and amplitude. If the output of the speaker or lamp is weak, we will connect one at a time. An oscilloscope can also be connected to the dynamo to show the output sinusoidal waveform. **7805** is a **voltage regulator** integrated circuit. It is a member of 78xx series of fixed linear voltage regulator ICs. The voltage source in a circuit may have fluctuations and would not give the fixed voltage output. The **voltage regulator IC** maintains the output voltage at a constant value. The xx in 78xx indicates the fixed output voltage it is designed to provide. 7805 provides +5V regulated power supply. Capacitors of suitable values can be connected at input and output pins depending upon the respective voltage levels.

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits.A **16x2 LCD** means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data.

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Volume. No. 5, Issue No. 2, July-December 2017, ISSN: 2320 - 8996

IV. WORKING METHODOLOGY

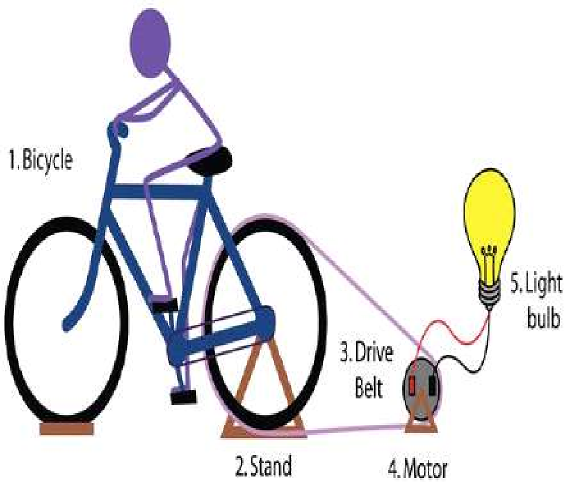

Figure1: Block diagram of small power generation.

A PMDC motor which is used as a generator is fixed at the hub of the rear wheel of the cycle.It is then connected to any dc appliance to which it gives power.[5] The generated electrical power could be used to charge a battery and could be stored or could be used to directly power appliances.The instantaneous voltage developed is around 14 volts which can be checked with the help of a multimeter. We could design an energy storage device that can be hooked up to the bicycle and is portable. It should be easily removable, compact, durable and capable of illuminating the LED via a current limiting resistor for at least 10 minutes.

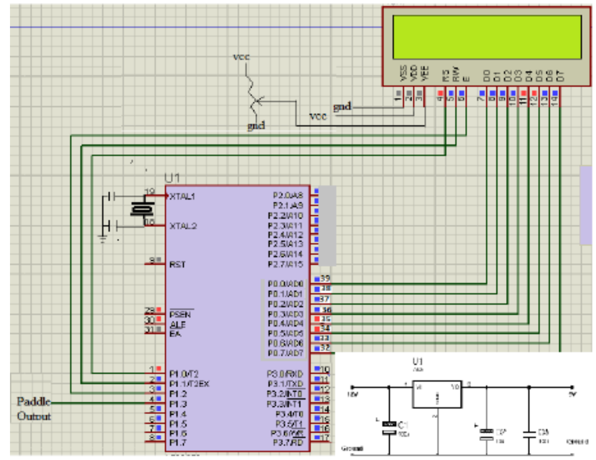

fig: complete circuit connection

This energy can be measured by using a microcontroller and LCD display to display instantaneous power. The chemical energy in a person's body is converted into mechanical energy with the use of bicycle and then further into the electrical energy with the motor. This electrical energy is stored in a battery which can be used to drive LED light and some other small appliances. If we want to use AC power than a inverter can also be used with this apparatus. VCO is used for constant output voltage. In this project we are using 7805 voltage regulator which has an output of 5V.For an average adult cycling at a normal rate it would take around 1 hour to store approximately 150W of power .Several cycle generators can be connected in parallel and connected to a battery which can store power or to an appliance which consumes more amount of power.More the cycling speed more is the instantaneous power developed.But a smoothing capacitor is to connected in the circuit which removes the ripples or the spikes from the voltage or current waveform produced.This can also be used to power AC appliance by connecting an inverter in intermediate stages.The PMDC motor selected should be according to the needs i.e for high power high rating and more rpm motor should be used.The total energy loss in a cycle generator will be around 42 to 67.5 percent (calculation example for highest loss: 100 watt input = 80 watt after 20% loss in motor/generator = 57.5 watts after 25% energy loss in voltage regulator = 37.5 watts after 35% loss in battery = 32.5 watts after 15% loss in converter = 32.5 watts output = efficiency of 32.5% or energy loss of 67.5%).

V. CONCLUSION

This project will help one develop engineering skills while learning about a clean way of generating electricity. This project is affordable as the total cost is around 1000 /-Rs only. By revolving the flywheel at normal speed the instantaneous power generated is around 80 watts. At high speeds it may go upto 110-120 watts. This setup can be installed on a bicycle. Therefore the user did not need to do extra efforts to charge this battery. As in rural areas and remote areas people mostly use a bicycle to go from one place to the other, so they can charge these batteries during their journies to their fields. This will reduce the efforts. We can light a LED of around 15 watts and a small DC fan around 2 hours with a fully charged battery of 12 volts. Project is easy to understand and develope as it is made basically for rural area purposes.

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An Ultra Thin Body Nanoscale Dual Material Double Gate SOI MOSFET

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Ghaziabad-201206, India
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Abstract—**In this paper, we compare the performance of symmetrical dual material double gate (SDMDG) SOI MOSFETs and asymmetrical dual material double gate (ADMDG) SOI MOSFETs. We investigate the influence of gate engineering on the analog performances of both the device structure for system-on-chip applications using a 2D device simulator (Silvaco TCAD). The gate engineering technique used here is the dual metal gate technology. The SDMDG structure shows better immunity to DIBL, near ideal Sub-threshold Slope (SS), high I_{on}/I_{off} ratio and improved analog performance like trans conductance generation factor, TGF (g_m/I_d), output conductance (g_d).**

Keywords— **SDMDG, ADMDG, DIBL, trans conductance generation factor.**

I. Introduction

As the bulk MOSFET is scaled down, the control of short channel effects becomes increasingly difficult leading to increased sub-threshold leakage current.[1] This is because the source/drain influence over the channel potential becomes significant relative to the gate control. Advanced transistor structures such as the UTB and the DG-MOSFET eliminate sub-surface leakage paths and extend the scalability of Si CMOS technology.[2] In the DMDG SOI MOSFETs structure, the surface potential is characterized by a step function, due to this potential profile the drain voltage is screened, reducing the drain induced barrier lowering (DIBL). The step potential profile is achieved by the use of different gate materials.[3] The use of DMG also increases the carrier transport efficiency and in turn increases the I_{on} of the device.[4] In the DMDG MOSFETs structure, P^+ poly is close to the source end, named M1, and N^+ poly is close to the drain end, named M2. In conventional single metal gate device, the electric field near the source is lowest and reaches the peak value at the drain end. Due to this reason, the hot electron injection between the gate and drain makes the device unreliable, and reduces its lifetime. Thus, the primary intention is to keep the peak electric field under the gate, and not near the drain end, without degrading the Ion. Hence, DMDG architecture is implemented for which the carriers will be accelerated more rapidly and the hot electron injection problem is also avoided. This architecture will thus improve the average carrier velocity which in turn enhances the I_{on}. The improvement in I_{on} and DIBL suppression is achieved for lower work-function metal near the drain side (M1 > M2). [5-9]

In this paper, the parameters considered for the comparison between SDMDG and ADMDG SOI MOSFETs are drain induced barrier lowering (DIBL), the Sub-threshold Slope (SS), the I_{on}/I_{off} ratio, the threshold voltage (V_{th}), the trans conductance (g_m), the trans conductance generation factor (g_m/I_d) and the intrinsic gain (A_v). For ultralow-power, high gain analog/RF circuits, the gate oxide thickness, ($t_f = t_b = t_{ox}$) and the silicon body thickness, t_{si} are optimized with the help of ATLAS 2-D numerical device simulator and a comparison is performed between these devices.

The model used in the simulation are the inversion-layer Lombardi constant voltage and temperature (CVT) mobility model, that takes into account the effect of transverse fields, along with doping and temperature dependent parts of the mobility and the Shockley–Read–Hall (SRH) model simulates the leakage currents that exist due to thermal generation. The Gummel's method (or the decoupled method) which performs a Gummel iteration for Newton solution.

II. DEVICE STRUCTURE

Depending upon the way the gate material used, DMDG MOSFETs may be categorized as following:

A. *Asymmetrical DMDG (ADMDG)*

An asymmetric DMDG-MOSFET consist of front gate having P^+ poly and N^+ poly Si material contacting laterally whereas the back gate have N^+ poly Si material only. The device structure is shown below as:

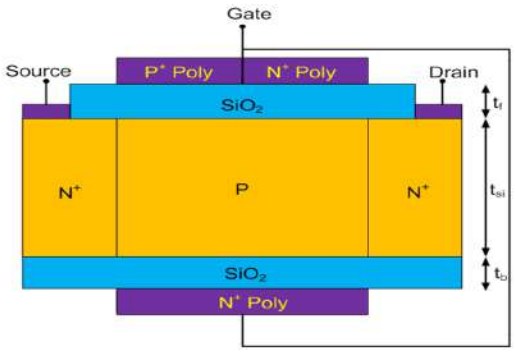


Fig.1. Structure of ADMDG SOI MOSFET.

B. *Symmetrical DMDG (SDMDG)*

A symmetric DMDG-MOSFET consist of front gate and back gate having P^+ poly Si and N^+ poly Si material contacting laterally.

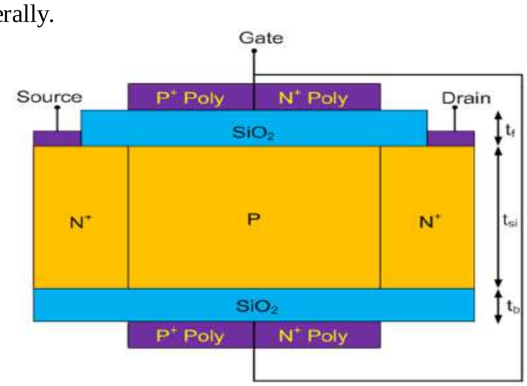


Fig.2. Structure of SDMDG SOI MOSFET.

TABLE I
TYPICAL PARAMETER VALUES

S. No.	DMDG SOI MOSFETs	
	Parameters	***ADMDG / SDMDG***
1.	Channel Length, L	20nm
2.	Front gate oxide, t_f	2nm
3.	Back gate oxide, t_b	2nm
4.	Film thickness, t_{si}	4nm
5.	Body doping, N_A	$1x10^{21}$ m^{-3}
6.	Source / drain doping, N_D	$5x10^{25}$ m^{-3}
7.	Length of source/drain regions	10nm
8.	Distance between S/D contact and gate	5nm
9.	Work function P^+ poly	5.25eV
10.	Work function N^+ poly	4.17eV

III. SURFACE POTENTIAL AND ELECTRIC FIELD

The unique feature of ADMDG and SDMDG SOI MOSFET device is the step function in the surface potential along the channel. Due to this the area under the P^+ poly in the gate of the DMDG structures is essentially screened from the drain potential variations. Hence, DIBL is reduced.

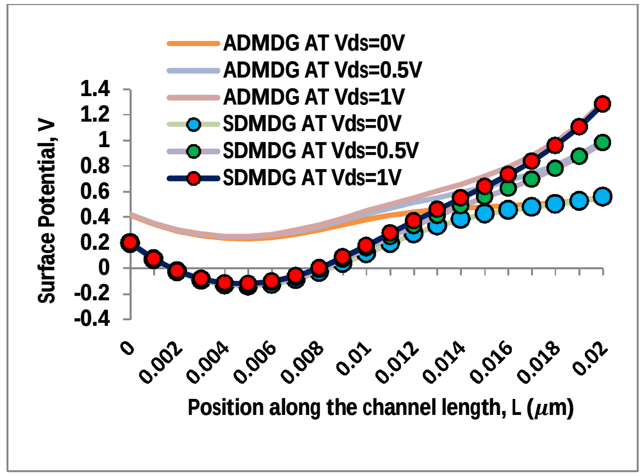


Fig.3. Surface-potential profiles of ADMDG and SDMDG SOI MOSFETs for a channel length L = 20nm, V_{gs} = 0V, V_{ds} = 0V, 0.5V and 1V.

Fig.3 shows the variation of surface potential along channel length. It can be seen from fig.3 that as the drain voltage increases (V_{ds}= 0V, 0.5V and 1V) the surface potential increases at the drain end and the source side is screened by the N^+ poly gate. Further it can be observed from fig.3 that the gate control over the surface potential is more in case of SDMDG compared to ADMDG. Hence, the SCEs are reduced in case of SDMDG.

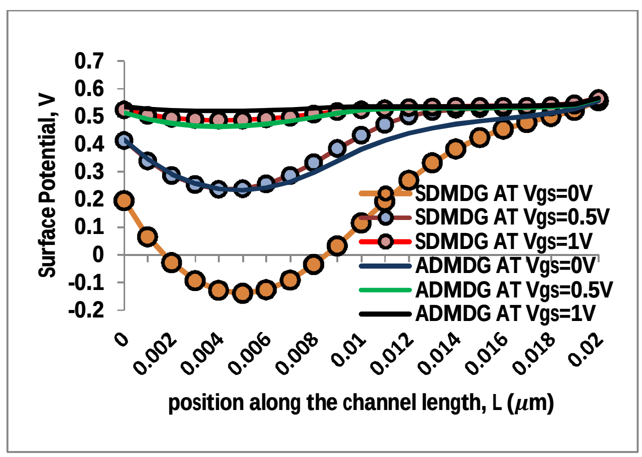


Fig.4. Surface-potential profiles of ADMDG and SDMDG SOI MOSFETs for a channel length L = 20nm, V_{ds} = 0V, V_{gs} = 0V, 0.5V and 1V.

Fig.4. Shows the variation in the Surface potential along with the channel length for different value of gate voltage (*Vgs = 0V, 0.5V and 1V*) and drain voltage (*Vds =0V*) for both the structures, we can observe that as the gate voltage is increases the surface potential curve shifted upwards because of the vertical electric field increases. The surface potential curve is more deeper which shows that the SDMDG structure has more control over the channel in comparison to ADMDG structure.

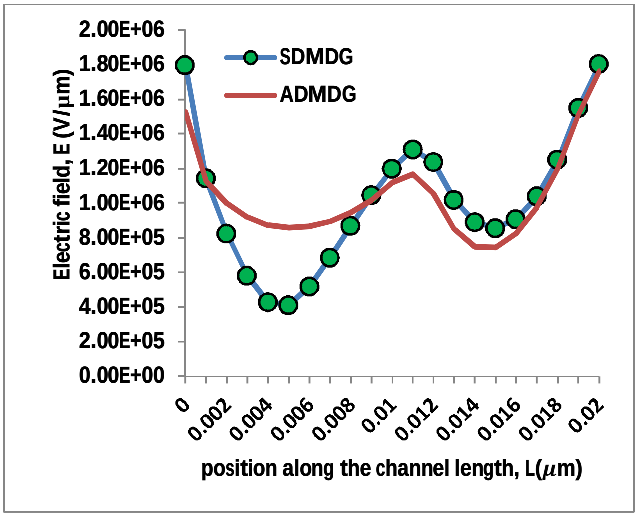


Fig.5. Electric-field variation along the channel length of the ADMDG and SDMDG SOI MOSFETs for Vds = 1V and Vgs = 1V. Channel length, L = 20nm, *L1 = L2*.

Fig.5. Shows the variation in the Electric field along with the channel length for gate voltage (*Vgs = 1V*) and drain voltage (*Vds=1V*) for both the structures, we can observe that in case of SDMDG SOI MOSFET the electric field at the source and in the middle of the channel where the two gate material (P^+ poly and N^+ poly) contacted laterally, is higher than the ADMDG SOI MOSFET. Therefore, the average electric field along the channel is high for SDMDG SOI MOSFET. This results in better carrier transport efficiency along the channel.

IV. I-V CHARACTERSTICS

A. I_D-V_{GS} CHARACTERSTICS

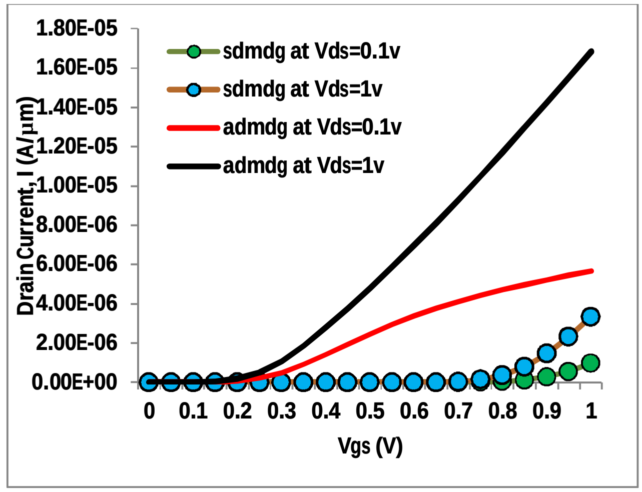


Fig.6. Drain current versus Gate voltage for SDMDG and ADMDG SOI MOSFET with *Vds* = 0.1 V and 1 V. Vgs = 0.1 V and 1 V. Channel length *L* = 20 nm, *L*1 = *L*2.

B. I_D -V_{DS} CHARACTERSTICS

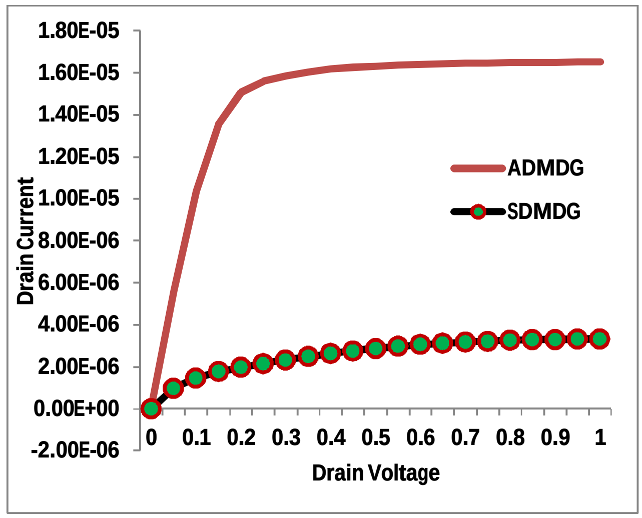
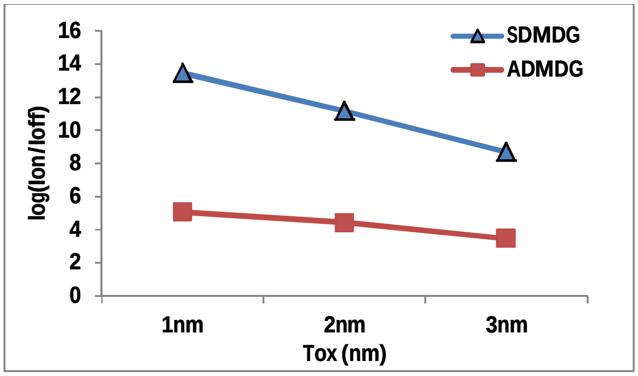


Fig.7. Drain current versus Drain voltage for SDMDG and ADMDG SOI MOSFET with *Vds* = 0V to 1 V and Vgs = 1 V. Channel length *L* = 20 nm, *L*1 = *L*2.

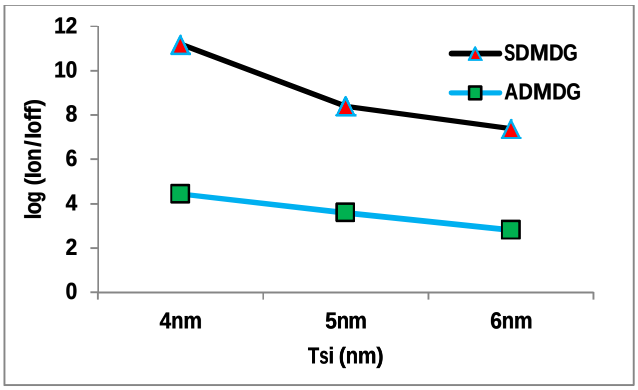
In fig.6 and fig.7, the comparison of current–voltage characteristics is shown for both the structures. We find that the drivability of SDMDG SOI MOSFET is not as good as that of ADMDG SOI MOSFET.

V. SIMULATION RESULTs

A. Ion/Ioff RATIO



(a)

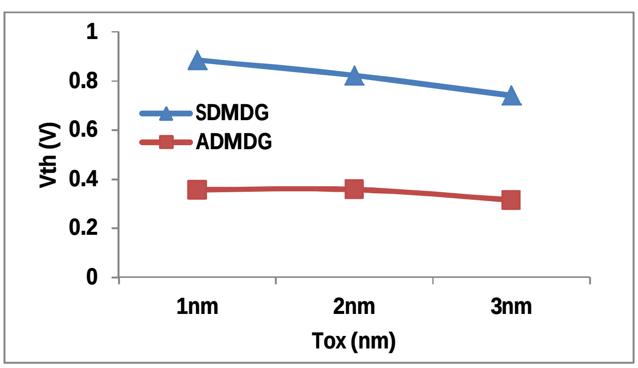


(b)

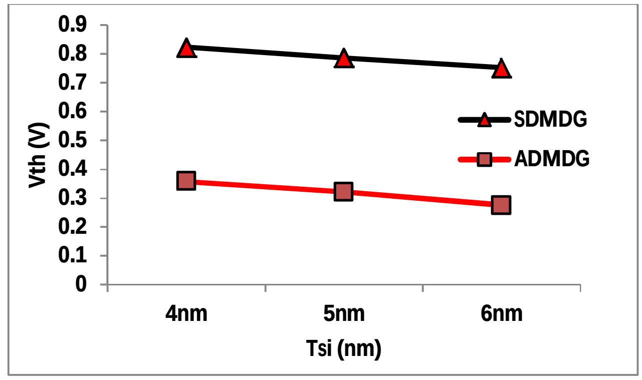
Fig.8. (a) log (Ion/Ioff) versus Gate oxide thickness. (b) log (Ion/Ioff) versus Silicon body thickness. (Vgs = 0V to 1V & Vds = 0.1V and 1V). Channel length L = 20 nm, $L1$ = $L2$.

Fig.8. shows that the I_{on}/I_{off} ratio of SDMDG is far better than the ADMDG SOI MOSFET. As the body thickness decreases, both I_{on} and I_{off} decreases but the I_{off} current decreases to a great extent. That results in an increase in the I_{on}/I_{off} ratio.

B. THRESHOLD VOLTAGE (V_{th})



(a)



(b)

Fig.9. (a) Threshold voltage versus Gate oxide thickness. (b) Threshold voltage versus Silicon body thickness. (Vgs = 0V to 1V & Vds = 0.1V and 1V). Channel length L = 20 nm, $L1$ = $L2$.

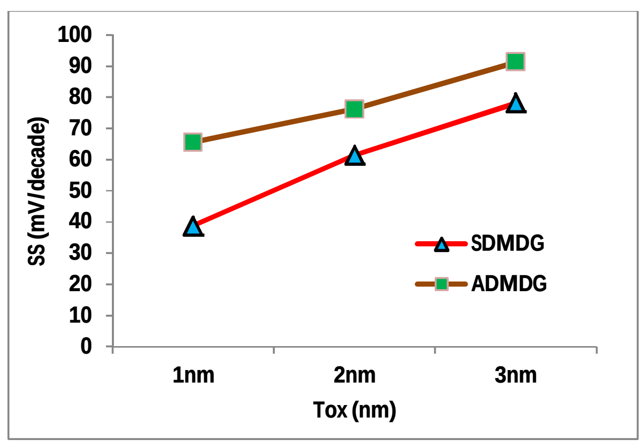
Fig.9. shows that as we increase the body thickness *(Tsi)* the threshold voltage *(Vth)* of both the device increases but *Vth* is higher in case of SDMDG SOI MOSFET. That results in a decrease in leakage current.

C. SUBTHRESHOLD SLOPE (SS)

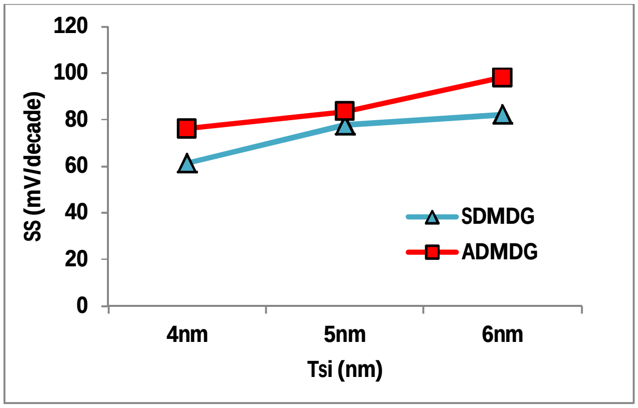
The Sub threshold Slope (SS) is the major parameter for calculating the off state current. Furthermore, SS is calculated as:

$$SS = \frac{1}{\frac{\partial(\log(I_d))}{\partial V_{gs}}} \quad \textbf{(1)}$$

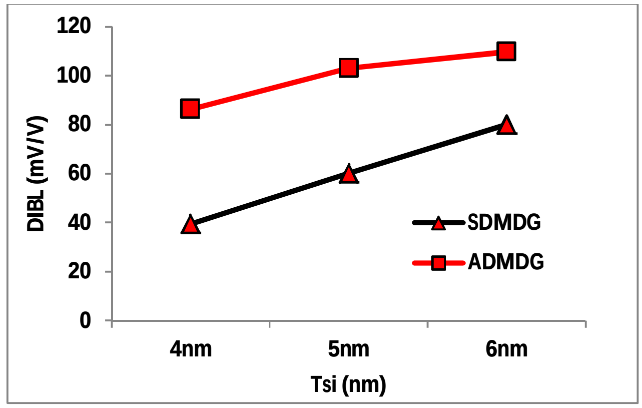
The SS value is extracted by calculating the inverse of maximum slope of Vgs versus log(I_d) curve.



(a)



(b)



(b)

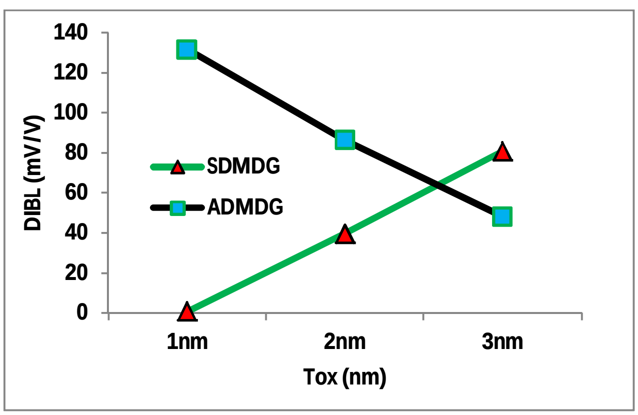
Fig.10. (a) Subthreshold slope versus Gate oxide thickness. (b) Subthreshold slope versus Silicon body thickness. (Vgs = 0V to 1V & Vds = 0.1V and 1V). Channel length L = 20 nm, $L1$ = $L2$.

Fig.10. shows that for Tsi=4nm and Tox=2nm we got near ideal value of subthreshold slope in case of SDMDG SOI MOSFET. As Tsi decreases, SS will also decreases. We got better SS for SDMDG SOI MOSFET.

D. DRAIN INDUCED BARRIER LOWERING (DIBL)

The value of DIBL is calculated as per the relation:

$$DIBL = \frac{V_{th2}-V_{th1}}{V_{ds2}-V_{ds1}} \quad (2)$$



(a)

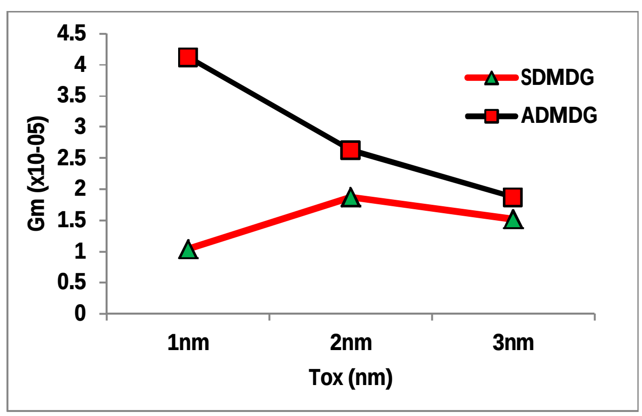
Fig.11. (a) DIBL versus Gate oxide thickness. (b) DIBL versus Silicon body thickness. (Vgs = 0V to 1V & Vds = 0.1V and 1V). Channel length L = 20 nm, $L1$ = $L2$.

Fig.11. shows that the DIBL effect is low in case of SDMDG SOI MOSFET. This is because of the symmetry in the gate electrode material used. The n+ poly will screened the source. Hence there is very less effect of drain voltage variation on surface potential near source.

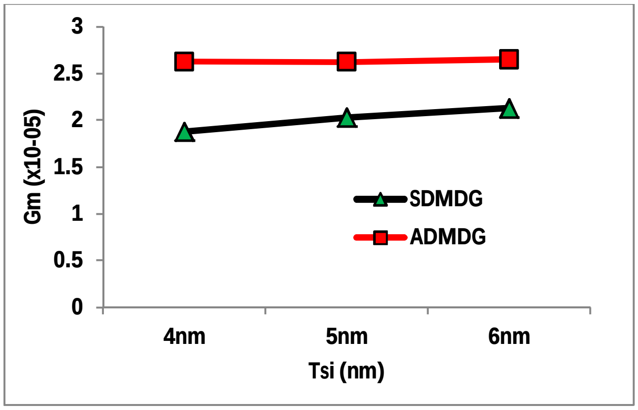
E. TRANSCONDUCTANCE (g_m)

As we know:

$$g_m = \frac{\partial(I_d)}{\partial(V_{gs})} \quad (3)$$



(a)



(b)

Fig.12. (a) Trans-conductance versus Gate oxide thickness. (b) Trans conductance versus Silicon body thickness. (Vgs = 0V to 1V & Vds = 0.1V and 1V). Channel length *L* = 20 nm, *L*1 = *L*2.

Fig.12. shows that as Gm is lower in case of SDMDG SOI MOSFET. Because of the high threshold voltage the drive current doesn't attain its saturation value for Gate voltage, Vgs=0V to 1V.

TABLE II
OPTIMIZED SIMULATION RESULT
For a Channel length, L=20nm and T_{ox}=2nm & T_{si}=4nm

S.No.	DMDG SOI MOSFETs		
	Parameters	***ADMDG***	***SDMDG***
1.	V_{t1} (at V_{ds}=0.1V)	0.280006	0.858033
2.	V_{t2} (at V_{ds}=1.0V)	0.357699	0.822379
3.	Subthreshold Slope (mV/dec)	76.2044	61.473
4.	g_m (S)	2.62×10^{-05}	1.88×10^{-05}
5.	I_{on}/I_{off}	2.72×10^{4}	1.51×10^{11}
6.	I_{on} (A/um)	1.69×10^{-05}	3.34×10^{-06}
7.	I_{off} (A/um)	6.19×10^{-10}	2.21×10^{-17}
8.	DIBL (mV/V)	86.3256	39.6156

III ANALOG PERFORMANCES

Transconductance *(Gm)* and output conductance *(Gd)* are the parameters mainly analyses the Analog performance of any Device. Other two derived parameters intrinsic gain *(Gm/Gd)* and trans conductance generation factor *(Gm/Id)* also helps the analysis of Analog response of the Device of the device.

A. TRANSCONDUCTANCE (g_m)

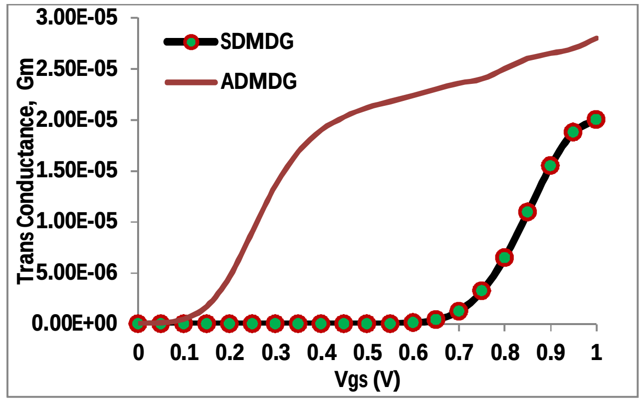


Fig.13. Transconductance versus Gate voltage. (Vgs = 0V to 1V & Vds = 1V). Channel length *L* = 20 nm, *L*1 = *L*2.

Fig.13. demonstrates the variation in the transconductance *(Gm)* with respect to applied gate voltage *(Vgs)* for both the structures. It can be observed that due to higher threshold voltage trans conductance *(Gm)* has been reduced for the SDMDG structure than ADMDG SOI MOSFETs. The lower trans-conductance is an advantage instead of a drawback, because it stands for smaller sub-threshold swing or faster current turning off.

B. OUTPUT CONDUCTANCE (Gd)

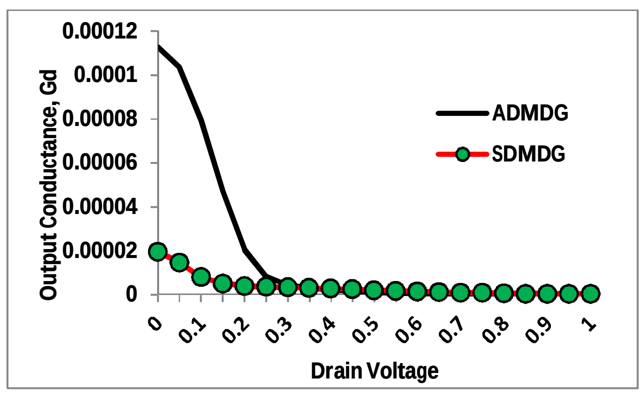


Fig.14. Output Conductance versus Drain voltage. (Vds = 0V to 1V & Vgs = 1V). Channel length *L* = 20 nm, *L*1 = *L*2.

Fig.14. demonstrates the variation in the output conductance *(Gd)* with respect to applied drain voltage *(Vds)* for both the structures. It can be observed that the value of output conductance *(Gd)* decreased in case of SDMDG structure over ADMDG SOI MOSFETs.

C. INTRINSIC GAIN, (Gm/Gd)

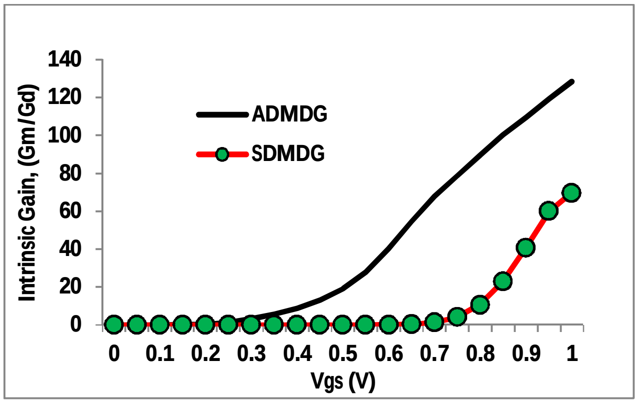


Fig.15. Intrinsic Gain versus applied gate voltage (at Vds=1V). Channel length L = 20 nm, $L1$ = $L2$.

Fig.15. demonstrates the variation in the intrinsic gain *(Gm/Gd)* with respect to applied gate voltage *(Vgs)* for both the structures. Because of a decrease in the Trans conductance and a decrease in the drain conductance, the voltage gain of the SDMDG structure is lower when compared with that of the ADMDG structure.

D. TRANSCONDUCTANCE GENERATION FACTOR, TGF (g_m/I_d)

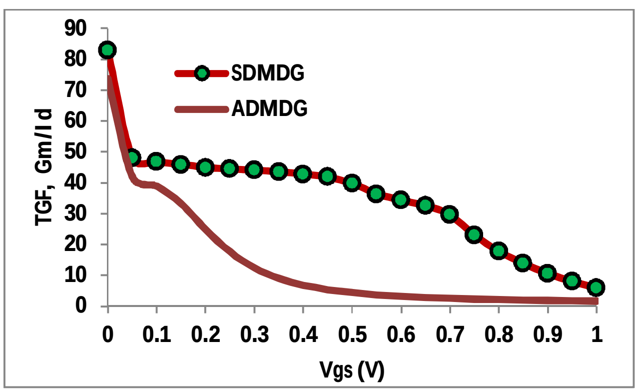


Fig.16. Trans-conductance generation factor versus Gate voltage. (Vgs = 0V to 1V & Vds = 1V). Channel length L = 20 nm, $L1$ = $L2$.

Fig.16. shows that the trans-conductance generation factor (TGF) or G_m/I_d ratio is viewed as the available gain per unit value of power dissipation. We got better G_m/I_d ratio for SDMDG SOI MOSFET.

CONCLUSIONS

The SDMDG SOI MOSFET shows better suppression of SCE's than ADMDG SOI MOSFET. We got improved I_{on}/I_{off} ratio, DIBL, reduced leakage current, I_{off} and near ideal sub-threshold slope. The drivability, I_d and trans conductance, G_m of the SDMDG device are not as good as that of the ADMDG device. But the Transconductance Generation Factor, TGF is high in case of SDMDG device.

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Study and Analysis of Environmental Issues for Scaled Version of Si-Ge Heterojunction Bipolar Transistor

Publisher: IEEE

Alok Kumar Pandey ; Arun Kumar ; Sheetal Singh **All Authors**

Abstract: Nowadays Si-Ge HBTs are playing an important role in the field of RF and microwave applications. Also Scaling of a device is an advance fashion in the innovation. In this... **View more**

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Abstract:
Nowadays Si-Ge HBTs are playing an important role in the field of RF and microwave applications. Also Scaling of a device is an advance fashion in the innovation. In this paper, we have scaled the Si-Ge HBT using scaling techniques and studied the behavior of the RF performance parameters of the DUT before scaling and after scaling with Ge content in base region.

Published in: 2018 3rd International Innovative Applications of Computational Intelligence on Power, Energy and Controls with their Impact on Humanity (CIPECH)

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Contents

I. Introduction

VLSI plays an important role in RF electronics and RF & Microwave communication. The choice of material and semiconductor device is key factor in the field of VLSI. Which material and semiconductor device we have use is totally depends on the Figure of Merit (FOM). A detailed comprehensive study has been done for the selection of semiconductor device. In the study we have found that HBTs have intrinsic high-power density, linearity and efficiency compared to field effect devices in the RF and Microwave communication [2]–[4].

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A Qualitative Analysis of Secured Handover Management Schemes for Mobile IPv6 Enabled Networks

Publisher: IEEE Cite This PDF

Arun Kumar Tripathi ; Surendra Kumar Tripathi **All Authors**

Abstract: Development in wireless technologies permits IPv6 enabled handheld mobile devices to access the Internet ubiquitously. An IP-address is required to identify the mobile ho... **View more**

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Abstract:
Development in wireless technologies permits IPv6 enabled handheld mobile devices to access the Internet ubiquitously. An IP-address is required to identify the mobile host on the Internet. Mobile IPv6 (MIPv6) scheme enables a mobile host to migrate from one subnet to another without changing its exiting IP-address. For IPv6 based mobility, Internet Engineering Task Force (IETF) proposed standard Mobile IPv6 as first mobility management scheme. It provides a powerful and flexible way to handle handover management. Standard MIPv6 is a host-based global mobility management scheme and endure from basic issues such as signaling overhead, handover latency and packet loss. Subsequently, IETF has standardized localized network-based Mobility Management schemes to overcome problems associated with global host-based

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mobility management schemes named as Proxy Mobile IPv6 (PMIPv6). It reduces handover latency and packet loss compared to host-based mobility management schemes considerably, yet, suffers from security issues. Later on, researchers proposed secured-PMIPv6 protocols for authentication of mobile as well as network devices within LMD. The paper reviews various handover management schemes for secure handover management. The performance of various schemes qualitatively investigated on vital parameters such as authentication cost, signaling cost, packetloss etc.

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Contents

I. Introduction

Advancement in the field of mobile and wireless technology has affected our lives significantly and compelled us to shift from a fixed wired network to the wireless and mobile network. In the last decade, wireless technologies have increased 1000 fold in data rate approximately. Nowadays, wireless multifunctional terminals such as smart phones, laptops, personal digital assistants, navigation systems etc. have become part of our daily lives. These mobile terminals support a large number of multimedia applications such as social media applications, live video streaming, online games etc. To provide uninterrupted services to these devices, the volume is increasing exponentially day by day. Analysis by Computer Information System Company (CISCO), reveals that the mobile data traffic may grow up to 49 Exabytes per month by the year 2021, which is approximately seven times of the data traffic in 2016. In addition to this, the mobile data traffic may increase at a Compound Annual Growth Rate (CAGR) of 47% from year 2016 to year 2021 [1].

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Design of Multi-band Antenna

Ms. Swati, Department of Electronics & Communication Engineering (IGDTUW Delhi)/ Department of Electrical & Eletronics Engineering (KIET Group of Institutions Ghaziabad) India

Abstract:--

A new method for designing the multiband antenna is presented in this paper. In this method, two split ring slots with opposite gap facing is mounted on circular patch antenna. This configuration uses probe feeding technique along with RT duroid 5880 substrate. To create different short circuits along the slots the electric field is manipulated The resonance frequencies are chosen to increase the number of bands at which antenna can operate. Advance Design system 2011-10 is used for the simulation of this design. Results verify its multiband operation.

Keywords:--

Multiband, probe feed, patch antenna, resonant frequencies.

Space based solar power-a review

JyotiSrivastava *Swati Singhal* *D.Blandina Miracle* *Swati*

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Abstract

In the recent decades, there has been a huge energy demand due to the exponential increase of the human population and consequently, the depletion of non-renewable energy sources. This creates the need to explore alternate routes for renewable energy resources. The solar energy was the best alternative of the conventional energy system in last few decades, but because of intermittent energy and huge land area requirement it is the need of the hour to look for an alternate solar energy system. ***Space-based solar power (SBSP)*** *is a step towards this technology to overcome the limitation of intermittent supply as solar energy is always available in the space. SBSP is the concept of collecting* solar power *in* outer space *and distributing it to* Earth*. Potential advantages of collecting solar energy in space include a higher collection rate and a longer collection period due to the lack of a diffusing* atmosphere*, and the possibility of placing a solar collector in an orbiting location where there is no night.*

1. Introduction

Energy generation to meet the demand is a very big issue, and almost 10-15% of the total economic expenditures in the world are used for meeting this supply and demand [1]. The total resources which can be used for energy generation in the world can be broadly categorized into fossil fuels, renewable sources and nuclear resources. The fossil fuels and nuclear sources comes under the category of non-renewable sources further[2]out of these three sources of energy, fossil fuels are the conventional sources which are used to meet the major portion of the energy requirements in the world but they are depleting with time and also have adverse consequences such as global warming. Nuclear sources are also harmful for the living beings. This lead to shift towards renewable sources which is the best promising alternative of energy generation as compared with the above two categories of energy sources. The renewable energy source includes solar energy, wind energy, and hydel energy. Out of these solar energy was used and researched in last few decades, but because of its intermittent supply, it is not a very efficient energy generation system. So, the researchers thought to overcome this limitation by generating the energy directly in space where the availability of sunlight is always there using satellite and then transmit it to the earth. SBSP is an effort related to this initiative. Although the proposed system is in research state and not in use anywhere till now, but the researchers are targeting to achieve it till the end of 2025. In the present system which converts solar energy in to electrical energy, a considerable fraction of incoming solar energy (55–60%) is lost on its way through the Earth's atmosphere by the effects of reflection and absorption. But in Space-based solar power, the system convert sunlight to microwaves outside the atmosphere, avoiding these losses and the downtime due to the Earth's rotation, but at great cost due to the expense of launching material into orbit. SBSP is considered a form of sustainable or green energy, renewable energy, and is occasionally considered among climate engineering proposals. It is attractive to those seeking large-scale solutions to anthropogenic climate change or fossil fuel depletion (such as peak oil).

1.1 History

In 1941, science fiction writer Isaac Asimov published the science fiction short story "Reason", in which a space station transmits energy collected from the Sun to various planets using microwave beams. The SBSP concept, originally known as satellite solar-power system (SSPS), was first described in November 1968[6]. In 1973 Peter Glaser was granted U.S. patent number 3,781,647 for his method of transmitting power over long distances (e.g. from an SPS to Earth's surface) using microwaves from a very large antenna (up to one square kilometer) on the satellite to a much larger one, now known as a rectenna, on the ground[7]. Glaser then was a vice president at Arthur D. Little, Inc. NASA signed a contract with ADL to lead four other companies in a broader study in 1974. They found that, while the concept had several major problems – chiefly the expense of putting the required materials in orbit and the lack of experience on projects of this scale in space – it showed enough promise to merit further investigation and research[8]. Between 1978 and 1986, the Congress authorized the Department of Energy (DoE) and NASA to jointly investigate the concept. They organized the Satellite Power System Concept Development and Evaluation Program[9][10]. The project was not continued with the change in administrations after the 1980 US Federal elections. In 1997 NASA conducted its "Fresh Look" study to examine the modern state of SBSP feasibility. In assessing "What has changed" since the DOE study, NASA asserted that the "US National Space Policy now calls for NASA to make significant investments in technology (not a particular vehicle) to drive the costs of ETO [Earth to Orbit] transportation down dramatically. This is, of course, an absolute requirement of space solar power"[30]. On Nov 2, 2012, China proposed space collaboration with India that mentioned SBSP is a Space-based Solar Power initiative so that both India and China can work for long term association with proper funding along with other willing space faring nations to bring space solar power to earth[32].

2. Space Solar Power Exploratory Research and Technology program

In 1999, NASA's Space Solar Power Exploratory Research and Technology program (SERT) was initiated for the following purposes:

- Perform design studies of selected flight demonstration concepts.
- Evaluate studies of the general feasibility, design, and requirements.
- Create conceptual designs of subsystems that make use of advanced SSP technologies to benefit future space or terrestrial applications.
- Formulate a preliminary plan of action for the U.S. (working with international partners) to undertake an aggressive technology initiative.
- Construct technology development and demonstration roadmaps for critical Space Solar Power (SSP) elements.

SERT went about developing a solar power satellite (SPS) concept for a future Gigawatt space power system, to provide electrical power by converting the Sun's energy and beaming it to Earth's surface, and provided a conceptual development path that would utilize current technologies. SERT proposed an inflatable photovoltaic gossamer structure with concentrator lenses or solar heat engines to convert sunlight into electricity. The program looked both at systems in sun-synchronous orbit and geosynchronous orbit. Some of SERT's conclusions:

- The increasing global energy demand is likely to continue for many decades resulting in new power plants of all sizes being built.
- The environmental impact of those plants and their impact on world energy supplies and geopolitical relationships can be problematic.
- Renewable energy is a compelling approach, both philosophically and in engineering terms.
- Many renewable energy sources are limited in their ability to affordably provide the base load power required for global industrial development and prosperity, because of inherent land and water requirements.
- Based on their Concept Definition Study, space solar power concepts may be ready to reenter the discussion.
- Solar power satellites should no longer be envisioned as requiring unimaginably large initial investments in fixed infrastructure before the emplacement of productive power plants can begin.
- Space solar power systems appear to possess many significant environmental advantages when compared to alternative approaches.
- The economic viability of space solar power systems depends on many factors and the successful development of various new technologies (not least of which is the availability of much lower cost access to space than has been available); however, the same can be said of many other advanced power technologies options.

- Space solar power may well emerge as a serious candidate among the options for meeting the energy demands of the 21st century. Space Solar Power Satellite Technology Development at the Glenn Research Center—An Overview. James E. Dudenhoefer and Patrick J. George, NASA Glenn Research Center, Cleveland, Ohio.
- Launch costs in the range of $100–$200 per kilogram of payload to low Earth orbit are needed if SPS are to be economically viable[11].

3. Japan Aerospace Exploration Agency

The May 2014 IEEE Spectrum magazine carried a lengthy article "It's Always Sunny in Space" by Dr. Susumu Sasaki[33]. The article stated, "It's been the subject of many previous studies and the stuff of sci-fi for decades, but space-based solar power could at last become a reality—and within 25 years, according to a proposal from researchers at the Tokyo-based Japan Aerospace Exploration Agency (JAXA)."

JAXA announced on 12 March 2015 that they wirelessly beamed 1.8 kilowatts 50 meters to a small receiver by converting electricity to microwaves and then back to electricity. This is the standard plan for this type of power.[34][35] On 12 March 2015 Mitsubishi Heavy Industries demonstrated transmission of 10 kilowatts (kW) of power to a receiver unit located at a distance of 500 meters (m) away[36].

4. Design

Space-based solar power essentially consists of three elements[2]:

(1) Collecting solar energy in space with reflectors or inflatable mirrors onto solar cells

(2) Wireless power transmission to Earth via microwave or laser

(3) Receiving power on Earth via a rectenna, a microwave antenna

The space-based portion of collecting solar energy will not need to support itself against gravity (other than relatively weak tidal stresses). It needs no protection from terrestrial wind or weather, but will have to cope with space hazards such as micrometeors and solar flares. Two basic methods of conversion have been studied: photovoltaic (PV) and solar dynamic (SD). Most analyses of SBSP have focused on photovoltaic conversion using solar cells that directly convert sunlight into electricity. Solar dynamic technology uses mirrors to concentrate light on a boiler which is not suitable to use in the space. The orbital location also matters a lot for placing a satellite in the space. According to the researchers, the SBSP satellite should be place in the geostationary orbit. The main advantage of locating a space power station in geostationary orbit is that the antenna geometry stays constant, and so keeping the antennas lined up is simpler. Another advantage is that nearly continuous power transmission is immediately available as soon as the first space power station is placed in orbit; other space-based power stations have much longer start-up times before they are producing nearly continuous power.

Wireless power transmission was proposed early on as a means to transfer energy from collection to the Earth's surface, using either microwave or laser radiation at a variety of frequencies.The wireless power transmission via Microwave is based on the conclusion of demonstration done by William C. Brown demonstrated in 1964, during Walter Cronkite's CBS News program, a microwave-powered model helicopter that received all the power it needed for flight from a microwave beam. Between 1969 and 1975, Bill Brown was technical director of a JPLRaytheon program that beamed 30 kW of power over a distance of 1 mile (1.6 km) at 84% efficiency[43].

Microwave power transmission of tens of kilowatts has been well proven by existing tests at Goldstone in California (1975)[43][44][45] and Grand Bassin on Reunion Island (1997)[46].

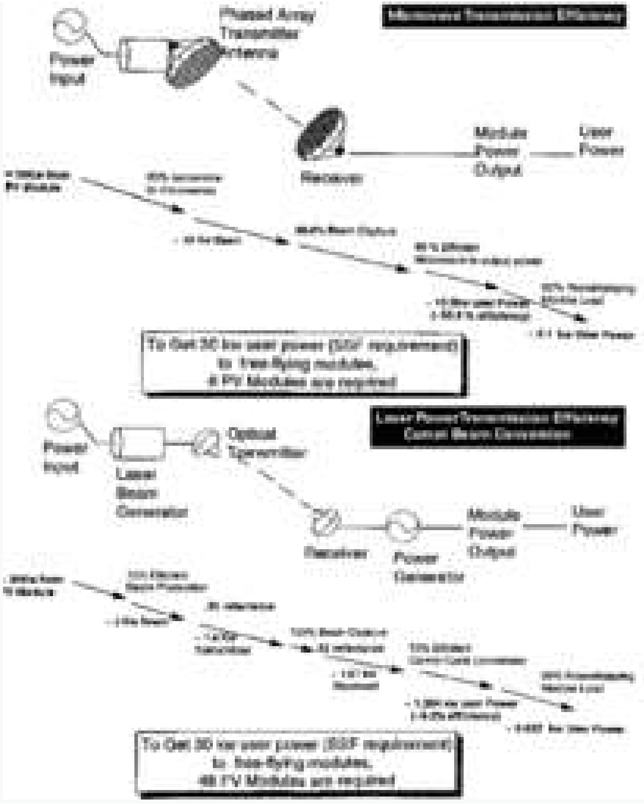

Figure 1.

Comparison of laser and microwave power transmission. NASA diagram

More recently, microwave power transmission has been demonstrated, in conjunction with solar energy capture, between a mountain top in Maui and the island of Hawaii (92 miles away), by a team under John C. Mankins[47][48]. Technological challenges in terms of array layout, single radiation element design, and overall efficiency, as well as the associated theoretical limits are presently a subject of research, as it is demonstrated by the Special Session on "Analysis of Electromagnetic Wireless Systems for Solar Power Transmission" to be held in the 2010 IEEE Symposium on Antennas and Propagation[49]. In 2013, a useful overview was published, covering technologies and issues associated with microwave power transmission from space to ground. It includes an introduction to SPS, current research and future prospects[50]. Moreover, a review of current methodologies and technologies for the design of antenna arrays for microwave power transmission appeared in the Proceedings of the IEEE [51]

Laser power beaming can also be used for the transmission of electricity generated from the space to the earth. It was envisioned by some at NASA as a stepping stone to further industrialization of space. In the 1980s, researchers at NASA worked on the potential use of lasers for space-to-space power beaming, focusing primarily on the development of a solar-powered laser. In 1989 it was suggested that power could also be usefully beamed by laser from Earth to space. In 1991 the SELENE project (Space Laser Energy) had begun, which included the study of laser power beaming for supplying power to a lunar base. The SELENE program was a two-year research effort, but the cost of taking the concept to operational status was too high, and the official project ended in 1993 before reaching a space-based demonstration[52].

In 1988 the use of an Earth-based laser to power an electric thruster for space propulsion was proposed by Grant Logan, with technical details worked out in 1989. He proposed using diamond solar cells operating at 600 degrees to convert ultraviolet laser light.

The designing receiver for receiveing the electricity generated in the space on the earth is one of the major hurdle in this project. Such receivers are called Rectennas on the earth. The Earth-based rectenna would likely consist of many short dipole antennas connected via diodes. Microwave broadcasts from the satellite would be received in the dipoles with about 85% efficiency[54]. With a conventional microwave antenna, the reception efficiency is better, but its cost and complexity are also considerably greater. Rectennas would likely be several kilometers across.

5. Launching costs

One problem for the SBSP concept is the cost of space launches and the amount of material that would need to be launched.

Much of the material launched need not be delivered to its eventual orbit immediately, which raises the possibility that high efficiency (but slower) engines could move SPS material from LEO to GEO at an acceptable cost. Examples include ion thrusters or nuclear propulsion. Power beaming from geostationary orbit by microwaves carries the difficulty that the required 'optical aperture' sizes are very large. For example, the 1978 NASA SPS study required a 1-km diameter transmitting antenna, and a 10 km diameter receiving rectenna, for a microwave beam at 2.45 GHz. These sizes can be somewhat decreased by using shorter wavelengths, although they have increased atmospheric absorption and even potential beam blockage by rain or water droplets. Because of the thinned array curse, it is not possible to make a narrower beam by combining the beams of several smaller satellites. The large size of the transmitting and receiving antennas means that the minimum practical power level for an SPS will necessarily be high; small SPS systems will be possible, but uneconomic. To give an idea of the scale of the problem, assuming a solar panel mass of 20 kg per kilowatt (without considering the mass of the supporting structure, antenna, or any significant mass reduction of any focusing mirrors) a 4 GW power station would weigh about 80,000 metric tons[58], all of which would, in current circumstances, be launched from the Earth. Very lightweight designs could likely achieve 1 kg/kW[59], meaning 4,000 metric tons for the solar panels for the same 4 GW capacity station. This would be the equivalent of between 40 and 150 heavy-lift launch vehicle (HLLV) launches to send the material to low earth orbit, where it would likely be converted into subassembly solar arrays, which then could use high-efficiency ion-engine style rockets to (slowly) reach GEO (Geostationary orbit). With an estimated serial launch cost for shuttle-based HLLVs of $500 million to $800 million, and launch costs for alternative HLLVs at $78 million, total launch costs would range between $11 billion (low cost HLLV, low weight panels) and $320 billion ('expensive' HLLV, heavier panels. To these costs must be added the environmental impact of heavy space launch missions, if such costs are to be used in comparison to earth-based energy production. For comparison, the direct cost of a new coal[60]or nuclear power plant ranges from $3 billion to $6 billion per GW (not including the full cost to the environment from CO2 emissions or storage of spent nuclear fuel, respectively); another example is the Apollo missions to the Moon cost a grand total of $24 billion (1970s dollars), taking inflation into account, would cost $140 billion today, more expensive than the construction of the International Space Station.

6. Potential and Drawbacks

Potential

The SBSP concept is attractive because space has several major advantages over the Earth's surface for the collection of solar power:

- It is always solar noon in space and full sun.
- Collecting surfaces could receive much more intense sunlight, owing to the lack of obstructions such as atmospheric gasses, clouds, dust and other weather events. Consequently, the intensity in orbit is approximately 144% of the maximum attainable intensity on Earth's surface.
- A satellite could be illuminated over 99% of the time, and be in Earth's shadow a maximum of only 72 minutes per night at the spring and fall equinoxes at local midnight[37]. Orbiting

satellites can be exposed to a consistently high degree of solar radiation, generally for 24 hours per day, whereas earth surface solar panels currently collect power for an average of 29% of the day[38].

- Power could be relatively quickly redirected directly to areas that need it most. A collecting satellite could possibly direct power on demand to different surface locations based on geographical baseload or peak load power needs. Typical contracts would be for baseload, continuous power, since peaking power is ephemeral.
- Elimination of plant and wildlife interference.
- With very large scale implementations, especially at lower altitudes, it potentially can reduce incoming solar radiation reaching earth's surface. This would be desirable for counteracting the effects of global warming.

Drawbacks

The SBSP concept also has a number of problems:

- The large cost of launching a satellite into space
- The thinned-array curse preventing efficient transmission of power from space to the Earth's surface
- Inaccessibility: Maintenance of an earth-based solar panel is relatively simple, but construction and maintenance on a solar panel in space would typically be done telerobotically. In addition to cost, astronauts working in GEO (geosynchronous Earth orbit) are exposed to unacceptably high radiation dangers and risk and cost about one thousand times more than the same task done telerobotically.
- The space environment is hostile; panels suffer about 8 times the degradation they would on Earth (except at orbits that are protected by the magnetosphere)[39].
- Space debris is a major hazard to large objects in space, and all large structures such as SBSP systems have been mentioned as potential sources of orbital debris[40].
- The broadcast frequency of the microwave downlink (if used) would require isolating the SBSP systems away from other satellites. GEO space is already well used and it is considered unlikely the ITU would allow an SPS to be launched[41].
- The large size and corresponding cost of the receiving station on the ground.
- Energy losses during several phases of conversion from photons to electrons to photons back to electrons[42].

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A Study on Green Energy Powered Cognitive Radio Network for Communication Network Architecture of Smart Grid

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Abstract–High information rate applications in smart grid can incredibly increase energy consumption, which has incited to an emerging trend of addressing the *energy efficiency* aspect of communication technology. Green energy powered cognitive radio (Green-CR) network is important technology to meet the high information rate prerequisites as well as to improve spectrum and energy efficiency. However, designing Green-CR networks for smart grid is challenging as it requires not only the optimization of dynamic spectrum access but also the optimal utilization of green energy sources. In this paper, spectrum aware and energy efficient Green-CR network model is introduced to overcome spatio-temporally varying spectrum characteristics and harsh environmental conditions for smart grid applications. Subsequent to presenting fundamental outline standards potential advantages and network architecture of Green-CR, a multi layered approach with small cells for efficient design methodology is proposed to provide energy efficient CR network at the smart grid utility.

Keywords–green cognitive radio network, smart grid, energy harvesting, green communication.

I. Introduction

Wireless communication plays an imperative part in realizing all essential features of smart grid such as, efficiency, reliability, resilience, sustainability and security [1], as it can offer smart grid a much greater degree of freedoms for information accumulation, dissemination, and processing than wired communication infrastructure. With the unique features of dynamic spectrum access technique, CR networks have the potential to make best utilization of scarce spectrum and support increasing demand for wireless applications including smart grid.

CR networks are context-aware reconfigurable wireless networks consisting two frameworks: the primary user (PU) framework and the secondary user (SU) framework. PUs are licensed users i.e. the have selected benefit to get to the licensed bandwidth, while the SUs are the unlicensed users in cognitive radio, which can just get to the bandwidth that is not utilized by the PUs [2]. Proposed CR framework based communications infrastructure guarantees to use possibly all spectrum resources efficiently in the smart grid. The idea of applying CR technology to smart grid was first proposed by A. Ghassemi *et al.* [3] in which the authors proposed to utilize CR based IEEE 802.22 standard in wireless regional area networks (WRANs) for smart grid backhaul data streams.

Different from current CR systems powered by the reliable on-grid energy source, continuous advances in green energy motivated us to concentrate on green energy powered networks. On the off chance that the green energy source is ample and stable in the sense of accessibility, CR system can be powered to opportunistically exploit the underutilized spectrum by harnessing free energy without requiring energy supplement from external power grid or battery [4]. As the smart grid advances and develops, green power farms that harvest energy from green sources can substantially reduce carbon footprints. The need for adopting green communication has been realized worldwide. There is a focus on following holistic approach for power optimization. The next generation architectures focus on developing new technology, cell deployment strategies and resource allocation policies to improve the energy efficiency of a wireless communication network. Akshita et al [5] surveyed various techniques for power optimization of the next generation wireless networks. Further, [6] developed green communication model for next generation wireless networks, which considers both the access and backhaul network elements. So far, a green communication architecture for smart grid communication architecture has not been premeditated.

The aim of this paper is to offer a comprehensive review on the recent works on the applications of CR network technology in smart grid, based on which we want to show an evolutional path of smart grid development based on spectrum aware and energy efficient Green-CR networks.

The rest of this paper is outlined as takes after Section II expounds energy challenges in cognitive radio. Section III presents the Green-CR network technology in the smart grid communication infrastructure. In the same segment, energy efficient CR systems with small cells are additionally talked about. Step by step instructions to green energy utilization in the smart grid environment, is examined first, in which only the energy dynamics is considered. This will provide some insights for the information transmissions in the CR system. At that point, with the introduction of spectrum dynamics, the energy utilization is discussed in Green-CR networks. Section IV discusses system model for smart grid communication infrastructure, followed by the conclusion drawn in Section V.

II. Cognitive Radio Energy Challenges

A CR system must make real-time decisions on continuous choices about which spectrum hole to sense, when, and for what surviving. The detected range data must be adequately sufficient to achieve exact conclusions with respect to the radio environment. Besides, spectrum sensing must be quick so as to track the transient varieties of the radio environment. Such

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prerequisite of spectrum sensing does not put CR energy challenges stringent prerequisites on the equipment usage of CRs as far as the detecting data transfer capacity, the handling speed, and the RF hardware, additionally speak to the fundamental energy-hungry segment of a CR. In what tails, the energy consumption challenges in CR transceivers and CRNs are examined, which are outlined in Fig 1.

A. CR Hardware High Energy Consumption

There exist various factors that altogether adds to the energy utilization of spectrum sensing in CR system. In any case, the CR transceiver hardware is required to accomplish adequately high affectability for a wide range (e.g., various GHz) while precisely identifying assorted and frequency-dependent primary signals at various received power levels. These spots serve necessities on the affectability, linearity, and element scope of the hardware in the RF front-end, and all the more particularly, the receiving wires, power enhancers and the analogue-to-digital transformation units [5], [6].

Moreover, preparing powers necessities of the signal processing units that investigate the detected range are high all together for the subjective radio to settle on a choice with generally low defer. Note that the environment is dynamic and the obstruction is adjusted both by the bursty traffic of primary clients and channel fading. Such stringent execution and preparing prerequisites require the CR transceiver hardware be power-hungry, and consequently, not green.

For example, the energy consumption of the High Power Amplifier (HPA) of a radio handset is ordinarily 70% of the aggregate energy utilized amid transmission - in any case the communication standard [1]. On the off chance that the energy utilization of the HPA in CR terminal can be proficiently overseen, e.g., by means of Peak to Average Power Ratio (PAPR) sensor, it can fundamentally lessen the energy utilization of the CR. This requires the configuration of adaptive HPA that can be tuned on the fly to increase distinctive signs that have a place with various communication benchmarks [1].

B. Listen-Before-Talk Idle Sensing

Talk Idle Sensing Existing range detecting systems rely upon identifying the exercises of the primary transmitters. Primary transmitter recognition plans are divided into matched filter detection, energy detection, feature detection, and interference temperature estimation. Right now, there does not exist any feasible way that permits CR terminals to estimate the interference at primary network receivers [5], [6] since primary clients are uninvolved and do not offer data with the CRN terminals. Despite the fact that there exists spectrum detecting procedures that adventure the bidirectional behavior of some primary systems or the weak leakage power of primary recipient RF circuits to surmise the presence or the non-attendance of a neighboring primary collector [7], such plans do not give an approach to quantify the cumulative interference at the primary recipient.

The basic component of all above spectrum detecting strategies is that they just think of one form or another of the conventional Listen-before-talk (LBT) methodology to identify primary transmitters. LBT procedures normally has the CR consistently listening to the distinctive range groups keeping in mind the end goal to get to the accessibility of spectral opportunities. While the CR is not really accepting information amid the unmoving listening process, regardless it still utilizes power that is comparable to the power consumed amid data reception. Since idle listening used as a part of LBT plans is constantly run by the CR over the spectrum bands of interest, it altogether adds to the energy utilization of the CR. Broad estimations in [8] have demonstrated that 60% of the energy utilized in real-world wireless innovations that utilize LBT is utilized in idle listening, even with the use of power saving modes. So as to diminish the energy utilization of CRs, LBT should be visited again to permit the CR to recognize the spectral opportunities taking into account the liminal measure of non-gainful idle listening.

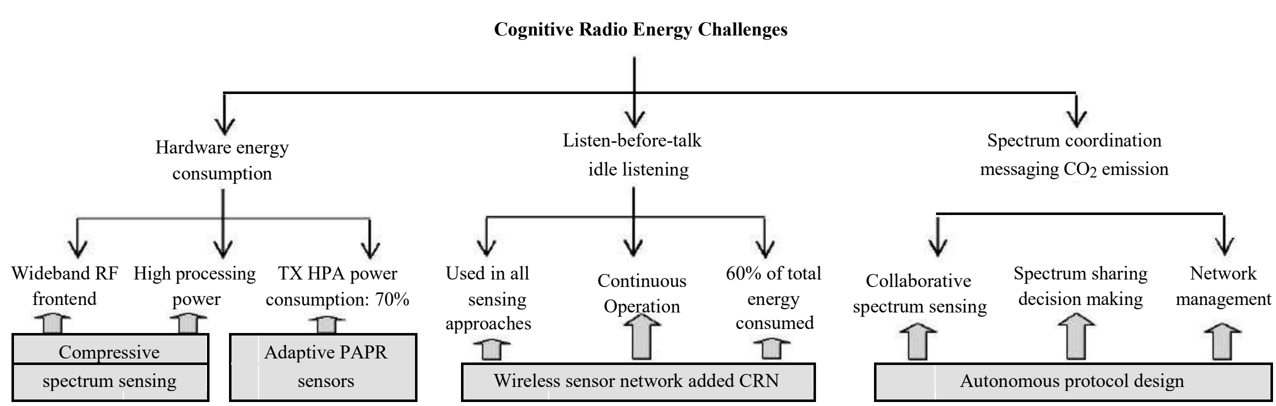

Fig.1 Energy challenges of CR sytem. The CR hardware and the LTB idle listening are the key energy consumption sources in CRNs. In the interim, the incessant range coordination message trade is the primary donor to the CO_2 outflow.

It merits saying that the limited detecting length of CR likewise restrains the precision of spectrum detection. Given a constrained detecting period, just a specific detecting precision can be ensured. As the sensing span expands, the dependability of the sensing data may increment. In any case, longer spectrum sensing windows are not as a matter of course helpful since the environment is dynamic and the energy on a given channel is regulated both by the bursty traffic, asynchronous initiation and end of packet transmissions, and channel fading.

C. Spectrum Coordination Messaging CO_2 Emission

In multi user CR systems, the coordination between numerous CR clients is a noteworthy challenge from networking perspective as well as from energy utilization viewpoint. In the event that legacy Medium Access Control (MAC) protocols intended for traditional networks were to be used as a part of CRNs, all CR clients that construe spectral opportunity will greedily endeavor to exploit the sensed opportunity. Review that legacy MACs frequently receive greedy procedures that attempt to best use a channel access (e.g., by using the most astounding transmission rate or picking the best channel). Such greedy methodologies disintegrate the good put of the CRN as the quantity of CR clients increment because of expanded blocking probability [4]. Moreover, such greedy MACs known to suffer from unfairness issues that may bring about some cognitive sender-receiver pairs sets to dominate different sets. A few centralized and distributed helpful MAC approaches have been as of late created for CR systems [9]-[11].

In any case, such plans depend on the explicit coordination between various transmissions which is a principle challenge in CRNs as it requires assembling and circulating spectrum information over the CRN and/or synchronizing the exercises of various flows. The use of a typical control channel for between stream coordination (and additionally for the coordination between a sender and its individual recipient) makes it the bottleneck of a CRN and the single point of failure for the whole framework [4].

Besides, the trading of spectrum coordination messages essentially adds to the CO2 outflow of CRNs. This is because of the gigantic number of messages exchanged so as to gather the spectrum information from various CR terminals and after that to disseminate the joint spectrum access discussion among them. With a specific end goal to diminish the measure of CO2 outflow of CRNs, spectrum sharing and access algorithms ought to minimize the explicit information sharing by either depending on local choices as much as possible or exploiting, learning and forecast techniques.

III. Green-CR Networks With Small Cells

As opposed to depending on cautious arrangement of ordinary CR systems, heterogeneous systems (HetNet's), which are comprise of a macrocell network overlaid by small cells, are proposed to determine the capacity demand issue. The small cells prompt higher spatial frequency reuse and lower power consumption. Furthermore, proposed green energy powered CR network is capable of liberating the wireless access networks from spectral and energy constraints. The limitation of the spectrum is alleviated by exploiting CR technology and dependence on the traditional unsustainable energy is assuaged by adopting energy harvesting (EH).

Green-CR network imposes more challenges than a regular CR system because the nodes with available spectrum, the nodes with sufficient power and the ones with data traffic to serve may all be different [5]. As compared with cellular networks powered by distributed green generators or green power farms, the operation of Green-CR network is more perplexing, because various framework architectures require different energy distribution within the network, *e.g.*, the centralized controller needs more energy in the spectrum sensing phase while secondary systems demand more energy in the information transmission phase. Besides, Cognitive functionality relies on upon the energy availability while spectrum availability in turn affects the energy consumption. In our proposed model energy harvesting is applied to address the problem of tapping energy from readily available ambient sources that are free for users, including wind, solar, biomass, hydro, geothermal, tides, and even radio frequency signals.

Contingent upon whether there is a storage capability for the power output of the harvesting system, the generic system model is ordered into:

- *Harvest-use modeling*: Mandates that the instantaneous energy harvesting rate should always be no less than the energy consumption rate.
- *Harvest-store-use modeling*: Provides a storage component, *e.g.* rechargeable batteries, to hoard the harvested energy for future utilization.

The energy harvesting procedure and energy consuming procedure *i.e.*, sensing, transmission, reception, etc, can be scheduled simultaneously, or in a time switching manner.

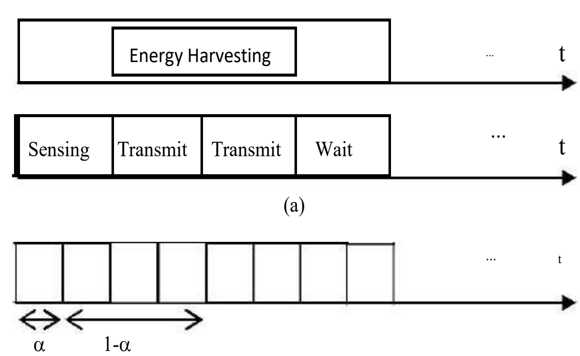

Fig. 2. The harvest-store-use mechanism of cognitive device
(a) Simultaneous energy harvesting and consuming (b) Time switching between energy harvesting and consuming

The unified model of the energy collecting method of these structures is given in Eq. (1).

$$E_h = \alpha\eta E \tag{1}$$

where E_h represents the energy harvested, E is the green power source. $0 < \alpha \leq 1$ is the time switching ratio that is consumed for energy harvested, and $0 < \eta < 1$ is the energy conversion efficiency.

Except for the isolated energy harvester and information recipient like Fig. 2(a), helped to establish energy harvester and information beneficiary can grasp two valuable designs: power splitting and time switching. As delineated in Fig. 3(a), when the RF signal achieves the recipient, some portion of it is used for power extraction and the rest for the concurrent data detection. Note that Fig. 2(b), which requires just one arrangement of antenna for both energy and information, is a special example of Fig. 1(b). The unified model of the RF energy harvesting process of these structures is given below in Eq. 2.

$$E_h = \alpha\, \eta\, |h^2| E \qquad (2)$$

where h is the channel condition between the RF energy harvester and the RF energy source. $|h^2|E$ gives the energy of the recipient RF signals.

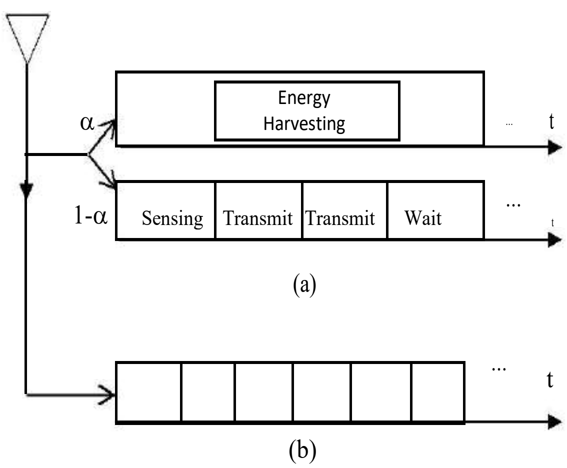

Fig. 3. The RF energy harvesting mechanism (a) Power splitting in the receiver (b) Time switching in the receiver

Energy harvested in the current time slot can only be utilized in subsequent time slots, inferable to the energy half-duplex constraint as indicated in Fig. 2(a) and Fig 3(a). Thus, before performing the cognitive functionality, the available residual energy is observable in all of the architectures. Proposed Green-CR is different in the sense of the dynamic nature of energy supply, i.e., opportunistic energy harvesting makes the energy-arrival rate no longer constant [6].

IV. GREEN-CR BASED SMART GRID SYSTEM MODEL

The communication architecture based on Green-CR for smart grid is comprised of three tired hierarchical structure counting Home Area Network (HAN), Neighborhood Area Network (NAN), and Wide Area Network (WAN) [7].

A. Cognitive Home Area Networks

HAN is basically a heterogeneous system with small cognitive cells, to give energy efficiency administration and demand reaction. In cognitive HAN, there is a key segment called cognitive home gateway (HGW) which can be coordinated into smart devices to provide two-way communications for smart grid by establishing a contact with various devices within the HAN to collect power-related data occasionally.

B. Cognitive Neighborhood Area Networks

As indicated in Fig. 4, a cognitive gateway in a NAN unites several HGWs together. The cognitive neighborhood gateway (NGW) is an information combination point, which is by and large a utility pole-mounted gadget, a power substation, or a communication tower. To inadequate the expense of obtaining spectrum bands, the NGW and the HGWs bestow in approved bands using CR innovation. The NGW circulated available spectrum bands to each HGW as indicated by the transmission request. The circulated generation frameworks offer advantages to electricity transmission since they are nearer to clients than traditional centralized power frameworks and facilitate demand response management in a NAN.

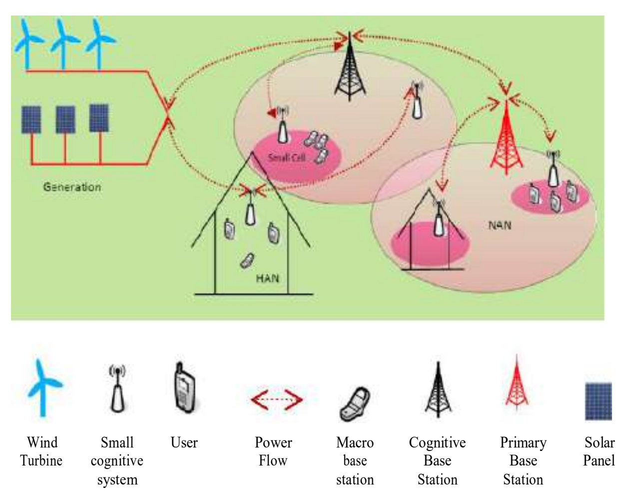

Fig. 4 Heterogeneous CR networks powered by Green energy

C. Cognitive Backhaul Networks in Wide Area Networks

WAN comprises of two interconnected systems, *i.e*., the center systems and backhaul systems. The center systems provide connection to the control center and commonly use fiber optics or cell systems to guarantee high information rates and low latency. The backhaul systems handle the broadband connection to NANs and monitoring devices. Applying CR technology in backhaul systems contributes to reducing the expanse for investment and enhancing the flexibility, capacity, and coverage. Each NGW is considered as a cognitive hub rather than an access point. The NGW has the capability of communicating with the cognitive base station distributed over a wide area through authorized bands unused by primary systems.

On one side, Green-CR communication frameworks that work in the unapproved bands are connected in the HAN to facilitate the heterogeneous wireless technologies; on the other hand, Green-CR communication frameworks that work in the approved band are connected in the NAN and WAN to powerfully get to the unoccupied spectrum opportunities. In this design, just nearby detecting information in the regions where the CR frameworks are found is acquired. From now on, the detecting precision increments with the number of CR frameworks.

The way of controlling a conventional generation facility is not suitable for a distributed renewable energy generation framework. Likewise, it is important that renewable energy sources tend to be variable and in like manner the working schedules of such power frameworks are property of dynamic variation. Assorted renewable energy sources have diverse active period amid a day. Amid the active period of renewable energy sources, higher information rate and more reliable services are needed for the data communication in distributed generation systems.

V. CONCLUSION

This paper discussed a diagram of the paradigm shift towards Green-CR system for communication network design of savvy grid. Not at all like the conventional CR systems, Green-CR systems know about maintainable advancement, and enhance the spectrum usage proficiency by means of spectrum awareness at low energy utilization and lessened CO_2 release to environment. We presented a system that can provoke move towards the green vision for smart grid by significantly reducing operational expenditure and CO_2 emissions.

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Contingency Analysis and Security Constraint based Optimal Power Flow in Power Network

Publisher: IEEE

Deepak Yadav ; Aditya Singh Chauhan ; Brijesh Singh **All Authors**

Abstract

Document Sections

Authors

Abstract: The objective of the present work is to observe the application of security constraint optimal power flow (SCOPF) technique in contingency management of power system. The... **View more**

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Abstract:
The objective of the present work is to observe the application of security constraint optimal power flow (SCOPF) technique in contingency management of power system. The contingency situations in power networks such as line outages and generation outages have been managed by using SCOPF solutions. The generation levels of various generators have been optimally rescheduled during contingent situation using SCOPF based load dispatch technique. In SCOPF, various other system constraints such as congestion, voltage deviation, and loss minimization have also been taken into account to achieve economic performance in the system. The interior point method (IPM) technique has been used to obtain the test results. The IPM based SCOPF methodology has been tested on an IEEE-9 bus system. The obtained test results show

that the IPM based SCOPF technique provides efficient solutions for economic load dispatch in power network during normal and contingent situation of line and generation outages.

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Contents

I. Introduction

The Power system is one of the leading fields where various operational activities have been involved, such as operational problems of a power system, security, reliability, and cost-effective load dispatch. One of the most challenging issues of modern power system infrastructure is analysis of contingency and optimal management methods. To insure a continuous power flow in power networks for meeting consumers' demand during contingency situations have also been a challenging task among the operators. The term, contingency analysis, is one of the most essential issue for establishing Power Management Systems (PMS) in power networks. The establishment of PMS in power networks is required advance analytical tools and algorithms for contingency analysis [1]. The objective is to provide a cost effective solution for power system operators. Mostly, the contingency situations raised because of generation and line outages [2]-[3]. In this situation, it is assumed that the system having capability to fulfill the power demands of the consumers through reserve capacities of the generators in the system. The rescheduling of generation is one of the usual practice adopted by the system operator [4]. Sometimes, the rescheduling decision making will be complex for the operators. Thus the optimal power flow (OPF) based system operation provide good solutions, especially during contingency [5]-[7].

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Keywords

Metrics

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Study and Analysis of Environmental Issues for Scaled Version of Si-Ge Heterojunction Bipolar Transistor

Publisher: IEEE

Alok Kumar Pandey ; Arun Kumar ; Sheetal Singh **All Authors**

Abstract: Nowadays Si-Ge HBTs are playing an important role in the field of RF and microwave applications. Also Scaling of a device is an advance fashion in the innovation. In this... **View more**

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Abstract:
Nowadays Si-Ge HBTs are playing an important role in the field of RF and microwave applications. Also Scaling of a device is an advance fashion in the innovation. In this paper, we have scaled the Si-Ge HBT using scaling techniques and studied the behavior of the RF performance parameters of the DUT before scaling and after scaling with Ge content in base region.

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Contents

I. Introduction

VLSI plays an important role in RF electronics and RF & Microwave communication. The choice of material and semiconductor device is key factor in the field of VLSI. Which material and semiconductor device we have use is totally depends on the Figure of Merit (FOM). A detailed comprehensive study has been done for the selection of semiconductor device. In the study we have found that HBTs have intrinsic high-power density, linearity and efficiency compared to field effect devices in the RF and Microwave communication [2]–[4].

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Disturbance Observer Based Robust Control Design of Variable Speed Wind Turbine

Publisher: IEEE

Alok Kumar Pandey ; Bhanu Pratap ; Akhilesh Swarup **All Authors**

Abstract

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Authors

Abstract: This paper investigates the design of a robust control for two mass model (2-MM) of a variable speed wind turbine (VSWT). The VSWT is a class of nonlinear system with a h... **View more**

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Abstract:
This paper investigates the design of a robust control for two mass model (2-MM) of a variable speed wind turbine (VSWT). The VSWT is a class of nonlinear system with a high degree of uncertainty of irregular wind speed. The uncertain behaviour of wind speed is directly unmeasurable due to the high cost of sensors. Thus, the proposed control strategy is designed on the basis of disturbance observer which avoids the construction of inverse operator leads to the problem of singularity. The closed-loop 2-MM VSWT system stability is established as asymptotically stable. The simulation results reveal the performance and robustness of the proposed control algorithm for 2-MM VSWT system.

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Contents

I. Introduction

Among various renewable energy sources, wind energy considers as the most promising source. It is supplying 3.7 % of global energy production and can be increased to 15%-18 % by 2050 as suggested by the international energy agency. Annual growth production of wind energy is 22 % from 2000 to 2015 [1], [2]. For maximum extraction of wind energy, it is necessary to maintain a constant rotational speed of the rotor. A control strategy is required to maintain rotor speed of variable speed wind turbine (VSWT) due to continuous change in the wind speed. However, a lot of challenges are still there like control of its dynamics, effective harvesting of energy and to maintain its robustness during irregularities that include velocity and direction of the wind so that it is infeasible to extract total power [3].

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Figures

References

Keywords

Metrics

Energy Conservation: Analysis & Improvement through Energy Audit

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Abstract— **Energy generated from either conventional or non-conventional resources are generally not fully utilized in efficient way results in overconsumption, reduced energy efficiency & increased cost. Effective energy scheduling through energy audit results in smart & efficient energy consumption. Energy auditing had been conducted based on one year KWH consumption in KIET Group of Institutions Ghaziabad and various recommendations through this paper will be necessarily helpful for all educational buildings to minimize energy consumption & improving energy conservation.**

Keywords-- **Energy audit, energy scheduling, energy consumption**

I. INTRODUCTION

Krishna Institute of Engineering and Technology (**KIET**) is a private engineering institute affiliated to Dr. A.P.J. Abdul Kalam Technical University, situated in Ghaziabad in the National Capital Region of India 30 km from Delhi. The institute is ISO certified and NBA accredited. The institute was started in 1998 under the aegis of the Krishna Charitable Trust. The institute has 8 academic departments, 3 boys hostels, 3 girls hostel, Auditorium, TBI, Central Library, a Multi-Purpose Complex with a focus on education in engineering, sciences, pharmacy and management. As on the date, the student strength of the institute is about **5341** with total faculty plus staff strength of about **529** and over an area of about **21** acre. The institute connected load is **1112 KVA** and annual electricity bill keeps up in several (**Cr**). This huge electricity bill attracts the attention naturally. Making the institute energy efficient will not only concern with reduction in electricity expenses but also helps us to remind our moral responsibilities of not wasting this precious resource which may be used by people of the country in need.

A. Objective of the work

The objective of Energy Audit is to promote the idea of Energy Conservation in the Campus of KIET Ghaziabad. The purpose of the energy audit is to identify, quantify, describe and prioritize cost saving measures relating to energy use in the Hostels, Departments and Institute Central Facilities [3].

The work eligible for Energy Audit Study should be directed towards:

•Identification of areas of energy wastage and estimation of energy saving potential in Hostels, Departments and Central Facilities.

• Suggesting cost-effective measures to improve the efficiency of energy use.

• Estimation of implementation costs and payback periods for each recommended action.

• Documenting results & vital information generated through these activities.

•Identification of possible usages of co-generation, renewable sources of energy (say Solar Energy) and recommendations for implementation, wherever possible, with cost benefit analysis, and to reduce environmental effects.

B. Audit Methodology

The methodology adopted for this audit was a three step process comprising of:

1. Load Calculation & Testing of measuring devices In preliminary load calculation phase, exhaustive data collection was performed using different tools such as observation, interviewing key persons, and measurements. Power analyzer, lux meter used for this purpose is well tested by Lamp Load methods [14].

Following steps were taken for Load collection:

- The team walk through each department, center, hostel etc.
- Information about the general electrical appliances was collected by observation and interviewing.
- The power consumption of appliances was measured using power clamp meter.
- The details of usage of the appliances were collected by interviewing key persons e.g. Warden (in case of hostels), caretaker (in case of departments) etc.
- Light intensity was measured using lux meters at

the places where light intensity was either very low or very high.

- Approximations and generalizations were done at places with lack of information.

Fig.1. Testing of power clamp meter

2. Load Analysis & interpretation-- is divided into two parts-

- **Time Schedule**-Working hours in each block and rooms with reference to time table provided.
- **Load Analysis-** it is basically energy utilized in KWH for whole year is tabulated.
- In data analysis, the data collected is processed to draw significant conclusions to pinpoint loopholes and identify the areas to focus upon. Analysis of the power consumption observations obtained was used to obtain the power consumption pattern and also to get the information about the points where electric power is wasted.

2.1-Time Schedule-

- Working hours of each room in every block of the institute, hostels, central library, multipurpose complex, laboratories, auditorium, TBI, streets etc. were observed.

2.2-Load Analysis-

- Load of each electrical equipment like tube lights, CFL, Air Conditioners, Refrigerators, Microwave Ovens, Fans, Projectors, Computers, Laboratory equipments, etc. were calculated of each room in each block and the power consumption was analyzed and then compared with total energy consumption of last year.

3. Recommendation –

On the basis of results of Load calculations and observations, some steps for reducing power consumption without affecting the comfort and satisfaction were recommended along with their cost analysis and finally payback period is calculated.

Following will be the steps involved in this process:

- The capital cost involved in replacing an appliance and/or process will be estimated.
- The energy saving by the move will be calculated in terms of price of energy per year.
- These two costs were compared to calculate the capital cost recovery time which defined as the total time by which the saving in energy bill balances the capital cost involved.

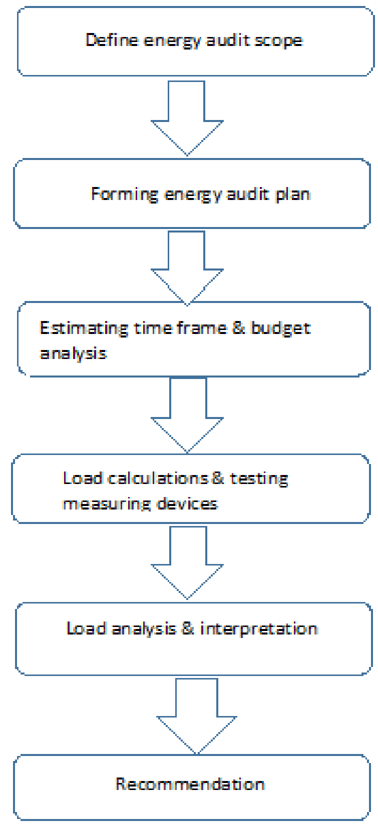

Fig.2. Flow chart of the proposed work

II. POWER CONSUMPTION ANALYSIS

A. The power consumption by each block per year is shown in Fig. 3.

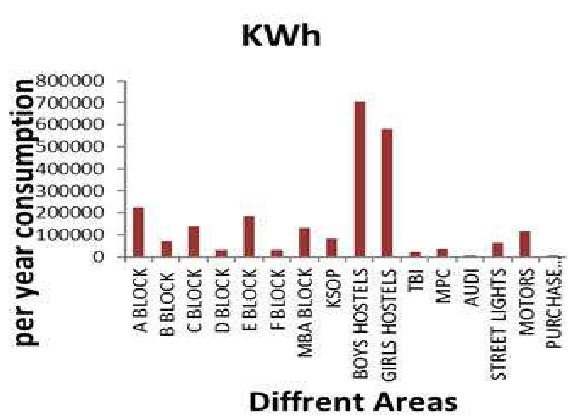

Fig.3 comparative analysis of different blocks

B. Overall campus consumption analysis:

In the above chart maximum consumption is observed in Boys and Girls Hostels because there are 6 hostels altogether. Second largest consumption was seen in Block A because it is the Administrative block and works continuously carried throughout the year. It was observed that huge amounts of Air conditioners (split and windows) together with centralized one consumes power significantly. E Block was third highest consumption area as it has 4 departments including CSE, CIVIL, IT, MCA. The reason was clear that more numbers of Fans, FTLs with more time duration of use, also blocks open for 5 days generally but it was not the case of Hostels which were open all over the week.

C. Equipment wise consumption:

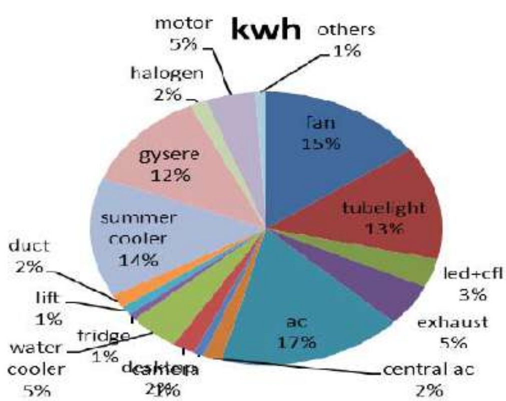

Fig.4 Percentage consumption of different equipment

It was observed from above pie chart that maximum consumption of energy per year due to AC which was 17% and it might be due to the large numbers of AC in A Block classes and in all the faculty cabins of various departments. Fans, tube lights, summer coolers and geysers share about equal energy per year and that is about 12-15% each. 5% energy is consumed by water coolers and exhaust Fans due to high wattage consumption, mainly in toilets, and also by motors that are used in Sewage plants, Fountains, etc. Rest of loads are very negligible as seen in figure 4.

D. Overall Energy Consumption of Hostels:

There are 3 boys' hostel and 3 girls' hostel in KIET with separate Mess for each. Most of rooms are triple seater with three Tube lights, two Fans and single seated with one fan and two tube lights. In winter season warm water facility is available through electric geysers in each boys' hostel. In girls' hostel also electric geysers of 2KW in each washroom are provided. Here we compare per year electricity consumption of individual hostel. Girls' hostels together with mess load is compared with boys' hostel.

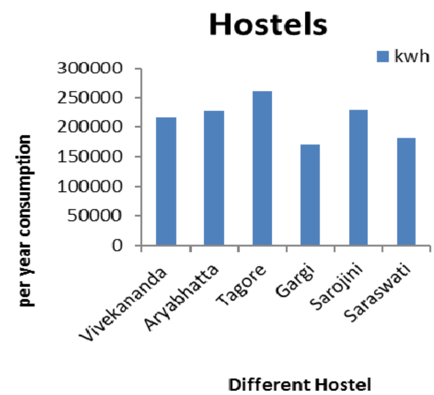

Fig.5. Comparative analysis of different hostels

E. Equipment wise hostel consumption:

As far as hostels are concerned, summer cooler loads were found to be 27% as almost all the room there is cooler and in operation during the summers. Second largest consumption was seen in heating elements which only used 120 days nearby but its wattage value is very high and attracts the attention to replace by some other mode of heating e.g. solar etc. Fans are in larger quantity with higher wattage value, however used only 200 days per year and it consumes third highest 20% of all hostels energy.

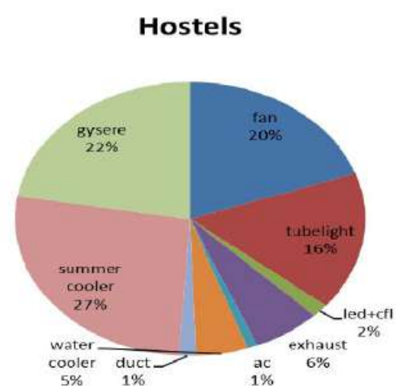

Fig.6. Equipment wise hostel consumption

F. Overall acedemic block energy consumption:

In KIET, there are 7 academic blocks and 1 academic cum administrative Block A. Block A consumes maximum energy per year and it is due to the fact that this block utilizes maximum number of Air conditioners (split & windows) along with centralized AC. Large quantities of Fans, FTLs and Water coolers. Second largest consumption was seen in Block E where CSE, CIVIL, MCA, IT departments classes run weekly along with Laboratories and Faculty cabins. Third highest consumption is of C Block as it takes the considerable share of energy consumption due to the college cafeteria, machine labs and mechanical workshop. Fourth largest is the MBA Block in which CRPC and Soft Skill departments are present including MBA classes.

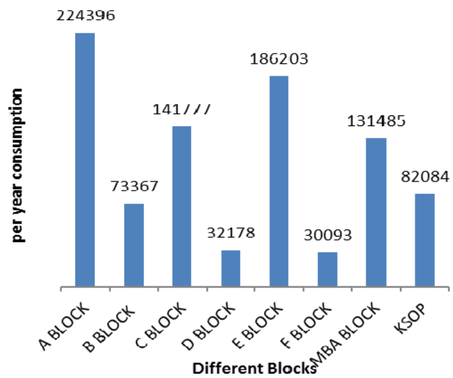

Fig. 7 Comparative analysis of academic blocks

G. Equipment wise acedemic block consumption:

Maximum energy consumption per year was found by Air conditioner and second largest by Fans and tube lights equally. However it is easily noticeable point that working period for Air conditioner is about 120 days and for Fans it is 140 days during summer days, of course it dominates Fan load due its high wattage consumption of AC's. Third largest consumption area was Desktops due to abundance of computer labs. Water cooler, Central AC, Exhaust Fans and LED and CFL were sharing the load equally with 4% each.

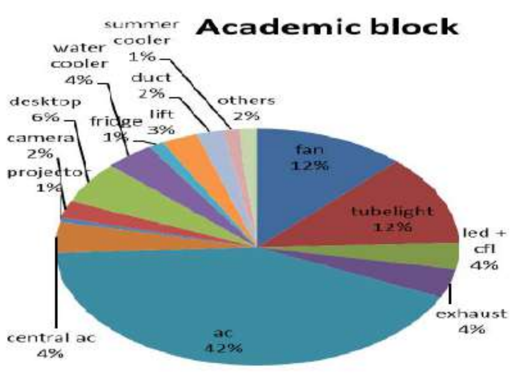

Fig. 8 Equipment wise academic blocks consumption

H. Other facilities consumption:

Motors take the highest amount of energy in the other facilities provided in the college campus in which the most prominent motor which take highest energy are Water Sewage Plant motors. It consumes huge electricity whole the year which is really the matter of discussion. In sewage plant, there are 11 motors of different HP ratings.

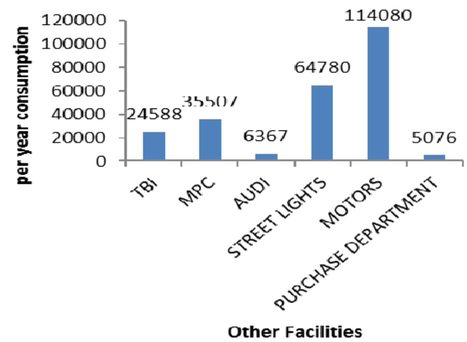

Fig.9. Power consumption by other equipments

SEWAGE PLANT MOTOR				
S.N	**Motors**	**Measured Power rating in watt**	**Quantity**	**hours /day**
1	3 HP	2138	2	12
2	5HP	3360	2	12
3	7.5HP	4600	1	12
4	7HP	4220	1	8
5	3HP	2138	2	8
6	10HP	5300	2	6
7	5HP	3360	1	6

Table 1. Power consumption by different facilities

I. Equipment wise consumption of other facilities:

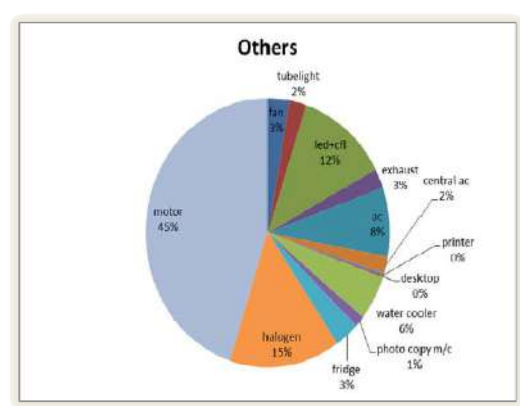

Fig.10. Equipment wise consumption

III. RECOMMENDATION

There are various ways of improving present situation. Based on previous analysis it is quite clear that as far as overall campus & hostels are concerned, if Fans of low rating is used it may be very useful in reducing the electricity bill. However during block wise load analysis it was found that UPS and Air conditioners cannot be underestimated as these areas seems to be having a lot of potential of improving energy efficiency.

A. Installation of bio gas plant:

Calorific value of biogas = 19.5 MJ/m^3
Calorific value of LPG = 46.1 MJ/m^3
Observed food wastage of 190 kg per day
Total LPG consumption in boys and girls hostel = 14 per day
Weight of one LPG (commercial cylinder) = 19 kg
Cost (varies time to time) of one LPG cylinder = 1200 Rs.
1 m3 biogas = 0.45 kg of LPG
40 kg food waste produces 20 m^3 biogas per day
190 kg food wastage produces 95 m^3 biogas per day
95 m3 biogas = 42.75 kg LPG or 2 LPG cylinder per day
Total cost of LPG per year (assume 280 days in a year working) = Rs.4704000
Cost of biogas produced per year = Rs. 756000 Per year
Installation cost = Rs. 600000
Annual saving = Rs. 756000
Payback period = 600000/ 756000 = 0.79 years (Approx.)

B. Lightning saving:

As per the Energy Conservation Building Code (ECBC) – 2006, published by the Bureau of Energy Efficiency (BEE), Govt. of India, and the recommended luminance are as given below in Table 2.

Table 2. Recommended Illuminance

Type of Interior Or Activity	Minimum Illuminance Required (Lux)
General	200
Reading room	200
Reading tables	200
Bathrooms	200
Computer workspace	300
Interior parking area	20
Music rooms	200
Sports hall	200
Corridors, cafeterias, mess	150
Food , cooking	300

Table 3. Observed Illuminance in campus (Lux meter reading)

Different areas	Measured Lux
Hostel rooms	250
Reading areas	300
Class room	250
Corridor	220

The lighting that is currently used in most of the hostels is T8 FTL with conventional ballast. It consumes 40 watt approximately measured by power meter. According to ECBC standard it was clearly observed that everywhere lighting standard violates and higher so first of all numbers of lighting elements are supposed to be reduced such that it may come within the specified region specially corridors.

B.1 FTL calculation

NO of T8 FTL in KIET = 2800
Observed working days = 250
Total KWH = 250*40*2800 = 28000
Total energy consumption cost per year = Rs. 231000 per year
Recommended T5 LED e.g. **SYSKA 18 W LED** more lumens (1880 lumens) and more hours life (50000 Hrs.)
Cost of each LED after discount (purchase in large amount) = Rs 300.
Total installation cost =2800*300 = Rs. 840000
Total payback period = 840000/231000 = 3.6 years

B.2 Recommendation for Metal Hallide

Currently, 30 Metal halide are placed throughout the college premise and some additional halides are also used time to time and it consumes 32850 KWH per year which cost Rs. 261157 per annum. Recommendation is to use LED in place of halide. We recommend 180 Watt LED e.g. **Wipro LED 180 Watt** with Lux luminous near about this particular Halide. It reduces electricity charges about less than 50%.

C. Low wattage ceiling fans:

Audit Team found that more than thousand Fans in college consumes approximately 60-70 watt power depending upon their ages (old) and due to after some maintenance also some Fans in mess were found in the range of 90 watt also. One biggest bottleneck was seen in some academic class rooms was that all Fans run without speed regulator and further one switch starts 3 Fans simultaneously (similar case for FTL also) which consumes energy unnecessarily without need. First of all, audit team suggest that every fan should be operated with **electronic regulator** so that Fan would run at required speed and a saving of **8-10 W** per fan can be achieved and second for individual Fan separate switch is required.
One important point here must be discussed is that if all Fan is replaced by new one with 40-50 watt e.g **USHA 43 watt ceiling Fans**, large energy saving would be achieved per annum.
During data collection it was observed that old Fans are in the range of 90 Watt and some Fans consumes more than 75 which was undergone maintenance and winding replacement. Thus, efforts should be to minimize repair work and should be done, if needed, by expert worker only

D. Use of motion sensors in corridor:

Corridors and toilets have large potential of saving energy as we discussed earlier that these area crosses the ECBC standard lighting criteria and energy may be saved by use of automation tools. Motion sensors automatically switched on

the light when there is any movement appears and switch off if not. This work greatly reduce the consumption in corridors and toilets. According to IIT Roorkee report on Audit [16], total cost of installation will be 750 Rs. Only in single corridor and payback period approximately one year.
Hence, the capital cost recovery time for installing motion sensors in corridors is 0.95 years. Toilets are also having comparable capital cost recovery time. Hence, this is a highly recommended step to largely reduce the consumption in corridors and toilets.

E. Guidelines for better use of Air conditioner:

The institute has in total 212 window type ACs and 117 split type ACs which make a very large part of total energy consumption of the campus. But, at many places it was found that AC is not used with best recommended practices. Even simple things, such as insulation, are not taken care of. Window panes were found broken at many places. Also, at certain places ACs were found to be used without keeping curtains. These poor practices account for increase in AC load and thus consumption [14].
Summarized below are some guidelines for most efficient use of ACs:

Proper Insulation – Good quality insulation must be maintained in the air conditioned rooms by keeping all doors and windows closed properly so as to prevent cool air go out and hot air come in.

Curtains – Always keep curtains on windows to prevent direct sunlight inside the room to avoid heating of cooled air. This reduces AC load significantly.

Maintenance – Proper maintenance and cleaning of ACs is required at regular intervals to make it work at highest efficiency. Any dirt in filter may reduce efficiency of ACs very significantly.

Operating – The ACs should be switched on 15 minutes before actual use and should be switched off before leaving the room.

F. Use of master switch outside the room:

Installation of Master switch outside a room is essential [14] especially Hostel rooms where students generally forget to switch off while leaving the room. Second, it was observed in faculty cabins that unnecessarily all FTLs and Fans switched on whole day irrespective of presence of faculty in their cabin. Implementation of Master switch is not feasible in faculty cabin as in most of the places there is no individual seating arrangement and improvement can only be achieved by proper awareness and instructions.

G. Installation of Solar Water Heating System:

Calculation for all the boys and girls hostels was done and payback period was calculated. According to Department of Renewable energy and ministry of New & Renewable Energy (MNRE) as well as Indian Renewable Energy Development Agency (IREDA) few important points regarding solar water heater and size and cost of Flat Plate Collector (FPC) was collected and summarized below.
A typical 100 liters insulated tank with 2 m2collector area will supply water at a temperature of 60-80°C.

Litre	Area (m^2)
100	2
200	4
300	6
500	8
1000	16

Table 3 Typical standard data (MNRE)

There is also some incentive schemes provided by government of India for SWHS users.

1) Capital subsidy@3300 per m^2FPC

2) Soft loan @5% per annum from IREDA, New Delhi

3) For 100 litre 2m^2 FPC area is required

4) Cost of FPC = 22000 Rs. and subsidy 3300*2 = 6600 Rs.

5) Cost of FPC after subsidy = 22000-6600 = 15400 Rs

Let us calculate payback period for all the hostels combined-

- Total no. of users (students) = 1450
- Total amount of hot water used per user = 14 litres / day
- Total amount of water used per day in Hostel = 20300 litre
- 2 m2 FPC area provides 100 litres hot water per day
- FPC area required = 406 m2
- Cost of 2 m2 FPC after subsidy = 22000-6600 =Rs. 15400.
- Total capital cost required for installation of SWHS = Rs.3126200
- Total electricity bill due to heating elements =Rs.2426880 Per year
- Payback period = 3126200 /2426880 Per year = 1.29 Years

Results shown above are very optimistic and also beneficial for society as according to MNRE report SWH of 100 litre capacity can prevent 1.5 Ton CO2 emissions per year.

H. Formation of student community:

There has to be college level student community that keeps track record of all energy consumption parameters and wastages. Its duty should be to spread the awareness program to save the energy throughout the institute.

I. Some hidden Loads:

Audit team noticed that there are about 150 electric kettles used mainly in boys' hostel having high wattage value near to 1.5 KW, in some cases, which moves on here and there. Further about 50 electric iron of very high wattage is used in both boys and girls hostels. Girls are provided a separate kitchen with induction heater and it is recommended to provide the same in boys' hostel to save huge amount of wastages unnecessarily. There are about 550 laptops in boys hostels and 430 laptops in girls hostels along with 50 for faculty members used per day but it is not considered in load but it also consumes a lot of energy and mainly students are advised to use economically and avoid its usage whole night without shut down although Master switch installation reduce these wastages in large extent.

IV MEASURING TOOLS USED

A. Lux meter:

Digital Lux meters are the devices used to measure luminous level at different points. This device is really helpful for light intensity measurement due to its good portability, robustness and accuracy. For light intensity measurement placement of lux meter is very important which is always the point of interest e.g. in study room it is placed on reading table and similarly various measurements were recorded.

Fig. 11. Typical Lux meter

B. Three phase clamp meter:

It is used to measure all kind of power e.g. active, reactive and apparent power along with the voltage L-N & L-L, current in phase and power factor. In our project, we used three phase clamp type meter which is easy to handle and measure the power at very complex points also. Frequency range between 20Hz to 200 Hz and voltage range upto 600 V with current range of upto 100 ampere. Power upto 750 KVA or KW or KVAR can be measured.

Fig. 12. Typical clamp meter

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Simulation Modelling of DC-DC Converter for Grid Side Connected Inverter

Publisher: IEEE Cite This PDF

Ranju Yadav ; Ankit Singhal ; Ashish. D. Thombre **All Authors**

Abstract: With the increasing demand of electrical energy, it became the necessity of human being and due to this its generation and utilization become one of the important concern... **View more**

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Abstract:
With the increasing demand of electrical energy, it became the necessity of human being and due to this its generation and utilization become one of the important concerns of the researchers, developers as well as for the industrialist. Different methodologies are achieved to harvest energy and convert it into required form with efficient use. In this paper a boost converter is used for the conversion of low DC voltage into high DC voltage with remodeled inverter and then voltage source inverter (VSI) synchronization to the grid is done. This paper consists of modeling of DC-DC converter for grid side connected inverter and presented the related output waveforms. Proposed circuit is simulated in MATLAB/SIMULINK 2013 and simulation results are provided.

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Contents

I. Introduction

Due to the increasing demand of energy consumption, renewaule resources are used for the generation of electrical energy. But Tremendous use of energy leads to overload the grid system which creates problem like instability, degradation ofpower quality, security and many more.

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Figures

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Keywords

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Simulation of Three Phase Voltage Source Inverter Based on SVPWM Technique

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Abstract

This paper presents simulation of two level voltage source inverter based on SVPWM (space vector pulse width modulation) technique. The concept of two level inverter is used to reduce the harmonic distortion in output voltage waveform without decreasing the inverter output power. Simulation results are presented to realize the validity of SVPWM technique.

Keywords

Voltage source inverter PWM SVPWM LCL filter with series damping resistor

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Improved Mathematical Modeling and Analysis of Photovoltaic Modules and Arrays

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***Abstract*—Solar Photovoltaic array is non-linear power source and under varying environmental conditions it is time consuming and extravagant to obtain operating characteristics. In order to overcome these restrictions an improved model of solar module/array has been proposed, this paper presents a step-by-step method for the simulation of SPV panels/arrays in MATLAB/Simulink. The governing curves of SPV array are also investigated for vast range of environmental conditions, substantial parameters and array configurations. The proposed method gives an exact decisive and easy to tune model of SPV array. Moreover, it provides an improved analysis of SPV array for various substantial parameters (series, parallel resistance, diode factor etc.) and environmental conditions (irradiance, temperature and partial shading) aspects.**

***Keyword*—photo-voltaic array, photo-generated current, solar irradiance, ambient temperature, single-diode model, series and parallel resistance**

I. INTRODUCTION

Solar power is a fast-growing industry in India and as of December 2016, the country's solar grid had a total capacity of 9 giga watts (GW). In January 2016, the Indian government expanded its solar plans to 100 GW of capacity, including 40 GW directly from solar rooftop, by 2022. The infinite, renewable, clean and noiseless nature of the solar energy makes it the most preferred sources of renewable energies which are increasingly finding application areas in today's human life [1]. However, despite of the mentioned advantages, this clean energy source has some disadvantages which should be overcome for an efficient use. High production costs of Photo Voltaic panels, less availability of efficient energy storage devices and dependency of energy production on the environmental conditions is some of the main issues which comes while production of solar energy[2,3,4].

The elemental entity responsible for the conversion of solar energy directly into electrical energy in a Solar Photo Voltaic (SPV) system is referred as SPV cell [6, 7]. The congregation of these SPV cells generally connected in series forms a SPV module. In order to get desired voltage level these modules are connected in series and to get desired current level modules are connected in parallel or surface area of each cell is increased. A SPV array can be a module or combination of modules in series and parallel configuration [8].

There are two ways to use output of SPV array 1) using DC output of array without any processing 2) using Power electronics converter for further processing of output power [16, 21]. The second method helps operates SPV array at optimal point by altering parameters at load side and controlling flow of power in grid connected system [4]. In order to study the performance of SPV system we require model that correctly stand for SPV cells, modules and arrays.

The main work in this paper is improved mathematical modeling of SPV cell/module/array and development of simulation model of module as well as array that correctly represents prevailing modules/array.

II. IDEAL PV CELL

When PV cell is exposed to light (photon), electrons are pushed out creating electron-hole pair in semiconductor material. If positive and negative terminals are connected to the conductors, having a closed electric network, constitutes photon generated current I_{Ph}. Therefore PV cell is PN junction diodes that operate as a current source which is compelled by solar irradiance. The PV cell is ineffective in darkness and it work as PN junction diode, it will generate current I_d when large supply voltage is connected across this diode during darkness that is reason why it is known as dark current(I_d). The Shockley diode equation represents this current as described by equation (1) [2].

$$I_d = I_S\left(e^{\frac{qVd}{kTc}} - 1\right) \tag{1}$$

Where, V_d is the voltage across the diode (D).For the ideal case, this voltage is equal to the cell voltage, V_C, k is Boltzmann constant (1.38 × 10-23 J/$^{o}{}_{K}$), q is electron charge (1.602 × 10^{-19} C), I_S is reverse saturation current of diode (0.000025 A), T_C is typical cell operating temperature (25 °C).

The simple (Ideal) equivalent circuit of PV cell is represented in figure.1. It consists of current source (I_{Ph}) and diode connected in antiparallel.

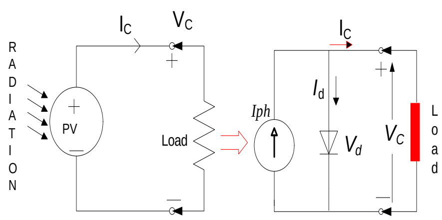

Figure 1 Ideal equivalent circuit of PV cell.

The Photon generated current flows in reverse direction of dark current and its value is independent of external voltage and this is reason why it is called as short circuit current(I_{SC} = I_{Ph}). This current is linear function of solar irradiance as increased irradiance causes incremented charge carriers. It can be seen from figure.1 that output cell current is the difference between photon generated current and dark current. As per standard convention photon generated current is reversed to represent the current from semiconductor theory. Mathematically Current-Voltage characteristics of a PV cell can be written as [9,10]:

$$I_C = I_{Ph} - I_d \tag{2}$$

III. MODELING OF PV CELL

Current-Voltage characteristics of a PV cell described by equation (2) are derived for ideal condition (internal resistance is zero and shunt resistance is infinite). However practically both have finite values that would change the characteristics. The equivalent considered is single diode model as shown in figure 2 of a PV cell includes a current source, diode, and series and shunt resistances.

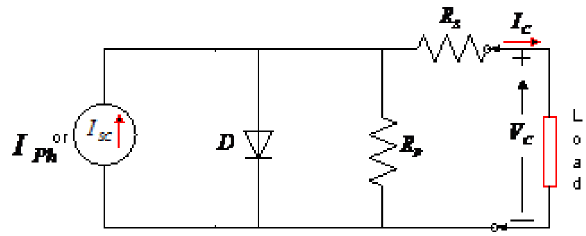

Figure 2 Single diode equivalent circuit of a Photovoltaic cell.

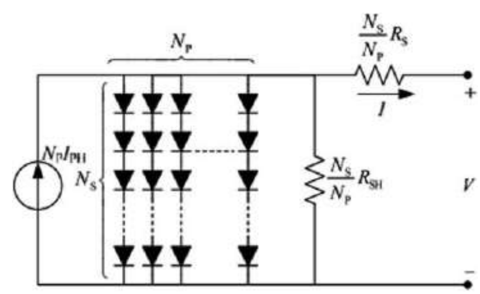

Figure 3 Equivalent circuit of a Photovoltaic array

Five parameters model of PV cell is represented by figure 2, The cell current can written as [1]:

$$I_C = I_{Ph} - I_d - I_{Sh} \tag{3}$$

$$I_C = I_{Ph} - I_S\left[e^{q\left(\frac{V_C + I_C R_S}{akT_c}\right)} - 1\right] - \left(\frac{V_C + I_C R_S}{R_P}\right) \tag{4}$$

Where: a is called as the “ideality factor of junction” (“a” is also represented as “n”). After rearranging the equation (4) we can write i-v equation as shown below.

$$V_C = \frac{akT_C}{q}\ln\left(\frac{I_{Ph} + I_S - I_C}{I_S}\right) - \left(\frac{V_C + I_C R_S}{I_S R_P}\right) - I_C R_S \tag{5}$$

In order to get practically utilizable power output, PV cells are connected together to form PV module and further series, parallel connection of modules form a PV array. PV module is obtained by connecting number of PV cells in series. The equation 1 gives relation of module current and voltage at given insolation S [21].

$$I_m = I_{Ph} - I_S\left[e^{q\left(\frac{V_{PV}+I_mR_S}{akT}\right)} - 1\right] - \left(\frac{V_{PV}+I_mR_S}{R_P}\right) \qquad (6)$$

PV module described by equation (6) is also known as five parameter model with parameters as I_{Ph}, I_S, q, a, $R_s$and R_p. Model parameters can be obtained either from manufacturer's data sheet or determined experimentally. These model parameters are variable and dependent with solar insolation and temperature. The photon generated module current is dependent on solar insolation and temperature given by equation (7).

$$I_{Ph=}I_{Ph,typ}(1 + C_I\Delta T)\,\frac{S}{S_{typ}} \qquad (7)$$

Where $I_{Ph,typ}$is typical photon generated module current at 1000 W/m^2 (S_{typ}) and 25 °C, ΔT is temperature difference between typical/standard temperature and module temperature, S is irradiance on the module and C_I is current coefficient.

The temperature dependence of diode saturation current is represented by equation 8 [11-13]:

$$I_S = I_{S,typ}\left(\frac{T_{typ}}{T}\right)^3 exp\left[\frac{qE_g}{ak}\left(\frac{1}{T_{typ}} - \frac{1}{T}\right)\right] \qquad (8)$$

Such that E_g being energy gap of the semiconductor (for Si, which has energy gap of 1.1eV at 25 °C and $I_{S,typ}$ is the typical saturation current:

$$I_{S,typ} = \frac{I_{sc,typ}}{\exp\left(\frac{V_{oc,typ}}{aV_{t,typ}}\right) - 1} \qquad (9)$$

Where $V_{t,typ}$ is called as the voltage equivalent of temperature at standard temperature T_{typ}.

The PV cell's saturation current I_S has dependence on cell's active area and the density of saturation current of semiconductors that forms device (J_o, [A/cm^2]). The saturation current density (J_o) further depends on various intrinsic parameter of semiconductors. This set of data is mostly unavailable for commercial PV modules. From the available experimental data, we indirectly acquired the typical saturation current $I_{S,typ}$ (9) and that is accessed by examining equation (6) at standard open circuit of PV module, having V= $V_{oc,typ}$, I=0 and I_{Pv}= $I_{SC,typ}$. The initial value of diode ideality constant "a" can be arbitrarily selected. Various researchers addressed methods to estimate the accurate value of this constant.[2,16]. Generally 1 ≤ a≤ 1.5 and choice rely upon the other parameters of the I-V model. An empirical analysis (R) may be used to get certain values of "a". "a" is completely empirical since represents ideality of diode. Some initial value of constant may be taken which can further modified based on curve fitting and its alteration improve model accuracy as represented by equation 10.

$$a = \frac{T}{T_{typ}}\,a_{typ} \qquad (10)$$

IV. UPGRADING THE MODEL

The reverse saturation current follows complex relation given by equation 8. Last section presents a PV model, which can be upgraded if equation (8) is changed by:

$$I_S = \frac{Isc,typ + C_I\Delta T}{\exp\left(\frac{Voc,typ + C_V\Delta T}{aVt}\right) - 1} \qquad (11)$$

Where $I_{sc,typ}$[A] is typical short circuit current, $V_{oc,n}$is typical open circuit voltage at the standard condition (usually 25 ◦C and 1000 W/m2),C_V is the voltage coefficient.

The purpose of correction is to co-relate with experimental results of V_{OC} (open-circuit voltage) for very wide range of temperature. The current coefficient (C_I) and voltage coefficient (C_V) is taken into account to get equation (11) from equation (8). The temperature surely effects the reverse saturation current and there is unlike way suggested by equation (11) to represent the dependence of I_S on the temperature. The above equation facilitate the PV model and wipes out model error around the open-circuit voltage and following different domains of the I-V curve.

The validity of upgraded model has been verified from computer simulation and from resemblance with experimental results. The voltage coefficient C_V incorporated in equation (11) can be obtained from the manufacturer's data sheet. For the temperatures different from the standard values it is now possible to get excellent I-V curve fitting by including voltage coefficient (C_V).

If one urge to use conventional equation (8) [14, 15, 16], rather than equation (11), it is likely to get the correct value of band gap E_g for the model such that V_{OC} obtained by model and V_{OC} of actual PV array must be similar in the extent T_{typ}≤T ≤ T_{max}..

TABLE – 1

Parameters of PV module at standard conditions (1000W/m^2, 25°C)[23]

Maximum power output	200.143 W
Current at maximum power	7.61 A
Open circuit voltage	32.9 V
Voltage at maximum power	26.3 V
Short circuit current	8.21 A
Number of cell connected in series	54

V. STEPWISE METHOD FOR MODELING OF PV MODULE/ARRAY WITH TAGS

PV array's mathematical model containing basic elements as current source, diode, parallel and series resistors is modeled with tags in Simulink. The PV module is simulated on the basis of equations presented in previous section and accomplished in the trailing steps.

Step1

Specify input parameters for modeling:

$I_{SC,typ}$ is short circuit current of the PV module at 1000W/m^2 and 25°C= 8.21 A; $V_{OC,typ}$ is open circuit voltage of the PV module at 1000W/m^2 and 25°C = 32.9 V; R_S is series resistance, generally it has a small value = 0.221Ω; R_p is shunt resistance, generally it has a large value = 414.405Ω; T_{typ} represent standard temperature = 298 K; A represents diode ideality factor = 1.3; K represent Boltzmann constant =1.38*10^-23.

Step2

The Photon generated module current is expressed by equation (7) and simulated as figure 4.

Step3

Module Saturation current is expressed by equation (11) and simulated as figure. 5

Step 4

Modeled current is expressed by equation (6) and simulated as figure. 6

Step 5

Modeled circuit for PV array subsystem is as expressed by equation (6) as figure.7

Step 6

The PV module/array simulation process is presented from figure 4 to 7. The PV simulation presented in this section can be used for a single PV module or a PV array having N_{SS} number of modules connected in series and N_{pp} number of parallel strings of modules as shown in Figure7.

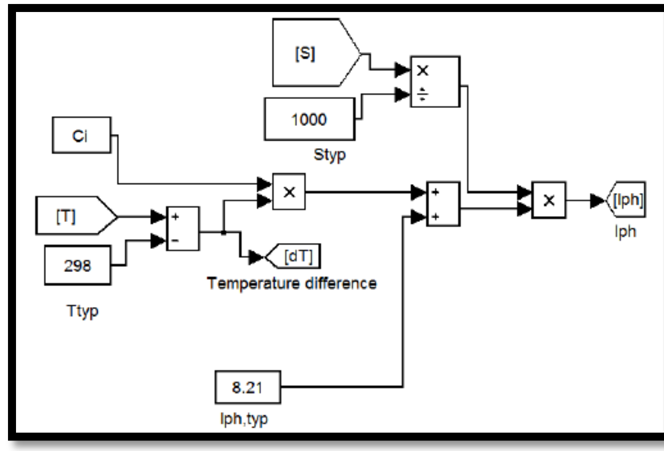

Figure.4. Simulation of Photon generated module current.

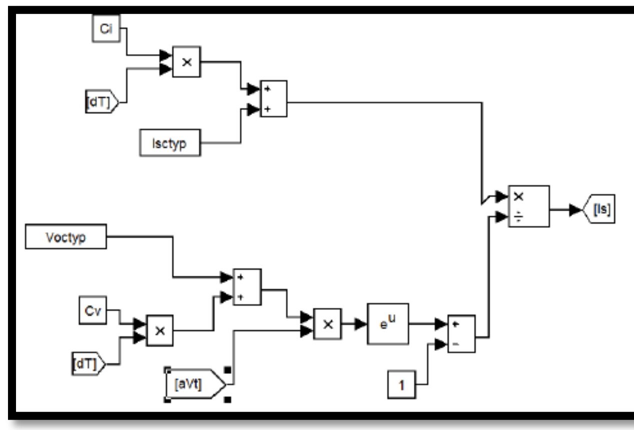

Figure.5. Simulation of saturation current.

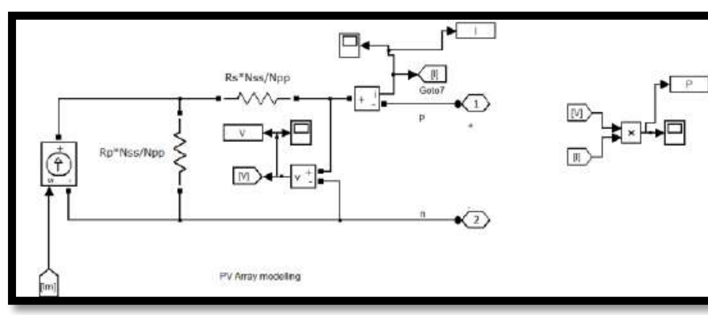

Figure 6 Simulation of PV array.

VI. RESULTS AND DISCUSSION

The array characteristics of presented PV model are assessed as:

1. With changing solar insolation and fixed temperature I-V and P-V characteristics as shown in figure 10 and11. Available insolation varies from 400 to 600 to 800 and 1000 W/m^2 whereas temperature remains fixed at 25°C. I-V and P-V characteristics indicates with increase in

solar insolation, there is increment in output current, voltage which finally results boost in power output.

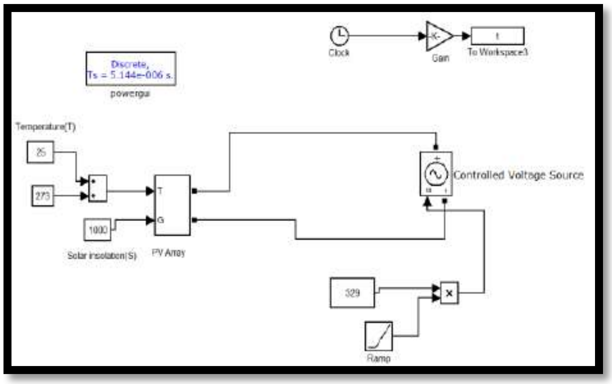

Figure .7. Simulation of PV array having Solar Insolation(S) and Temperature (T) as input parameter

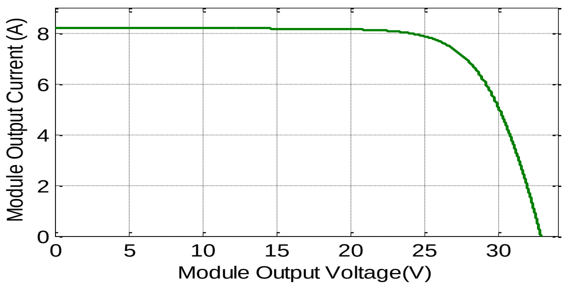

Figure.8. I-V characteristics at standard condition

2. With changing temperature and fixed solar insolation, I-V and P-V characteristics are plotted as shown in figure 12 and 13. Available temperature changes with values of 25°C, 35°C, 45°C and 55°C while insolation level remains fixed at 1000W/m^2. I-V and P-V characteristics indicate with increase in temperature, there is insignificant increment in output current whereas the output voltage reduces greatly. This results in decrement of output power with increase in temperature.

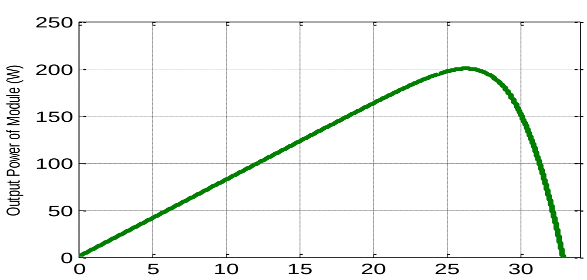

Figure.9. P-V characteristics at standard condition.

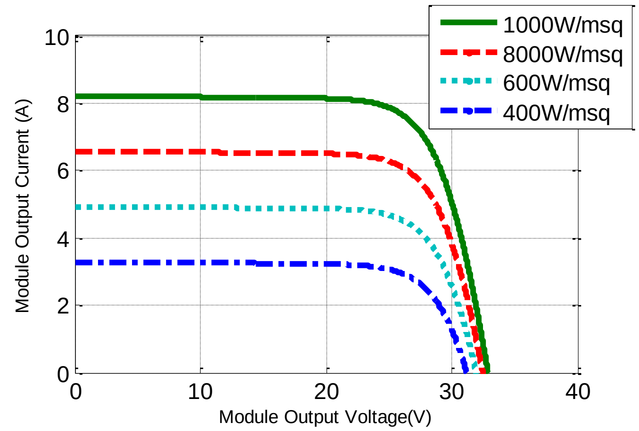

Figure.10. I-V characteristics at variable Sx.

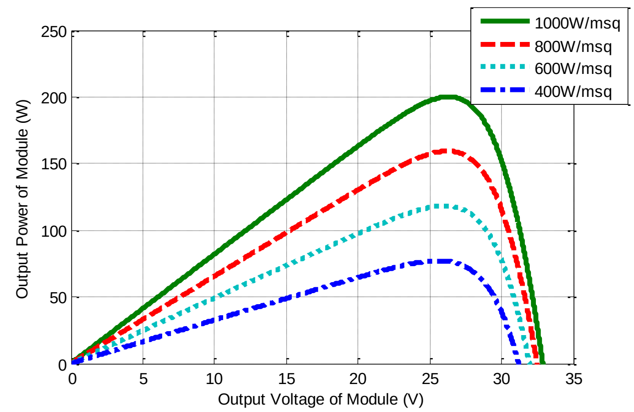

Figure.11. P-V characteristics at variable Sx.

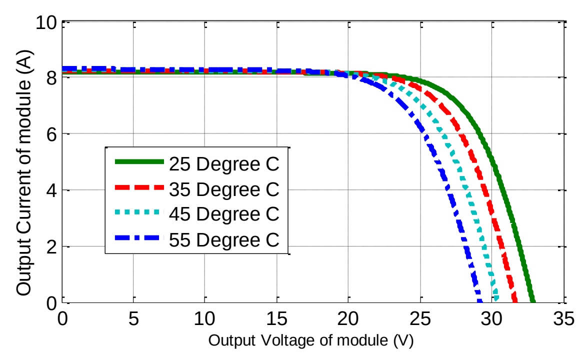

Figure.12.I-V characteristics at variable temperature.

3. I-V and P-V characteristics are plotted for variable R_S (Series resistance) and constant R_P (Parallel resistance), insolation, temperature as shown in figure.14 and 15. Available R_S changes with values 0.055, 0.110, 0.221, 0.442 and 0.884Ω respectively.

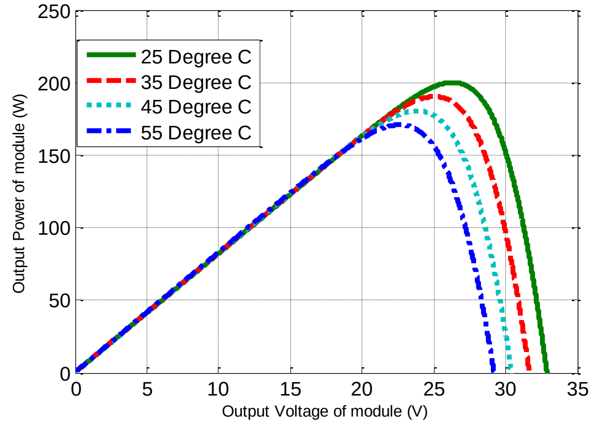

Figure.13. P-V characteristics at variable temperature.

It can be seen from I-V and P-V characteristics as value of series resistance increases from standard value (at which experimental maximum power output is equal to maximum power output evaluated from equation 6) maximum power output decreases whereas when value of R_S decreases from standard value then there is increment in maximum power output.

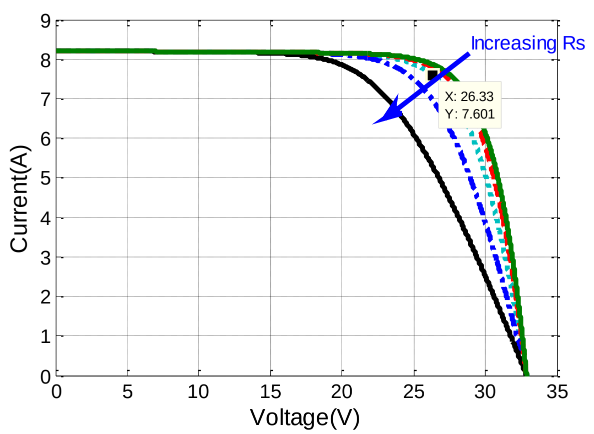

Figure.14. I-V characteristics of module at variable series resistance R_S.

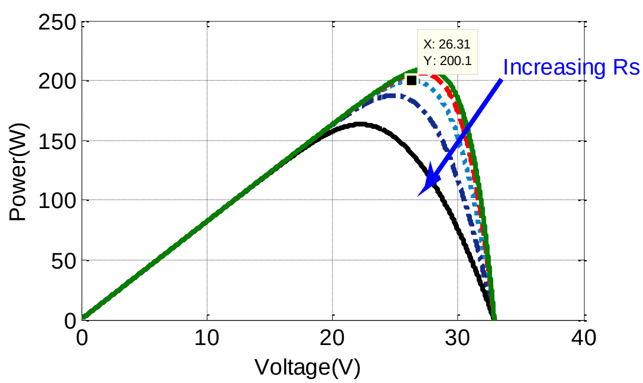

Figure.15. P-V characteristics of module at variable series resistance R_S.

Table: 3.2

Response of R_S on maximum power output, Voltage at maximum power and Current maximum power.

R_S (Ω)	P_{MAX}(W)	V_{MP}(V)	I_{MP}(A)
0.055	**209.7**	27.44	7.64
0.110	**206.5**	26.98	7.65
0.221	**200.1**	26.31	7.61
0.442	**187.6**	25	7.5
0.884	**163.34**	22.41	7.284

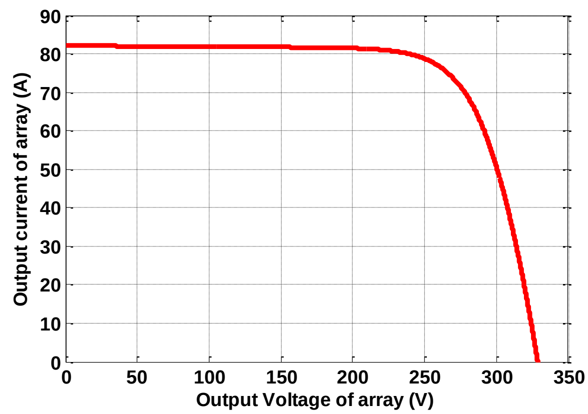

Figure.16. I-V characteristics of array at standard condition.

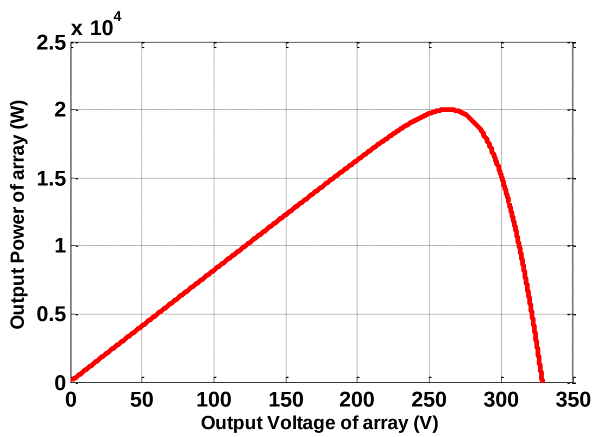

Figure.17. P-V characteristics of array at standard condition.

4. I-V and P-V curves for PV array having N_{SS} & N_{PP} = 10 are obtained as shown in figure 16 and 17. PV modules are connected in series to increase the voltage level of array and series strings of PV modules are connected in parallel to increase the current level of array. The module considered has 54 series connected cells. The PV array having 10 modules connected in series i.e. N_{SS}=10, the value of array voltage is 10 times that of single module and there are 10 such series strings connected in parallel so, the output current of

array is 10 times that of single string, so the output of array will be 100 times of single module.

VII. CONCLUSION

A step wise simulating procedure is presented for PV module/ array. The presented modeling technique helps to serve people in understanding I-V & P-V characteristics of PV modules. Further it can be used as powerful tool to anticipate the performance of SPV cells, panels and array under fluctuating environmental conditions (irradiance, temperature and partial shading) and substantial parameters (series, parallel resistance, diode factor etc.). The effect of change in solar irradiance and operating temperature are also presented. The typical value of series and shunt resistance (R_S and R_P) are also evaluated in iterative manner so that the MATLAB/Simulink model parameter matches with the practical PV array.

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Energy Conservation: Analysis & Improvement through Energy Audit

Publisher: IEEE

Sudhir Kumar Singh ; Brajesh Kumar Tiwari ; Alok Kumar Pandey **All Authors**

Abstract: Energy generated from either conventional or non-conventional resources are generally not fully utilized in efficient way results in overconsumption, reduced energy effic... **View more**

Metadata

Abstract:
Energy generated from either conventional or non-conventional resources are generally not fully utilized in efficient way results in overconsumption, reduced energy efficiency & increased cost. Effective energy scheduling through energy audit results in smart & efficient energy consumption. Energy auditing had been conducted based on one year KWH consumption in KIET Group of Institutions Ghaziabad and various recommendations through this paper will be necessarily helpful for all educational buildings to minimize energy consumption & improving energy conservation.

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Contents

I. INTRODUCTION

Krishna Institute of Engineering and Technology (KIET) is a private engineering institute affiliated to Dr. A.P.J. Abdul Kalam Technical University, situated in Ghaziabad in the National Capital Region of India 30 km from Delhi. The institute is ISO certified and NBA accredited. The institute was started in 1998 under the aegis of the Krishna Charitable Trust. The institute has 8 academic departments, 3 boys hostels, 3 girls hostel, Auditorium, TBI, Central Library, a Multi-Purpose Complex with a focus on education in engineering, sciences, pharmacy and management. As on the date, the student strength of the institute is about 5341 with total faculty plus staff strength of about 529 and over an area of about 21 acre. The institute connected load is 1112 KVA and annual electricity bill keeps up in several (Cr). This huge electricity bill attracts the attention naturally. Making the institute energy efficient will not only concern with reduction in electricity expenses but also helps us to remind our moral responsibilities of not wasting this precious resource which may be used by people of the country in need.

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Figures

References

Keywords

Metrics

A Bibliographical View on Research and Developments of Photovoltaic and Thermal Technologies as a Combined System: PV/T System

Anmol Gupta, Sourav Diwania, Sanjay Agrawal, Anwar S. Siddiqui and Yash Pal

Abstract In this hybrid photovoltaic thermal (PV/T) system, air or water is utilized as a circulating fluid which helps in maintaining electrical efficiency as well as utilization of thermal energy (space heating, crop drying, etc.) at the output. In this article, a review of innovative work in the field of PV/T system and thermal modelling of PV/T collector is presented. The thermal model having different equations for PV-integrated flat plate collector, energy balance for air or water heating system stored thermal energy, the instantaneous energy efficiency and the instantaneous exergy efficiency has been presented. Analytical articulations for different thermal parameters and electrical parameters, considering energy balance for several segments or components of PV/T collector is obtained. Various optimization techniques used in the field of PV/T collector, in view of the exergy concept is also presented.

Keywords Exergy efficiency · Photovoltaic thermal · Optimization · Genetic algorithm

NOMENCLATURE

α_t	Absorptivity of glass
b	Width of PV/T collector (m)
L	Length of PV/T collector (m)
dx	Small length (m)

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A_c Area of the solar cell (m^2)
I_{sl} Solar radiation intensity (W m^{-2})
η_c Efficiency of the solar cell (%)
$C_{a/w}$ Specific heat of air/water (J kg^{-1} K)
$m_{a/w}$ Mass flow rate of air/water in the channel (kg/s)
$Q_{U,N}$ Useful heat gain for N no. of channels (kWh)
h_{p1} Penalty factor due to the presence of solar cell material, glass and EVA
T_a Ambient temperature (°C)
T_c Solar cell temperature (°C)
T_{bs} Temperature of the back surface (°C)
T_{aw} Temperature of air/water (°C)
α_c Absorptivity of solar cell
β_c Packing factor of solar cell
h_t Heat transfer coefficient of tedlar (W/m^2K)
τ_g Transmittivity of glass
U_{ca} An overall heat transfer coefficient from the solar cell to ambient (W/m^2K)
U_t Convective heat transfer coefficient through the tedlar (W/m^2K)
h_{p2} Penalty factor due to the presence of an interface between tedlar and working fluid

1 Introduction

Hybrid PV/T technology is a combination of both solar thermal and solar photovoltaic technology. A solar photovoltaic system changes sunlight into electric power while solar thermal changes sunlight into heat yet a PV/T system converts sunlight into heat and electricity simultaneously. The temperature of the PV module increases tremendously when light radiations of certain intensity fall on it, causing reduction in electrical efficiency. It is found that for every 1 °C rise in temperature of PV surface, it will cause 0.4–0.5% decrement in its electrical efficiency.

PV/T system has gained greater attention in the last four decades because of its quality to generate both electric power/energy and thermal energy all the while and joins the electrical and thermal parts in one element over the conventional PV system and solar thermal system. The application areas of PV/T technology are space heating, water heating, drying, integration of photovoltaic thermal in buildings, etc. [1] (Fig. 1).

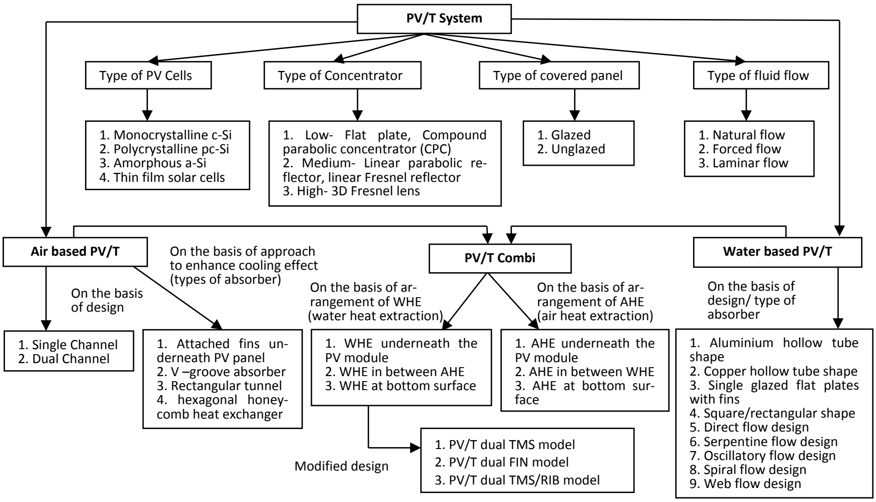

Fig. 1 Classification of PV/T system in view of various literatures

2 PV/T Air Collector

A considerable number of researches have been conducted in the designs of PV/T air collector because its performance is affected by several parameters such as position, dimensions of air duct, input temperature, velocity of flowing air into channel and surface roughness of air duct. A channel or duct is applied below the PV panel in which air is used to absorb the heat energy from the solar cell by conductive or convective process so as to improve the electrical efficiency of the system. The critical factor about the popularity of PV/T is the low efficiency of the cell that varies from 6% to 16% at the temperature of 25 °C but in some of the countries, the ambient temperature rises up to 35 °C. The rising of temperature decreases the module efficiency, hence heat removal from the module is necessary [2].

Hegazy [3] presented four different designs of PV/T collectors based on airflow and investigated the thermal, electrical and overall performance as shown in Fig. 2. The comparative study shows that system-(c) gives appropriate result as it converts solar energy in the form of high-grade electrical energy and low-grade thermal energy, and also it is simple to install in rural areas. Wolf [4] performed the analysis of PV/T system and individual solar PV and solar thermal system and concluded that exergy analysis is a valuable method for the evaluation and comparison of various solar systems.

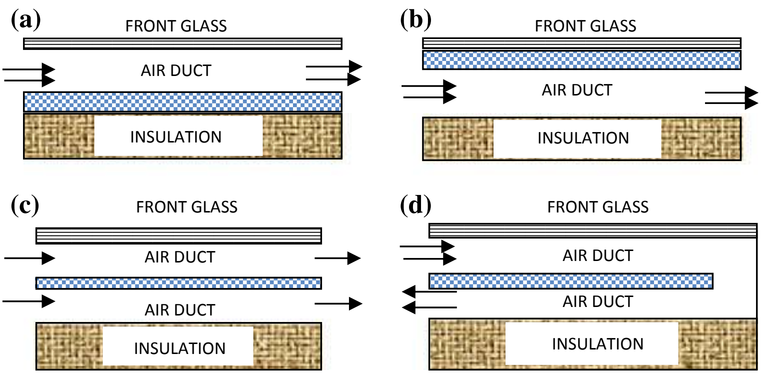

Fig. 2 Cross-sectional view of common designs of PV/T air collector

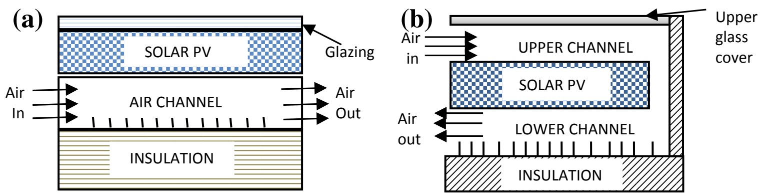

Fig. 3 Cross-sectional view of single-pass and double-pass PV/T air collector with fins

2.1 *Effect of Glazing*

The overall energy output or thermal energy output can be maximized by using glass cover above the PV surface to trap the extra heat energy which will increase the thermal energy output almost double that of unglazed PV/T, but decreases the electrical energy output [5] (Fig. 3).

2.2 *Effect of Adding Thin Metallic Sheets (TMS) and Fins*

Tripanagnostopoulos et al. [6] presented a study of PV/T air collectors and suggested that the surface roughness and thin metallic sheets (TMS) used in the air channel are the cost-effective and simple methods for heat removal from the PV panel. Mojumdera et al. [7] experimentally observed the electrical and thermal efficiencies of the system with TMS as 13.75 and 56.19%, respectively.

2.3 *Effect of Packing Factor*

Packing factor refers to the area of the module covered by the solar cell to the left blank and it affects the output power and operating temperature of the photovoltaic module. Vats et al. [8] found that with an increase in packing factor, the temperature at the output of the channel increases by absorbing the higher amount of thermal energy. Hence, the temperature of the PV module increases which causes a decrease in electrical efficiency. At lower packing factor, the absorber area is less, hence the electrical efficiency if further reduced.

3 PV/T Water

PV/T air has the main problem of temperature issue because an air-based system cannot work effectively at high-temperature areas as there are constraints of low heat capacity, low density, etc.; instead of air, water can carry maximum heat so researchers work in the field of PV/T water. In some areas, during summer season the ambient temperature is very high and for the PV/T air standard, operating is at 20 °C temperature so PV/T water is preferred due to its higher density [9] (Fig. 4).

Huang et al. [10] relate the performance of conventional solar water heater system with a new design which is a combination of the photovoltaic and thermal solar system and evaluated electrical efficiency of 9%. Ji et al. [11] fabricated a flat box aluminium alloy PV for large contact area with a circulation water heating system and the experimental results are obtained with its electrical efficiency of 10.15%, thermal efficiency of 45% and daily total energy of 52%. Chow et al. [12] designed and presented a PV/T system having aluminium alloy flat box collector. In this work, electrical efficiency of the system is 10% with a thermal efficiency of 45–48% for closed circuit and thermal efficiency of 49–52% for open circuit.

The logical articulation of PV/T water heater in steady flow rate of hot water is acquired by Tiwari et al. [13]. Ibrahim et al. [14] executed simulation on seven types of water absorbers. The spiral flow configuration indicates the best result, it has the highest thermal efficiency and parallel cell efficiency of 50.12% and 11.98%, respectively. Dupeyrat et al. [15] investigated the impact of water flow in a flat plate PV/T having single glazing and found thermal efficiency as 79%, electrical efficiency

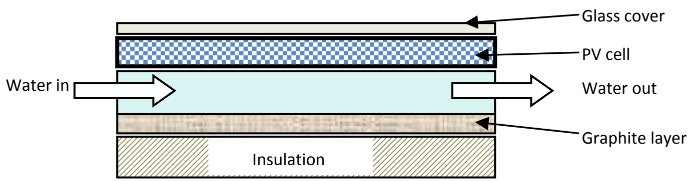

Fig. 4 Cross-sectional view of PV/T water system

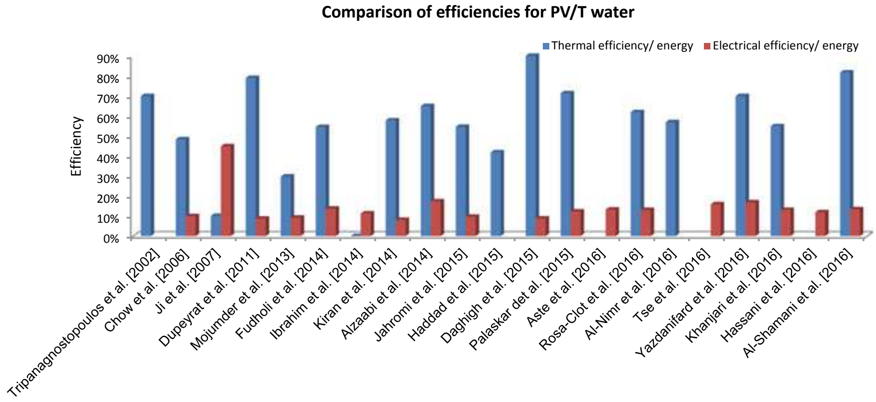

Fig. 5 Comparison of thermal and electrical efficiency for PV/T water system

as 8.8% and in totality, the efficiency is 88% for the propelled configuration. Liang et al. [16] composed a PV/T water collector combined with graphite; it produced the highest electrical efficiency of 7.2% and essential energy saving efficiency of 45%. Yazdanpanahi et al. [17] numerically estimated exergy efficiency of PV/T considering pressure drop in flow channels and maximum efficiency of 13.95% is observed experimentally. Yazdanifard et al. [18] presented mathematical modelling and simulation of flat plate PV/T water system with and without glass cover. It is found that PV/T system with glazing has better energy efficiency (Fig. 5).

4 PV/T Combi

To improve the absorption process on photovoltaic and to get maximum performance of the overall system, the combination of various types of coolant media are utilized (Fig. 6).

PV/T combi achieved better overall energy efficiency, particularly in the generation of electrical energy since heat is removed from the photovoltaic module by integrating both air and water media [19]. Six PV/T combi system designs based on

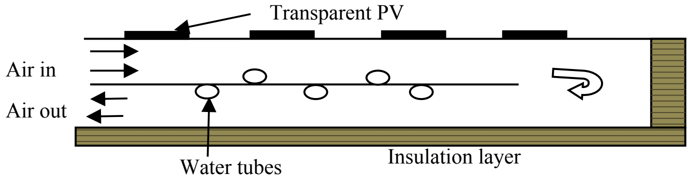

Fig. 6 Cross-sectional view of PV/T-combined system

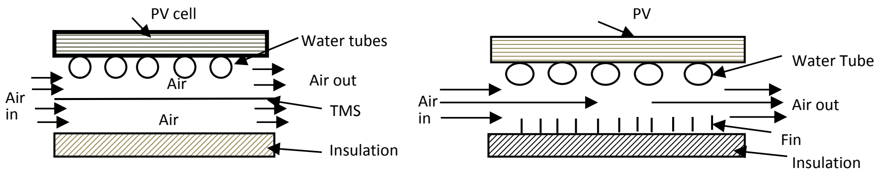

Fig. 7 Cross section of PV/T/dual solar system with TMS modification and with fins

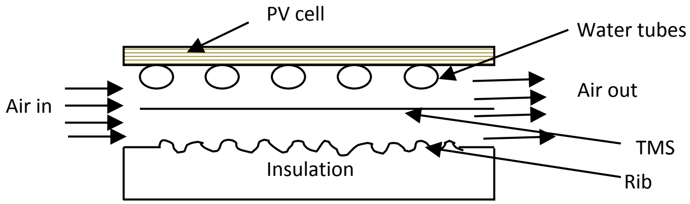

Fig. 8 Combination of TMS with ribs on opposite air channel

the arrangement of air-type and water-type absorber are presented and their performances are observed by Tripanagnostopoulos [20]. Tripanagnostopoulos et al. [21] worked on PV/T combi unit with slight modifications in the air heat extraction unit.

A thin metallic sheet (TMS) is placed between the air channel and the modification is named as PV/T/dual-TMS. This result in a temperature rise of TMS leads to an increase in temperature of the circulating air and hence the thermal efficiency improves (Fig. 7).

A fin plate element is used throughout the length of the air duct and the modification is named as PV/T/dual-fin. This results in increasing the temperature of the air at the output which will further help in improving the thermal efficiency. In the PV/T/dual-TMS/RIB model, ribs are used on opposite channel wall. This model combines the advantages of the above two models mentioned (Fig. 8).

5 Modelling of PV/T Collector

The transfer of heat can take place by means of three mechanisms: conduction, convection and radiation. Heat transfer coefficients of different modes are essential for analysis [22, 23].

Energy balance for solar cells of the PV module (for glass—tedlar PV module)—

$$\tau_g[\alpha_c\beta_c + \alpha_t(1-\beta_c)]I_{sl}bdx = [U_{ca}(T_c - T_a) + U_t(T_c - T_{bs})]bdx + \eta_c\alpha_c\tau_g\beta_c I_{sl}bdx \tag{1}$$

Energy balance for the back surface of tedlar—

$$U_t(T_c - T_{bs})bdx = h_t(T_{bs} - T_{aw})bdx \tag{2}$$

Energy balance for air/water flowing below the tedlar—

$$\left[m_{a/w}C_{a/w}\frac{d}{dx}T_{aw}.dx\right] + [U_{wa}(T_{aw} - T_a) * bdx] = h_t(T_{bs} - T_{aw})bdx \tag{3}$$

Thermal efficiency of PV/T collector—

$$\eta_{th} = \frac{Q_{u,N}}{bLI_{sl}} \tag{4}$$

Electrical Efficiency of PV/T collector—

$$\eta_{el} = \eta_o[1 - \beta_0(T_c - T_o)] \tag{5}$$

where η_o—efficiency at standard test condition, β_0—temperature coefficient, T_o—outlet temperature

Overall thermal energy gain—

$$\sum Q_{overall,thermal} = \sum Q_{thermal} + \frac{\sum Q_{Electrical}}{\eta_{c,power}} \tag{6}$$

Overall Exergy gain—

$$\sum Exg_{thermal} = Q_{thermal}\left[1 - \frac{T_a + 273}{T_{awout} + 273}\right] \tag{7}$$

$$\text{Exergy Efficiency } \eta_{EXG} = \left(\frac{Exg_{outflow}}{Exg_{inflow}}\right) \times 100 \tag{8}$$

6 Optimization Using Soft Computing

Optimization using soft computing techniques is proved to be very efficient to evaluate the design parameters of PV/T air and water collector. Singh et al. [24] optimized the parameters of a single-channel hybrid photovoltaic thermal air collector using the genetic algorithm (GAs). The overall exergy efficiency of the system is found to be 16.88% at the optimized value of parameters. Singh and Agrawal [25] work on improving the results of GA approach by using the fuzzy-based rules. The overall exergy efficiency with GA–FS approach is observed as 15.82% which is much better than an optimized system with GAs and an unoptimized system. Singh et al. [26] used Evolutionary Algorithm (EA) for parameter optimization of glazed SCPV/T.

An annual carbon emission reduction of around 88% is observed than unoptimized system. Sobhnamayan et al. [27] presented an optimized PV/T water collector system in view of the exergy concept. To optimize exergy efficiency, genetic algorithm is utilized for the given PV/T water collector system. Maximum exergy efficiency of 11.36% is experimentally obtained with optimum inlet velocity and pipe diameter.

7 Conclusion

The PV/T system is in the emerging phase and at present, there is vast acceptability for facilitating development as well as advancement in the presently available PV/T system. Numerous researchers are in this field to enhance the performance of the ordinary air and water PV/T system; whereas, some researchers have presented a small number of innovative ideas in the field of PV/T as heat pipe, nanofluid and phase change materials. The purpose of the review of traditional PV/T systems, so that bibliophile will be assessed advancement in the field of PV/T. Summary of essential PV/T methods and additional attributes of thermal and electrical systems like efficiency, exergy and energy is obtained towards the finish of each section, in order to obtain real facts with respect to technical improvement in PV/T systems initially. Apart from the advantages, further research is required to optimize cost, improvement in efficiency and technological design development.

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Exergetic Analysis of Glazed Photovoltaic Thermal (Single-Channel) Module Using Whale Optimization Algorithm and Genetic Algorithm

Sourav Diwania, Anmol Gupta, Anwar S. Siddiqui and Sanjay Agrawal

Abstract Photovoltaic thermal (PV-T) system gains greater attention in the last four decades because of its quality to produce both electrical and thermal energy simultaneously and unites the electrical and thermal components in a single unit over the conventional photovoltaic system and solar thermal system which are capable of producing electricity and thermal energy, respectively. There are various parameters which affects the performance of the PV-T system such as dimensions of the channel (duct), depth of the tedlar, thickness of insulation layer, solar cell fabrication technology, velocity of fluid flowing through the channel, temperature of the fluid at the inlet and outlet of the channel ,and cell temperature but in this paper, only four of the above parameters have been considered for optimization study. But in the proposed work, only four parameters such as air channel length (L_M), depth of the air duct (d), fluid velocity through the duct (V_F), and temperature of the air at the inlet of duct (T_{in}) have been considered for optimization using two dissimilar optimization algorithms such as whale optimization algorithm (WOA) and genetic algorithm (GA). The outcomes show that an improvement around 31.147% in exergy efficiency and 41.29% in thermal efficiency of glazed PV-T (single-channel) module is observed using WOA technique when compared with GA. Furthermore, WOA is better in contrast to GA because of faster rate of convergence in identifying the parameters.

Keywords Exergy efficiency · Photovoltaic thermal (PV-T) · Whale optimization algorithm (WOA)

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1 Introduction

In today's scenario, the demand for renewable energy is increasing day by day because the energy generated from conventional energy sources is not pollution-free. Apart from all the renewable energy sources available, solar photovoltaic is most popular because of the availability of sunlight in most part of the globe. A PV system converts sunlight into electricity while solar thermal converts sunlight into heat, but a PV-T system converts sunlight into heat and electricity simultaneously. A channel or duct is used below the PV panel in which air/water is used as a circulating fluid or cooling medium to assimilate the heat energy from the PV panel by conductive or convective process in order to enhance the electrical efficiency of the system. It was reported in the literature that electrical efficiency of the solar cell decreases with increase in temperature of upper surface of solar cell. The crucial factor about the popularity of PV-T collector is the low efficiency of the solar cell that varies from 6 to 16% at the temperature of 25 °C but in some of the countries the ambient temperature rises up to 35 °C. The rising of temperature decreases the module efficiency therefore, the extraction of heat energy from the backend surface of PV module is necessary. Depending upon the type of cooling medium, PV-T system is classified as PV-T air collector, PV-T water collector, and PV-T combi system in which both air and water are used as cooling medium. From the last three decades, a lot of research and development is done in this field in order to reduce the cost and complexity of the PV-T system. In this direction, Wolf [1] performed the experimental investigation on PV-T system and individual solar PV and solar thermal system. The PV-T is installed in Boston, USA to supply a single family residence. The area of designed collector is 50 m^2 and the collector is of non-concentrating type as shown in Fig. 1.

Crystalline silicon technology is used in the fabrication of solar PV array. From the outcomes obtained from the experimental investigation, it was concluded that that PV-T system is technically feasible and cost-effective as compared to the individual system used for electricity and thermal production. An active cooling system was designed by Teo [2] in which parallel array of cooling ducts was attached with back side of PV panel. The results obtained from the experimental analysis show

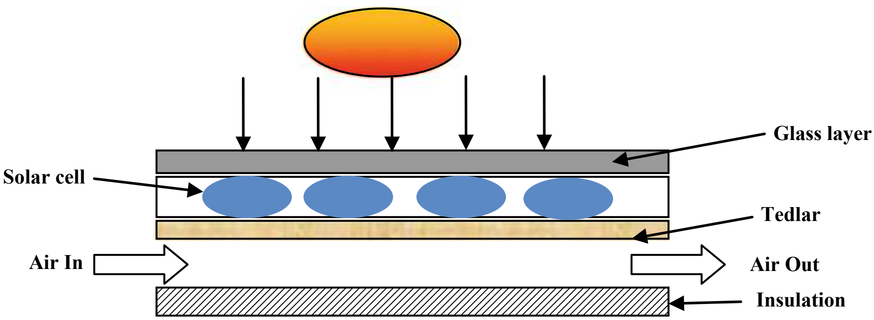

Fig. 1 PV-T air collector

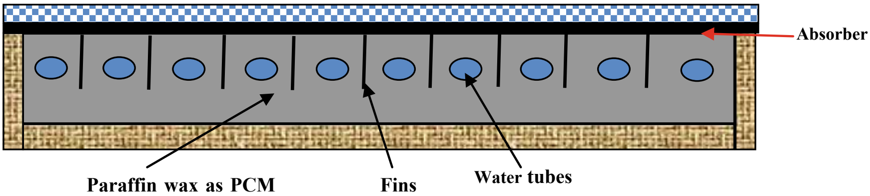

Fig. 2 PV-T water collector system with PCM

that the electrical efficiency of the system was enhanced by 4–5% with the active cooling system. Kalogirou et al. [3] reviewed the applications of various solar thermal collectors. The author discussed the latest advancement in the PV-T technology, i.e., application of phase changing materials (PCM) in the channel so that better thermal and electrical performance of the PV-T system is achieved. PCMs are used in the cooling medium due to its high latent heat of fusion, it increases the thermal absorbing capacity of cooling medium and keep the temperature fluctuations under the controlled range. Stropnik et al. [4] discussed the advantage of using PCM in the cooling medium as shown in Fig. 2. It was concluded that the average electricity production in the city of Ljubljana was enhanced by around 7.3% by mixing PCM in the cooling medium. Certain design modifications such as use of additional glass cover (upper glaze), use of thin metallic sheets and fins in the channel, etc., were also adopted by various researchers around the globe because these design modifications help in achieving the better the performance of the PV-T system. An additional glass cover (glaze) is used above the PV surface in order to trap more heat energy due to which thermal efficiency of the system improves significantly. It was reported that thermal output of the glazed PV-T system is almost double that of unglazed PV-T but decreases the electrical energy output [5]. Apart from this, there are certain disadvantages of the glazing such as edge shedding and increased temperature of the surface which leads to reduction in electrical output [6] and increases the sensitivity of photovoltaic module toward reflection losses and leads to the formation of hot spots.

The reflection losses are then reduced by using antireflective coating and hence improves the electrical efficiency of the system as compared to an ordinary glass cover [7]. Since there are a lot of design parameters which affect the performance of PV-T system. Therefore, optimization of parameters using soft computing techniques proved be very efficient in the designing of the system. In this direction, Singh et al. [8] use the genetic algorithm (GA) approach to optimize the parameters of single-channel photovoltaic thermal air collector. The outcomes demonstrate that the thermal and electrical performance of the system enhances significantly when the parameters were optimized using GA as compared to un-optimized system. In another study, the author [9] investigates the performance of the system with multi-objective function using genetic algorithm for the climatic conditions of New Delhi (India). Singh and Agrawal [10] implemented the hybrid GA-FS approach to the single-channel PV-T and the performance is compared with GA and un-optimized system. The objective function during the course of optimization is exergy efficiency. The conclusions drawn from the outcomes showed that the exergetic performance of the PV-T system is significantly enhanced using GA-FS approach as compared to GA and an un-optimized system. Singh et al. [11] worked upon evolutionary algorithm approach to optimize the parameters of glazed PV-T module and concludes that the performance of the system is improved when compared with un-optimized system.

2 System Description

In the proposed work, two different algorithms such as whale optimization algorithm (WOA) and genetic algorithm (GA) have been implemented on a single-channel glazed hybrid PV-T air collector system to find out the optimum value of parameters in order to maximize the exergetic performance of the system. There are various parameters which affect the performance of the PV-T system such as dimensions of the channel (duct) below the panel, depth of the tedlar, thickness of insulation layer, type of solar cell fabrication technology, velocity of fluid flowing through the channel, temperature of the fluid at the inlet and outlet of the channel, and temperature at the upper surface of the PV panel but in this paper, only four of the above parameters have been considered for optimization study. These four parameters were air channel length (L_M), depth of the air duct (d), fluid velocity through the duct (V_F), and temperature of the air at the inlet of duct (T_{in}). The overall exergy efficiency is considered as an objective function. The exergy efficiency, thermal efficiency, and electrical efficiency of the system are calculated according to the thermal modeling given by Agrawal and Tiwari [12].

3 Tool Used for Optimization

In this paper, two dissimilar optimization algorithms such as whale optimization algorithm (WOA) and genetic algorithm (GA) have been used to optimize the parameters of glazed PV-T (single-channel) module. WOA is a recently developed algorithm which was based upon the hunting behavior of humpback whales. WOA is introduced in 2016 by Mirjalili and Lewis [13]. For feeding themselves, humpback whale kills the little fishes close to the upper water surface. During this process, they formed a spiral or nine-like structure of bubbles in order to encircle its prey. They go down to 12 m and formed spirals of water bubbles to confuse the fishes and then swim up toward the surface as shown in Fig. 3.

This foraging behavior of humpback whales is called bubble-net feeding method. The movement of whale is classified in two ways, one in which whale goes down, make bubbles, and then goes up and second method includes different stages: coral loop, lobtail, and capture loop. When one of the whales updates its position to reach an optimal location, other whales are also attracted toward that and updated their

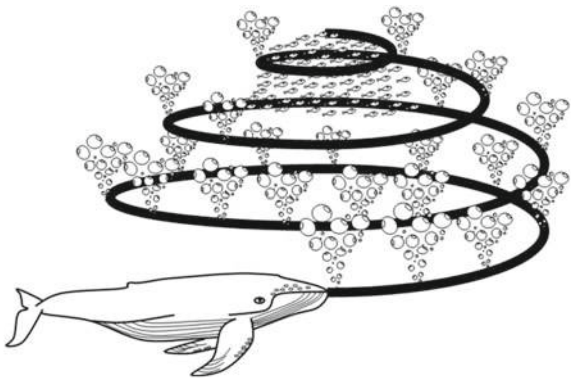

Fig. 3 Bubble-net feeding behavior of humpback whales [13]

positions according to Eq. 1.

$$\vec{D} = \left| \vec{P} \cdot \overrightarrow{Y^*}(t) - \vec{Y}(t) \right| \tag{1}$$

$$\overrightarrow{Y}(t+1) = \overrightarrow{Y^*}(t) - \vec{D} \cdot \vec{Q} \tag{2}$$

$\vec{P}$ and $\vec{Q}$ are coefficients, $\overrightarrow{Y^*}$ is the position vector of best position obtained so far, and $\vec{Y}$ is the position vector. The P and Q vectors are calculated as follows:

$$\vec{Q} = 2 \cdot \vec{a}\vec{r} - \vec{a} \tag{3}$$

$$\vec{P} = 2 \cdot \vec{r} \tag{4}$$

where $\vec{a}$ decreased from 2 to 0. The searching location dimension of whale is based upon the number of tuning variables. Since four design parameters have been considered for optimization, so a hypercube for searching space can be considered in which either optimal position or area around optimal position is the target of whale. The optimal location for whale will be that for which value of exergy the set of searching space parameters will be highest among nearby searching space positions. The flow chart which explains the proposed work is shown in Fig. 4.

4 Result and Discussion

The optimization is performed on the data for a day taken from Indian Meteorological Department, Pune for New Delhi India climatic conditions as shown in Table 1. We have compared the results obtained by optimizing the parameters with WOA with the results obtained when the parameters were optimized using genetic algorithm (GA) using the same input data.

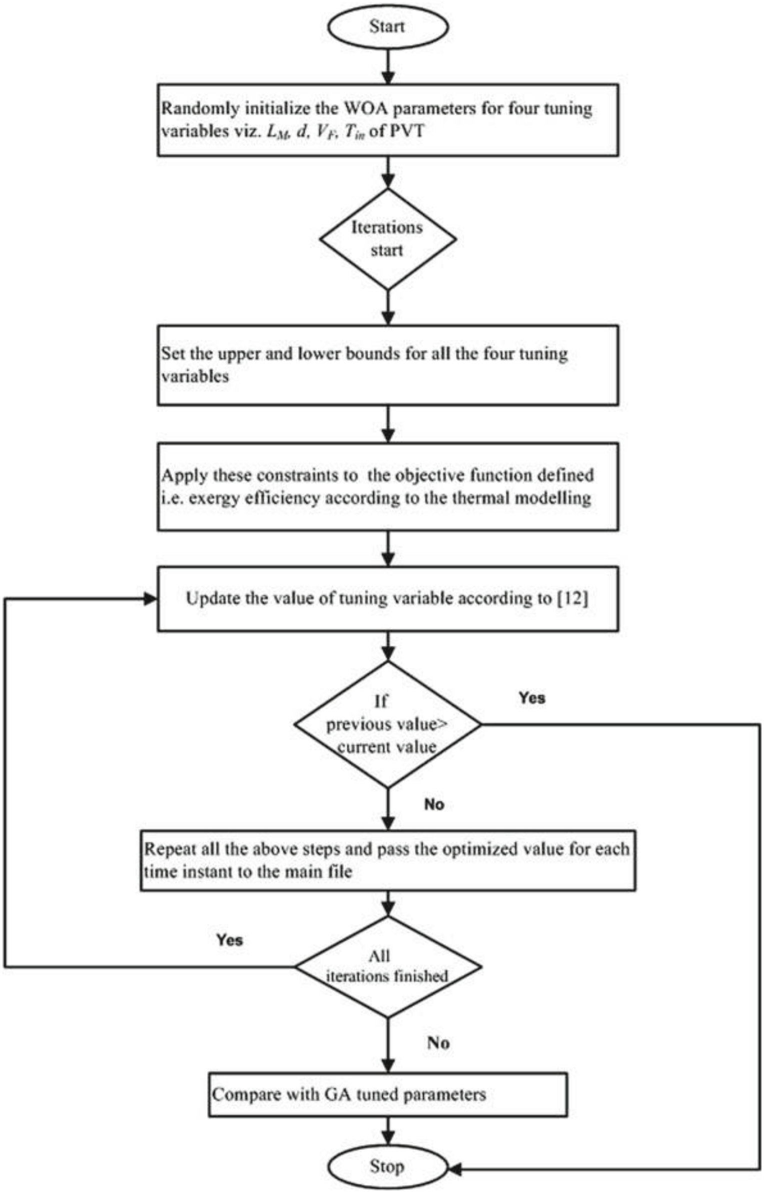

Fig. 4 Flow chart for WOA algorithm

Table 1 Input data taken from IMD, Pune

Daytime (h)	Intensity of sunlight (W/m^2)	Ambient temperature (°C)
08:00	132.99	7.90
09:00	355.56	7.90
10:00	554.69	7.90
11:00	680.73	6.60
12:00	726.74	6.40
13:00	733.85	7.70
14:00	656.08	10.60
15:00	500.00	13.00
16:00	311.46	15.00
17:00	106.42	16.50

The optimization techniques are used to solve nonlinear complex programming problems as in this work and good optimization is validated only if the iterations convergence reaches earlier and no further variation in the results is observed.

The results show that the iterations converge at a faster rate when WOA is used as an optimization technique and also it takes very less time for the identification of optimum value of design parameters for the Glazed PV-T module. The convergence curve is shown in Fig. 5. WOA optimization is best in terms of convergence rate when compared with GA. The optimization curve shows that the iteration is converging after 32 iterations in case of WOA whereas, in case of GA, it is converging after 60 iterations.

For the proposed study, exergy efficiency is considered as an objective function. Exergy efficiency is high-grade electrical energy obtained from the PV-T system. Figure 6 demonstrates that pattern for exergy efficiency is increasing from 08:00 to 13:00 h and maximum when the intensity is maximum. When the intensity of

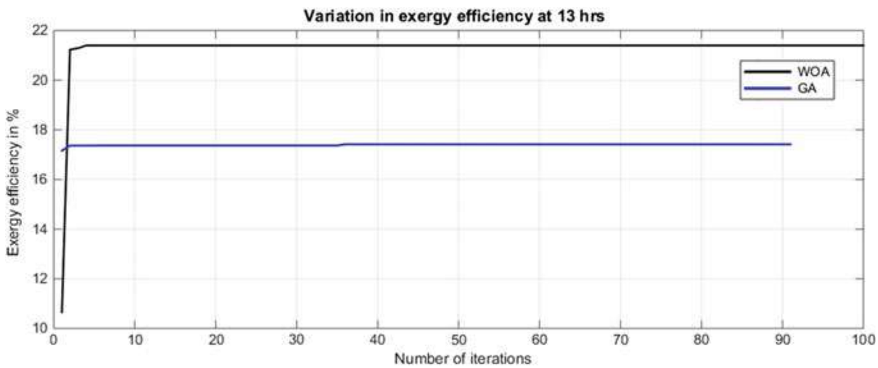

Fig. 5 Convergence curve of WOA and GA at 13 h

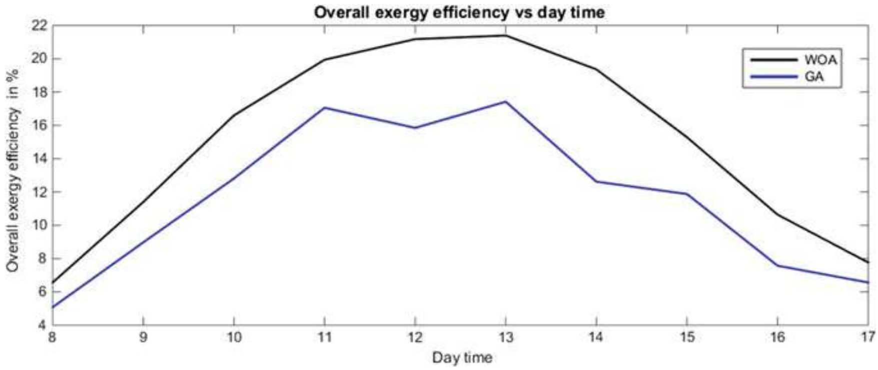

Fig. 6 Overall exergy efficiency of glazed PV-T module using WOA and GA

sunlight is decreasing, i.e., from 13:00 to 17:00 h, the exergy efficiency is decreasing. From the optimization curve, it is observed that exergy efficiency obtained when the parameters were optimized using WOA is 15.0119% and by using GA, the exergy efficiency is 11.58211%. Hence, from the results, significant improvements in the exergy efficiency of the system were observed using WOA.

The variation in thermal performance of the glazed PV-T system with time is shown in Fig. 7. The observations from the plot demonstrate that the thermal efficiency is maximum when the intensity of sunlight is maximum (i.e., around 12–13 pm) and thermal efficiency is minimum when the intensity of sunlight is minimum. The outcomes show that significant improvement in thermal efficiency was observed when the parameters were optimized using WOA.

The deviation in overall thermal efficiency with time is shown in Fig. 8. The outcomes demonstrate that the calculated value of overall thermal efficiency of the PV-T system is 43.67272% by using WOA while the calculated value of overall thermal efficiency is 33.30057% by using GA at the optimized values of parameters. The

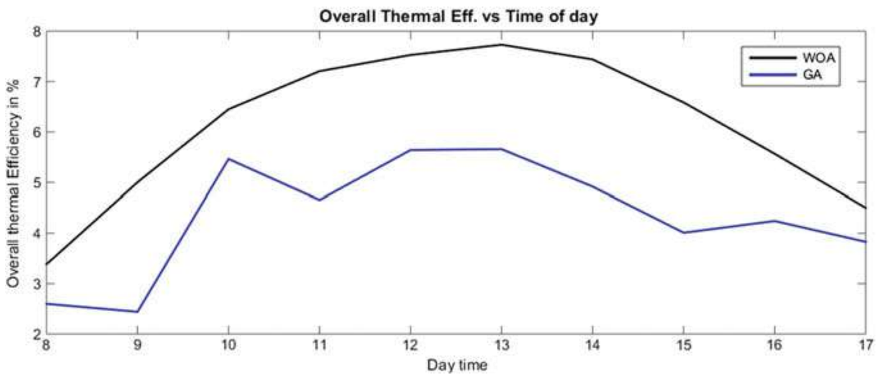

Fig. 7 Thermal efficiency of glazed PV-T module using WOA and GA

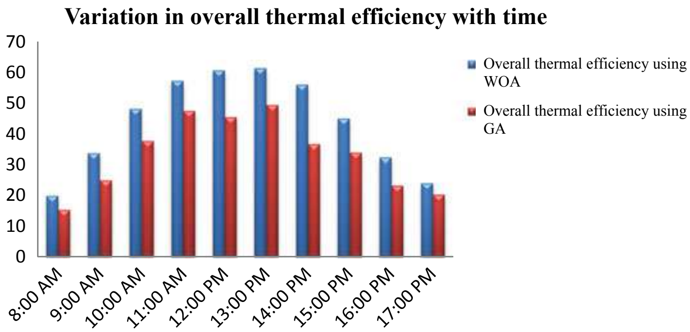

Fig. 8 Comparison of thermal efficiency using WOA and GA

outcomes demonstrate that an improvement of around 31.147% in overall thermal efficiency was observed when the parameters of glazed PV-T were optimized using WOA.

5 Conclusion

In this paper, two different optimization techniques have been implemented to glazed PV-T (single-channel) module to optimize its four variable parameters. For this purpose, the exergy efficiency of the system is considered as objective function. The outcomes of the proposed analysis demonstrate that exergy efficiency and thermal efficiency of the PV-T system were significantly enhanced by optimizing the parameters using WOA. The optimum value of exergy efficiency at the optimized value of parameters is shown in Appendix. The results show that an improvement of around 31.147% in overall thermal efficiency and 41.29% in exergy efficiency was observed when the parameters were optimized using WOA. The proposed work concludes that WOA is proved to be an efficient technique for optimizing the parameters of glazed PV-T (single-channel) module as its convergence rate is faster as compared to GA.

Appendix: Optimized Value of Parameters

Parameter to be optimized	WOA	GA
Length of the air channel, L_M (m)	0.3	0.27948
Air channel depth, d (m)	0.1	0.00092
Fluid velocity at the inlet, V_F (m/s)	1.5	1.37070

(continued)

(continued)

Parameter to be optimized	WOA	GA
Temperature of fluid at inlet, T_{in} (°C)	4.98	3.62050

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Effect of thermoelectric materials in electrical and thermal performance of photovoltaic thermal (PVT) collector

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Effect of thermoelectric materials in electrical and thermal performance of photovoltaic thermal (PVT) collector

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Abstract. A photovoltaic integrated thermal (PVT) collector with thermoelectric material has been proposed in this communication, where a channel or duct has been used below the photovoltaic module in which air has been circulated to extract the heat taken by the photovoltaic module. Hence in PVT system, electrical energy from photovoltaic and thermal energy from duct are taken at the output. In this collector, thermoelectric (TE) is used to change the thermal energy by removing the waste heat of photovoltaic module into electric energy. In proposed PVT with thermoelectric system, TEs are generally appended at the back of the photovoltaic to improve the efficiency of PVT collectors. Thermal modelling has been presented for PVT collector with thermoelectric. The effect of thermoelectric material has been analysed for PVT collector. The electrical energy gain for photovoltaic collector and overall electrical energy gain with thermoelectric has been theoretically calculated. From the computed results, the overall electrical output is observed of PVT system with thermoelectric material; it is higher than only PVT system due to thermoelectric. As PVT system without thermoelectric generates only electrical energy due to PV and thermal energy but PVT system with thermoelectric generates electrical energy due to PV and thermoelectric both as well as thermal energy so overall exergy of PVT system with thermoelectric is higher than only PVT system. Hence PVT system with thermoelectric shows better results than only PVT system in respect of electrical, thermal and overall exergy gain.

Keywords: PVT collector, PVT collector with thermoelectric, thermal modelling, electrical gain, exergy gain

1. Introduction

Nowadays the renewable energy resources are very popular in terms of the energy generation process. As per the survey, the production of energy through the renewable sources was 9% in the year 2009 will be expected to grow 23% in 2035. Solar power plant is an important source of clean energy and generates a large amount of power in the present scenario. In solar photovoltaic, maximum of the incident sunlight is transformed into heat and only 15%-20% is changed into useful output electrical energy. The generated heat decreases its electrical efficiency as well as reduces the life time of PV module [1]. An integration of photovoltaic with thermal technology has been presented as photovoltaic thermal (PVT) system to use this waste heat. A channel or duct is applied below the PV panel in which air/water is applied to take the heat energy from the photovoltaic by conductive or convective process so as to improve the electrical performance of this hybrid system [2]. Hence both electrical and thermal energies are obtained at output of PVT system. A considerable number of researches have been conducted in the designs of photovoltaic air/water collector because its performance is affected by several parameters [3].

Mojumdera et al. [4] analyse single-pass PV/T air collector with thin rectangular fins throughout the length of air channel to dissipate heat. Kumar & Rosen et al. [5] presented the comparative study of double-pass PV/T air based collector with and without fins. Fins are used in this system at the base to improve the efficiency of given system by enhancing heat transfer rate. Vats et al. [6] discussed the effect of increasing packing factor on the overall annual energy of photovoltaic and found that increase in packing factor not always increase the overall output energy because with increase in packing factor, the temperature at the output of channel increases by absorbing the higher amount of thermal energy. Dubey and Tiwari [7] outlined and exhibited integrated PV/T solar based water collector. Some logical articulations were inferred as climatic conditions and design parameters, on the basis of absorber area observed that if coverage area of PV is reduced to one third than instantaneous efficiency rises from 33% to 64%.

Chow et al. [8] considered changes when coating on PV/T-thermosyphon system is used from exergy and thermodynamics perspective. From exergy perspective observed that expansions of packing factor, efficiency of cell, wind speed and proportion of water mass to collector region were ideal for system without glazing while surrounding solar radiation and temperature were positive for system with glazing. Mishra and Tiwari [9] examined water based PV/T-system based on constant collector temperature. It was found that fully covered PV was appropriate for generation of electricity as well as partially covered PV was reasonable for generation of heated water. Fudholi et al. [10] presented of spiral/web/direct flow absorber and observed that system's total efficiency was 68.4% for spiral absorber PV/T collector; it is found better than web and direct absorber. Dupeyrat et al. [11] created PV/T water system having better lamination of cell to get more heat exchange in between fluid and absorber. Hazi et al. [12] created a numerical model; it measured monetary markers and energy limits of PV/T water system and represented payback time was less for given system.

Thermoelectric (TE) are basically combination of many thermocouples and used to change the thermal energy by removing the waste heat of photovoltaic module into electric energy. The temperature of photovoltaic module can be reduce and control by using thermoelectric. In proposed PVT-TE hybrid module, TEs are generally appended to the back of the photovoltaic to improve the efficiency of PVT air/water based collectors [13].

A lot of research has been conducted in the field of PVT in last 30 years but there is very limited study in the literature of PVT with thermoelectric system. Lertsatitthanakorn et al. [14] designed an air based TE solar collector with double-pass in Thailand. It is reported that the overall efficiency of this hybrid TE system is increased. Yang and Yin [15] based on theoretical approach observed for a hybrid system comprising of photovoltaic, thermoelectric and hot water gives 30% more output electrical power contrasted with photovoltaic hot water thermal system and only PV system. Deng et al. [16] presented a hybrid design containing photovoltaic, thermoelectric generators with a heat collector. Also, it is exhibited that the overall efficiency of thermoelectric generators and photovoltaic are improved in this hybrid system. Onget. al. [17] assessed the execution of a PV based, evacuated tube heat pipe system for water heating and additionally, TE modules for generating electrical energy. Experimentally different temperatures are recorded by taking various water coolant flow rates and electrical efficiency is calculated as about 0.16%. Li et al. [18] experimentally considered a hybrid photovoltaic thermoelectric generator system in which TEG module is attached by a micro-channel heat pipe with PV to remove the heat. The electrical performance of this given hybrid PV/TEG is compared with a conventional PV system under different ambient conditions. It is found an improvement in overall electrical efficiency by 0.82% of this hybrid system over conventional PV system.

Dimri et al. [19, 20] presented thermal modelling of PVT-TE collector to observe the efficiency of this hybrid system. The designed PVT-TE collector is compared with only PV and PV-TE collector, and found that PVT-TE collector gives better overall electrical efficiency than PV-TE and PV collector by 4.7% and 7.3% respectively. Dimri et al. [21] considered a PVT-TE collector with different kinds of base materials of photovoltaic modules. It is found that for opaque base material, the overall electrical efficiency by 1.9 – 2.8% and thermal efficiency by 20.8 – 21.8% of PVT-TEC water collector is more than PVT-TEC air collector. The performance of all three types of base cover material (opaque, semitransparent and Aluminium) of PVT-TEC water collector is considered and on comparing it is found that the performance for PVT-TEC water collector with Aluminium base is much better than other. In literature, hybrid PV-TE generator system is found in many studies and many of them having heat sink in the TE generators cold side to make a large temperature gradient. However, the expelled heat for this situation is discharged to the environment so the overall efficiency of the system is reduced as this energy is lost. Lekbir et al.[22] proposed a nanofluid based hybrid PVT-TEG design. As nanofluid is having higher cooling potential than heat sink so in this design nanofluid is used in place of heat sink to increase both photovoltaic and TE generators performance, and also using waste heat as valuable energy.

2. System description

In this paper, a PVT collector with thermoelectric has been considered, where the thermoelectric material is used below the PV module to convert waste heat in to electrical energy as shown in Figure 1. In this given model, a channel has been used below the photovoltaic and thermoelectric material in which air is passed to absorb the heat of the panel. The electrical output of photovoltaic improves by placing a thermal system below the PV and thermoelectric. Additional electrical energy is also generated by using thermoelectric material. In this system, an insulation layer below the thermal channel has been used to trap the heat so that heat may not dissipate through the bottom part of the system. In this research work, analyse the electrical and thermal performance of the PVT system with thermoelectric.

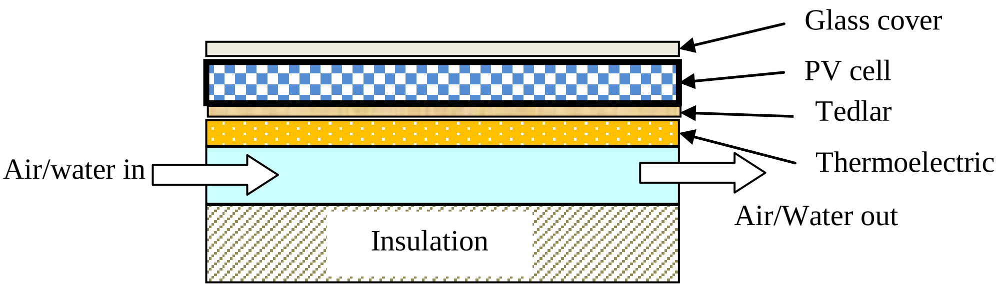

Figure 1. Proposed photovoltaic thermal system with thermoelectric material [18]

3. Thermal modelling

The energy balance equations have been developed for photovoltaic thermal air collector integrated with thermoelectric material [19-24], when taking an elemental area bdx. The following equations can be given for different part of the integrated PVT thermoelectric system:

a) For photovoltaic module-

$$\tau_g \alpha_{sc} I(t) bdx = U_{t,c-a}(T_{sc} - T_a) bdx + h_t(T_{sc} - T_{tec,top})\beta_{tec} bdx + U_{b,c-a}(T_{sc} - T_f)(1 - \beta_{tec}) bdx + \eta_{sc}\tau_g I(t) bdx \quad (1)$$

b) For tedlar-

$$h_t(T_{sc} - T_{tec,top})\beta_{tec} bdx = U_{tec}(T_{tec,top} - T_{tec,bottom})\beta_{tec} bdx \quad (2)$$

c) For TE module-

$$U_{tec}(T_{tec,top} - T_{tec,bottom})\beta_{tec} bdx = h_{tf}(T_{tec,bottom} - T_f)\beta_{tec} bdx + \eta_{tec} U_{tec}(T_{tec,top} - T_{tec,bottom})\beta_{tec} bdx \quad (3)$$

d) For fluid flowing below TE module-

$$h_{tf}(T_{tec,bottom} - T_f)\beta_{tec}bdx + U_{b,c-a}(T_{sc} - T_f)(1-\beta_{tec})bdx = m_f C_f \frac{dT_f}{dx}dx + U_b(T_f - T_a)bdx \quad (4)$$

The expressions for T_{sc}, $T_{tec,top}$ and $T_{tec,bottom}$ are obtained, after solving Eqs. (1-3) and given as:

$$T_{sc} = \frac{(\alpha\tau)_{eff}I(t) + U_{t,c-a}T_a + h_t T_{tec,top}\beta_{tec} + U_{b,c-a}(1-\beta_{tec})T_f}{U_{t,c-a} + h_t\beta_{tec} + U_{b,c-a}(1-\beta_{tec})} \quad (5)$$

$$T_{tec,top} = \frac{h_{p1}(\alpha\tau)_{eff}I(t) + U_{tec,top-a}T_a + U_{tec}T_{tec,bottom}\beta_{tec} + U_{tec,top-f}T_f}{U_{tec,top-a} + U_{tec}\beta_{tec} + U_{tec,top-f}} \quad (6)$$

$$T_{tec,bottom} = \frac{(\alpha\tau)'_{eff}I(t) + (1-\eta_{tec})U_{tec,bottom-a}T_a + h_{tf}T_f\beta_{tec} + (1-\eta_{tec})U_{tec,bottom-f}T_f}{(1-\eta_{tec})U_{tec,bottom-a} + h_{tf}\beta_{tec} + (1-\eta_{tec})U_{tec,bottom-f}} \quad (7)$$

By taking the inlet and outlet boundary conditions, following expression for average fluid temperature is computed:

$$\bar{T}_f = \left[\frac{[h_{p3}(\alpha\tau)'_{eff} + h'_{p1}(\alpha\tau)_{eff} + h'_{p2}h_{p1}(\alpha\tau)_{eff} + h'_{p3}(\alpha\tau)'_{eff}]I(t)}{(U_{fa} + U_b)} + T_a\right]\left[1 - \frac{1-exp\left(\frac{-(U_{fa}+U_b)bL}{m_f C_f}\right)}{\frac{(U_{fa}+U_b)bL}{m_f C_f}}\right] + T_{fi}\left[\frac{1-exp\left(\frac{-(U_{fa}+U_b)bL}{m_f C_f}\right)}{\frac{(U_{fa}+U_b)bL}{m_f C_f}}\right] \quad (8)$$

After putting $\bar{T}_f$ from Eq. (8) in Eq. (7), the TE bottom end temperature, $T_{tec,bottom}$ is calculated. Further, putting $T_{tec,bottom}$ in Eq. (6), the expression for TE top end temperature, $T_{tec,top}$ is obtained. Finally, by putting $T_{tec,top}$ in Eq. (5), the expression for average solar cell temperature, T_{sc}can be computed.

4. Comparative results of PVT module with and without thermoelectric

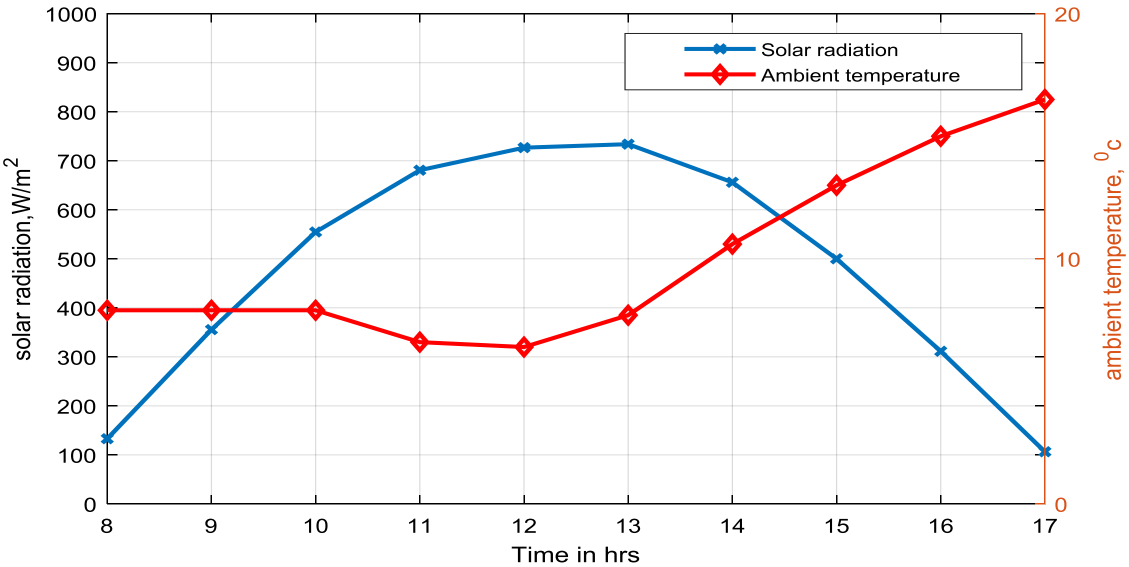

Figure 2. Variation of solar radiation and ambient temperature with time

In this module, a channel is used below the PV module and thermoelectric in this air is used for cooling and to absorb the heat from the photovoltaic and also to keep one terminal of thermoelectric as cool. In the given model, the electrical efficiency is considerably enhanced by using channel and thermoelectric material below the photovoltaic module. Fig. 2 shows the variation of the solar radiation (in W/m2) and ambient temperature (^{o}C) for New Delhi, India from 8:00 a.m. to 5:00 p.m. on a day of January, 2019. It is observed from the graph as shown in Fig. 2 that solar radiation is maximum at 1:00 p.m. and ambient temperature is in the range of 6–17 °C.

Fig. 3 indicates the variation of theoretically calculated electrical energy gain generated by photovoltaic, thermoelectric material and overall gain for the PVT system with thermoelectric material. The overall electrical energy of this hybrid system is the total electrical energy due to photovoltaic and thermoelectric material; it is higher than the electrical energy only due to the photovoltaic only. Hence the electrical energy of the given photovoltaic thermal collector with thermoelectric is better than only PVT collector.

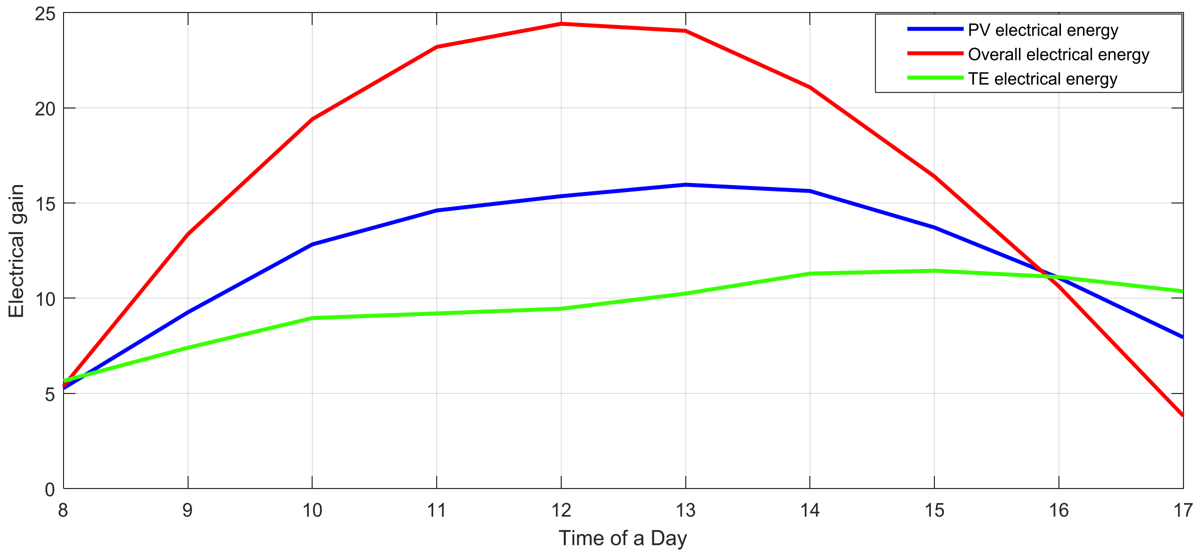

Figure 3. Variation of theoretically calculated electrical energy by PVT collector with thermoelectric material

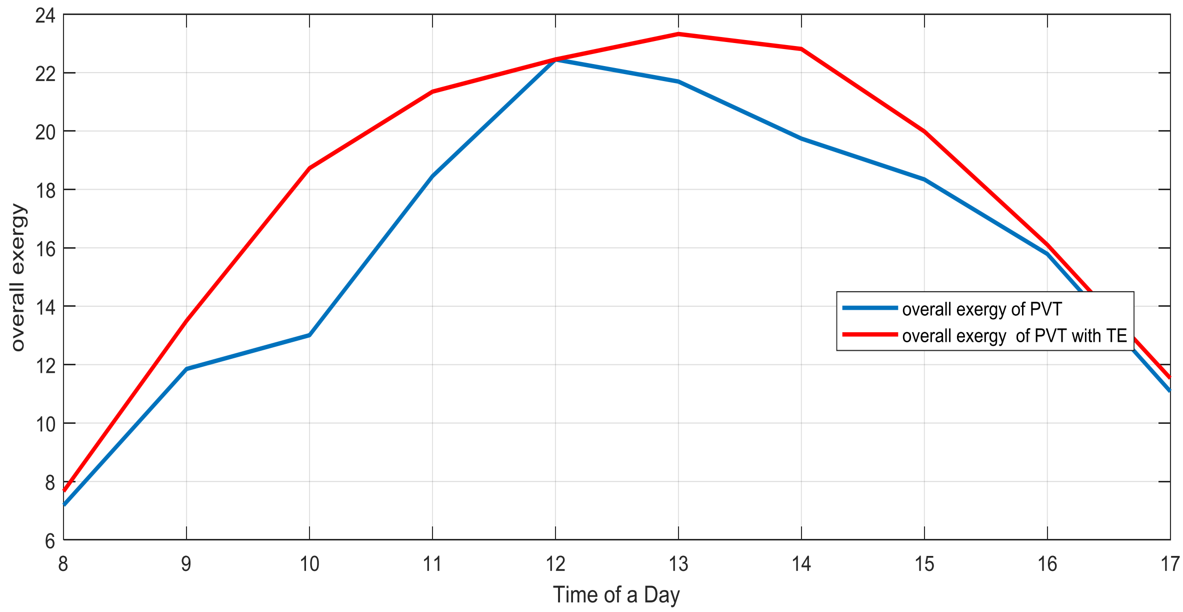

Figure 4. Variation of overall exergy of PVT collector with and without thermoelectric material

Variation of overall exergy of the PVT collector with and without thermoelectric material is shown in Fig. 4. It is observed that overall exergy of PVT collector with thermoelectric material having component of thermal energy along with electrical energy of photovoltaic and thermoelectric is higher than the overall exergy of PVT collector that is having component of thermal energy and electrical energy of photovoltaic only.

5. Conclusions
In the given work, theoretical modelling for PVT collector with thermoelectric material has been presented and compared with the PVT collector. TAs per the above study, the following points have been concluded:
• The overall electrical energy of PVT collector with thermoelectric is higher than the PVT collector only, as thermoelectric material is capable to generate electrical energy.
• In this proposed PVT module with thermoelectric material, TEs are appended to the back of the photovoltaic to attain the improved performance of PVT air collectors.
• This PVT collector with thermoelectric material shows better overall exergy, when compared with same type PVT collector.

6. Nomenclature

τ_g	Transmittivity of glass	α_{sc}	Absorptivity of solar cell
b	width of collector(m)	T_a	Ambient temperature(^{0}C)
L	length of collector(m)	T_{sc}	Solar cell temperature(^{0}C)
dx	Small length (m)	T_f	Temperature of air(^{0}C)
A_c	Area of solar cell(m^2)	β_{tec}	Packing factor of thermoelectric
$I(t)$	Solar radiation intensity(W m^{-2})	η_{tec}	Efficiency of thermoelectric (%)
η_{sc}	Efficiency of solar cell(%)	h_{p1}, h_{p2}, h_{p3}	Penalty factor due to glass, tedlar and thermoelectric respectively
C_f	specific heat of fluid or (J kg^{-1} K)		
m_f	Mass flow rate of fluid in channel(kg/s)	h_t , h_{tf}	heat transfer coefficients (W/m^{2}K)
$T_{tec,top}$, $T_{tec,bottom}$	Temperature of top and bottom surface of thermoelectric (^{0}C)	$U_{tec,top-a}$, $U_{tec,bottom-a}$, $U_{tec,top-f}$, $U_{tec,bottom-f}$, $U_{b,c-a}$, $U_{t,c-a}$, U_b, U_{fa},U_{tec} - overall heat transfer coefficients for different parts of hybrid system	

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Performance assessment of hybrid PVT air collector using GSA-CS algorithm

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Performance assessment of hybrid PVT air collector using GSA-CS algorithm

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Abstract. In the last few decades, enormous attention is drawn towards PV/T systems due to their advantages as compared to solar PV or solar thermal systems individually. In this proposed paper, hybrid Gravitational Search Algorithm (GSA)-Cuckoo Search (CS) has been implemented to optimize the parameters of glazed hybrid PVT air collector. Although there are various parameters which affects the thermal and electrical performance of PVT system but in this paper only four parameters namely Channel length below the PV panel, channel depth, velocity of fluid flowing through the channel and temperature of fluid at the inlet of the channel have been considered for optimization using the hybrid approach. The outcomes shows that GSA-CS algorithm is proved to be very efficient techniques to be used to optimized the parameters of hybrid PVT module. The result of the analysis shows that the average value of exergy efficiency is 14.8228% when the parameters are optimized using hybrid GSA-CS algorithm.

Key Words: Gravitational Search Algorithm; Cuckoo Search; PVT module

1. Introduction

The industrial reformation in the 18th century has tremendously hiked the energy demand globally. Around 14% of total energy consumption globally is provided by sustainable power sources [1]. Amongst all the available renewable energy sources, the solar PV has the highest capital cost, but due to its lower operational cost and maintenance [2], this technology is acknowledged around the world. Other advantages of solar PV are increased efficiency and pollution free energy [3]. The installed capacity of solar PV is increasing day by day worldwide due to its above-mentioned point of interests.

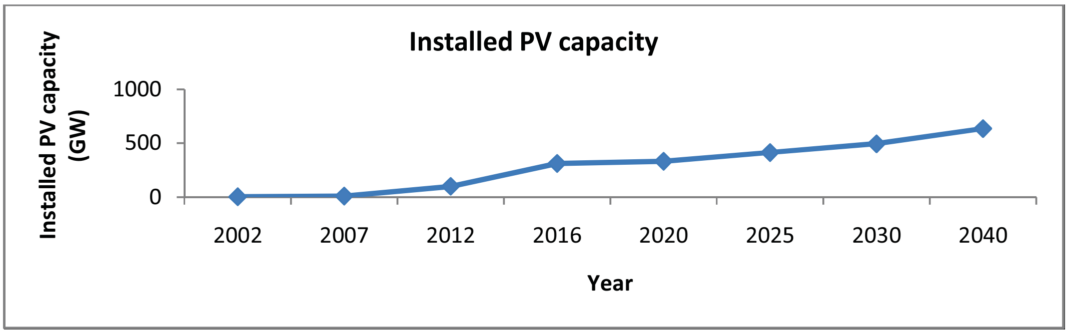

Figure 1. Worldwide installed capacity of PV

Banker & Pearce [4] discussed the development in PV technology over the last the two decades. The PV technology gained popularity due to decline in the price of a photovoltaic module. This reduction in cost is mainly due to competition among the manufacturers. Different governments in various parts of the world also show interest in emerging PV technology. Incentives had also been provided to the consumers in many parts of the world. Liou [5] discussed different silicon and non-silicon based technologies utilized for photovoltaic applications as depicted in Figure 2.

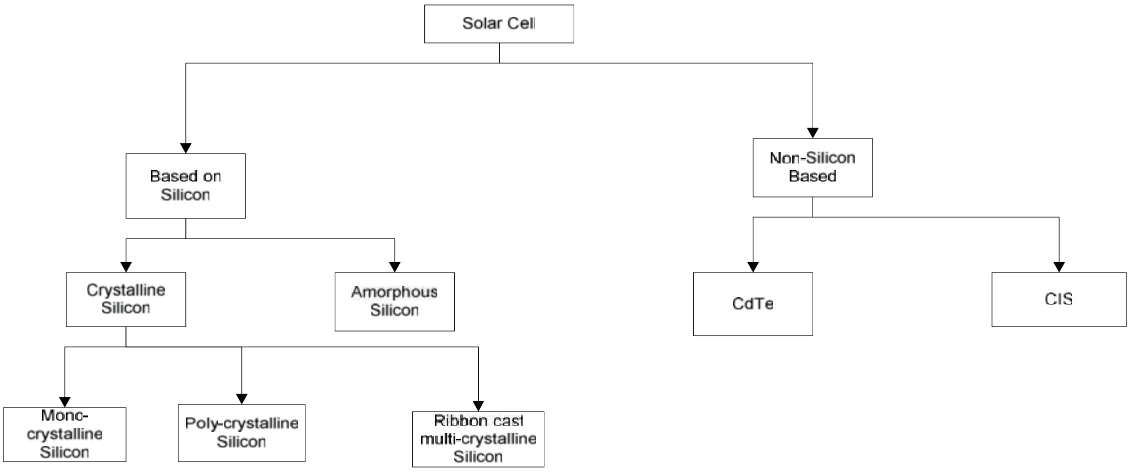

Figure 2. Classification of PV technologies [5]

The crystalline silicon technology is widely accepted as compared to other solar cell technologies because it exhibits higher efficiency as compared to other silicon based PV modules. In the most recent research, efficiency of multi-crystalline silicon technology up to 23% is reported in the literature [6]. But there are various hindrances such as easy availability of the sun energy, lesser efficiency and high payback time. Most of the incident sunlight is converted into heat and only a small portion (15%-19%) of it is converted into electrical energy. This heat energy not only reduces the life time of PV module but also decreases its electrical efficiency [7]. In order to utilize the wasted heat, the concept of PVT is introduced. The PVT system combines the solar PV technology and solar thermal technology. In PVT system, a duct/channel/tube is used below or above the module and circulating fluid is used in the channel to pull out the heat energy absorbed by the panel [8].

An experimental study is conducted by Ahn et al. [9] to examine the performance of PVT- air collector. The heated air exhausted from the channel was again passed through heat recovery ventilation (HRV) to preheat the heated air to improve the thermal efficiency (η_{th}) of the system. It has been observed from the experimental investigation that the thermal and electrical performance of the system has improved significantly. Slimani et al. [10] compared a single pass design of PVT-air collector with a glazed double pass PVT- air collector. The outcomes of the experiments show that the introduction of glazing (additional glass cover) caused an increase in temperature of all layers due to the greenhouse effect. The outlet temperature of double pass design reached up to 47 °C while in single pass design, the maximum temperature at the outlet was around 32 °C. The increase in temperature of upper PV module surface causes the decrease in electrical efficiency (η_{ele}). Thus, the double pass design has a lesser electrical efficiency compared to single pass design. Sarhaddi et al. [11] worked upon a mathematical expression of overall energy of flat plate PVT air collector. From the experimental evaluation, the electrical, thermal and overall efficiencies of the flat plate PVT system are found to be 10.01%, 17.18%, and 45%, respectively. From the experimental analysis, following inferences are drawn: 1.The η_{th} and $\eta_{overall}$ of PVT- air collector reduced with an increase in input temperature at the channel, 2. The η_{th} and $\eta_{overall}$ increases with increase in inlet air velocity, 3. The η_{th} and $\eta_{overall}$ initially increases with an increase in solar radiation intensity (up to 100 W/m2) but later the overall energy efficiency and electrical efficiency tend to reduce slightly.

Hegazy [12] experimentally investigated the effectiveness of the four different types of PVT-air collector depicted in Table 1. These PVT configurations are classified as model A, B, C and D based on the position of channel.

Table 1. Classification of PVT module based on position of air channel

Model	Air flow pattern
A	Above the PV panel
B	Below the PV panel
C	Single pass type with channel both sides of PV
D	Double pass type with channel both sides of PV

The effect of air velocity through the channel and selectivity of absorber plate has also been examined. From the experimental investigation, following inferences are drawn: 1. The electrical energy output and thermal output of model B and model D are almost similar and higher than that of model A, 2. The model C demands least fan power, hence its electrical efficiency is better than other three configurations discussed and 3. The thermal gain of any particular model increases with increase in fluid mass flow rate through the channel but at the same time, this requires more fan power hence has a slightly lower electrical efficiency. Qureshi et al. [13] discussed the impact of various environmental parameters viz. Air velocity, humidity, atmospheric temperature and temperature of solar cell on the performance of hybrid PVT- air collector.

PVT- system with upper glazing traps the heat from the sunlight and helps in improving the thermal efficiency when compared with unglazed system. Additional glass cover (glazing) is used above the PV surface to trap more heat energy which increases the thermal energy output almost double that of unglazed PVT but decreases the electrical energy output [14]. Other effects of glazing are edge shedding and increased temperature which may lead to reduction in electrical output [15] and increase the sensitivity of photovoltaic module towards reflection losses and lead to the formation of hot spots. The η_{ele} the PVT- air collector is inversely proportional to number of glass cover (glaze). As the number of glass cover over the PV module increased, the η_{th} of the system increases while the η_{ele} reduces [16].

Jin et al. [17] worked upon modified PV/T air collector by adding rectangular tunnel heat exchanger in the channel and compared its performance with conventional PV/T air collector. From the experimental investigation, it has been concluded that the thermal and electrical efficiencies for the modified system were 54.70% and 10.02% respectively which is significantly higher as compared to conventional PV/T air collector. Hussain et al. [18] uses honeycomb heat exchanger of hexagonal shape in the air channel. It has been concluded from the experimental investigation that the thermal efficiency of the system was improved significantly with the modification in the air channel. At a solar irradiance level of 828 W/m2 and mass flow rate of 0.11kg/s, the ηth of the system was found to be 87%.

2. System description

In the proposed work, a single channel gazed PVT module is considered having 36 cells arranged in 9 rows as shown in Figure 3. The solar cells are arranged in series and in parallel to increase the voltage and current ratings respectively of the module. The objective of the proposed work is to analyze the exergetic performance of the PVT system using hybrid GSA-CS algorithm. In the proposed model, the extra glass cover is used above the PV module to trap the sunlight. Below the PV module, a channel is used in which air is circulated to absorb the heat energy of the panel. The layer of insulation is used below the channel so that the trapped heat in the channel may not dissipate through the bottom part of the system. Only four variable parameters i.e. Channel length, channel depth, velocity of air flowing through the channel and temperature of fluid at the input of channel have been considered for the analysis.

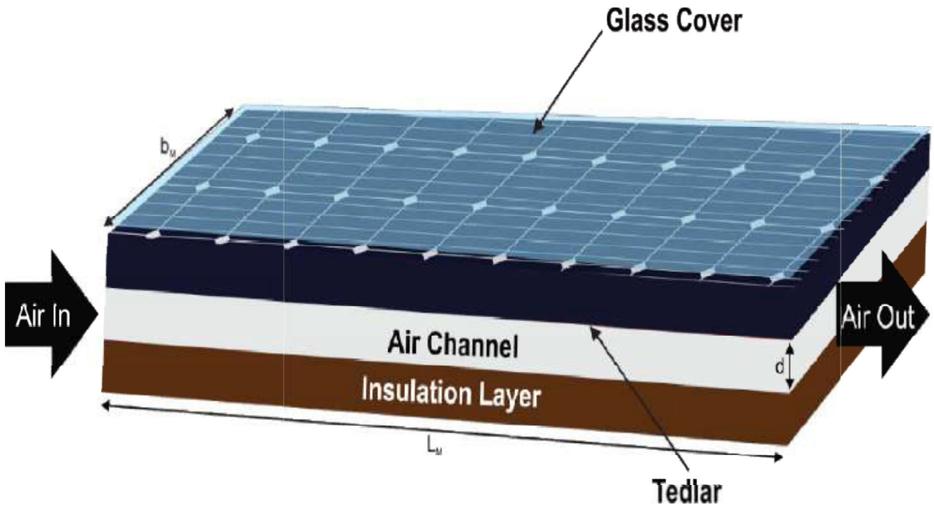

Figure 3. Proposed single channel photovoltaic thermal module [20]

3. Optimization of the system

In this paper, the hybrid GSA-CS algorithm is used to find out the optimum value of objective function (exergy efficiency) by considering the values of variable parameters within the specified limit (upper and lower bound). The hybrid GSA-CS algorithm combines the best properties of gravitational search algorithm and cuckoo search algorithm. In GSA, each search agent is categorized according to its position, gravitational mass, velocity and inertial mass. In cuckoo-search (CS) algorithm, the swarms were divided into various groups according to their identity (roosters, chickens and hens). The groups were decided on the basis of fitness function. The swarms with highest fitness value will be categorized as roosters while the swarms having lowest fitness value will be identified as chickens and rest will categorized as hens. Hens can choose a group for its survival haphazardly and the relation between the hens and chickens is resolved arbitrarily. In Cuckoo Search algorithm, the initialization of population is arbitrary. That's why it can't ensure success in every solution. The irregular arrangements of population cause the solution to be far away from the optimized solution. In each selected group, every chicken can be viewed as an answer, though a moved chicken is another arrangement. The optimal arrangement is held at last, which is the extreme objective of this calculation. The hybrid GSA-CS optimization technique is applied to the PVT module and the fitness value of each search agent is calculated according to gravitational search algorithm. The best fitness value so far is the optimal location of the search agent. The position of the search agent is updated in the next iteration according to the cuckoo search algorithm [19]. The best updated solution is find out using the hybrid approach for t = t+1 iterations. The pseudo code for the hybrid GSA-CS algorithm is shown in figure 4.

```
1.  Initialize all the design parameters of PVT system
2.  load the solar irradiance and temperature data for a day
3.  for i=1:number of time instants
4.          randomly initialize the GSA-CS parameters for four tuning variables of solar cell
5.          for j=1:GSA-CS iterations
6.                  set the upper and lower bounds for all four variables parameters
7.                  pass these to objective function written to calculate the exergy efficiency
8.                  save this exergy value for first iteration.
9.                  If exergy (t+1)>exergy(t)
10.                         Best_sol(t+1)=current_position(t+1)
11.                 End if
12.                 Update the current positions as per GSA update equations
13.                 Pass the GSA updated to cuckoo search algorithm to inherit its local serach
                    property.
14.                 Update the GSA updated position by levy flight formulation by cuckoo
                    search.
15.                 Check for constraints
16.                 If constraints ==True
17.                         Accept the update position
18.                 Else
19.                         Randomly initialize the current positions
20.                 End if
21.                 Repeat the steps from 7-20
22.
23.         End for
24.         If iteration (t)==iteration (end)
25.                 Select the best solution
26.         End if
27. End for
28. pass the optimized value for each time instants to the main file
29. stop if all the time instants design variables are optimized
30. take the mean value of design parameters
```

Figure 4. Pseudo-code for hybrid GSA-CS algorithm

4. Optimization results and analysis

The exergetic performance of glazed PVT module has been evaluated by optimizing its four different variable parameters (length of the channel, depth of the channel, velocity of air flowing through the air duct and temperature at the input of the air channel) using hybrid GSA-CS algorithm. In glazed PVT module, a single channel is used below the PV module in which air is used as a cooling fluid to absorb the heat energy from the PV surface. By using channel/duct below the PV module, its electrical efficiency is enhanced significantly. Therefore, the removal of heat from the PV module is necessary. The hourly data for solar radiations and ambient air temperature used for the optimization has been taken from IMD, Pune for a day in the month of January for the climatic conditions of New Delhi, India as shown in Figure 5 [20]. There are various parameters which have an impact over the effectiveness of PVT module but in this proposed work, only four parameters have been considered. For the proposed module, the variation in temperature at the output of channel, exergy efficiency, electrical energy and thermal energy have been calculated according to thermal modeling presented by Agrwal and Tiwari [20].

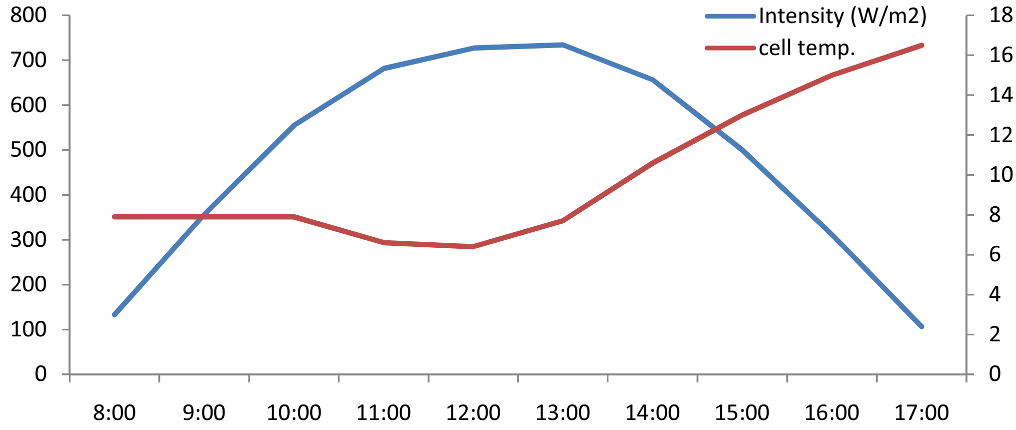

Figure 5. Variation in intensity and temperature with time

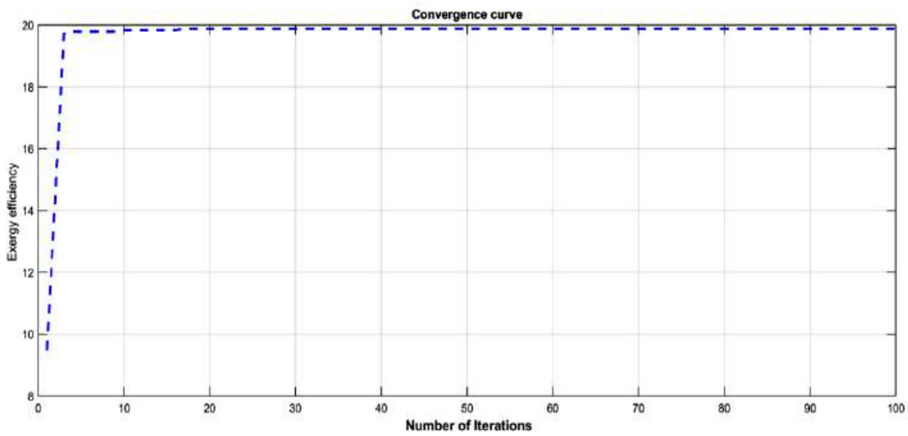

Figure 6. Convergence curve for PVT using GSA-CS algorithm

The convergence curve for the hybrid GSA-CS algorithm for the different time of a day shows that the iteration converges at a very fast rate and it takes less time in the recognition of optimized value of parameters. The curve showing the convergence rate is depicted in Figure 6 when the intensity of sunlight is maximum i.e. 1:00 PM. From the plot, it has been observed that the exergy efficiency (ηEx) is highest when the intensity of sunlight is maximum.

The variation in ηEx of the PVT module with time of a particular day is depicted in Figure 7. The Trend for exergy efficiency is increasing when the intensity of sunlight is increasing i.e. from morning 08:00 AM to 13:00 PM and it shows decreasing trend when the intensity of sunlight is decreasing i.e. from 13:00 PM to 17:00 PM. By using hybrid GSA-CS optimization algorithm, the solution converges with less than 10 iterations and also the convergence time is very less. The average value of ηEx of the PVT system is 14.85228% at the optimized values of the parameters as shown in table 2.

Table 2. Optimized values of variable parameters

Exergy efficiency	Length of channel	Depth of the channel	Temperature of fluid at the input	Velocity of fluid at the input
14.85228	0.414538 m	0.3 m	2.3	1.5 m/s

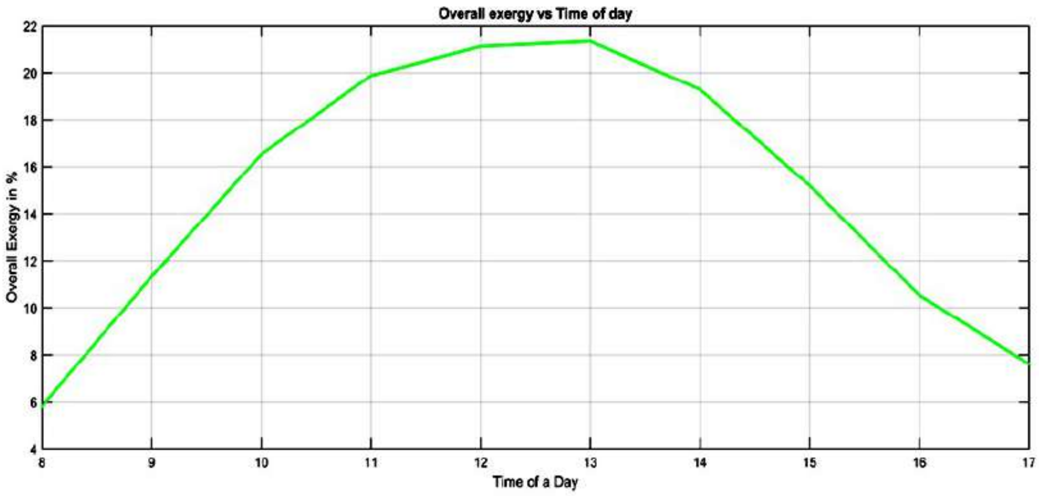

Figure 7. Variation in overall exergy efficiency of system with of a day

5. Conclusion

The following conclusions are drawn on the basis of above study:

• The convergence rate of hybrid GSA-CS algorithm is fast. The solution converges in less than 20 iterations.

• The average value of exergy efficiency (η_{Ex}) of the glazed PVT module is 14.85228% at the optimized value of parameters.

• The hybrid GSA-CS algorithm is proved to be an efficient technique for optimizing the parameters of PVT systems.

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Experimental Validation & Performance Analysis of 100kW Solar Photovoltaic System

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Akhilesh Rai ; Anmol Soni ; Anmol Gupta ; Ashish Thombre **All Authors**

Abstract: This paper focused on modelling & simulation of 100kW Solar Power Plant. In today's world as the demand of supply is increasing, a technology is needed to meet requiremen... **View more**

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Abstract:

This paper focused on modelling & simulation of 100kW Solar Power Plant. In today's world as the demand of supply is increasing, a technology is needed to meet requirements using renewable resources. The application of renewable energy in electrical power system is growing fast. Solar energy is the most clean, ample and endless of all the renewable energy resources till date. In this system, sunlight is harvested by using a technique like maximum power point technique (MPPT) to meet requirements without affecting the environment. In this paper, the development of PV array model & Simulink implementation with a mathematical model is discussed on MATLAB R2015a. This system is also connected to the grid to transfer the produced surplus energy. The effectiveness of power plant analysed by various characteristics.

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Contents

I. INTRODUCTION

Solar power is the conversion of energy from the sun into electricity directly using photovoltaic (PV) system. Solar energy is intermittent due to day/night cycles and unpredictable weather conditions. To use this energy efficiently, an optimized system is introduced. As the output obtained from the system is dc in nature and cannot be used directly to run various loads but when dc power is converted into ac, the efficiency of a system gets reduced. In order to increase efficiency & the utilization of solar energy different models studied over the world on PV system [1]-[5].

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A Five–Level PWM Inverter for Hybrid PV/Fuel Cell/Battery Standalone Power System

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Avinash Pareek ; Prashant Singh ; Anmol Gupta **All Authors**

Abstract: Renewable energy sources (RES) has found attention of power system researchers as alternate energy sources recently. On the other hand RES based generation has emerged as... **View more**

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Abstract:

Renewable energy sources (RES) has found attention of power system researchers as alternate energy sources recently. On the other hand RES based generation has emerged as one of the best option due to global environmental concerns, especially for off-grid load locations like islands, mountains, etc., where diesel generators are main source of power generation. This paper presents an efficient photovoltaic (PV) generation integrated with multilevel inverter to ensure regulated power at user end. In order to track the maximum power of PV applications Perturb and observe (PO) algorithm is used which is based on the maximum power point tracking (MPPT) principle. However in PV based power generation, control problems surfaces because of large variation in irradiance round the clock. This issue is controlled by hybrid PV

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generation system which is application of secondary power source as battery and fuel cell integrated with PV generation unit. The DC output of standalone hybrid PV-SOFC-Battery generation system is inverted by a single-phase multilevel converter. This output of developed standalone hybrid PV-SOFC-Battery generation system is used to supply the single-phase load. The results have been verified with MATLAB/Simulink for different load applications.

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Contents

I. Introduction

The energy demands of human beings has increased exponentially over the course of time. Fossil fuels will be depleted in the coming years and the only answer to those needs will be fresh alternate energy which will in turn improve energy proficiency and force quality issues [1].

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Comparative Study of Techniques Used in Prediction of Student Performance

Minakshi Chauhan , Varsha Gupta

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of students involved. Analysis and prediction of student performance is key step to identify the poor academic perfor
prediction, the corrective actions must be taken to improve performance of students and enhance the quality of educ
surveyed the techniques commonly used to predict the performance of students and also analysed the factors affect
performance.

Keywords:
EN Classification Clustering Data Mining Techniques Educational Data Mining Fuzzy Logic

Discipline:
INFORMATICS: INFORMATICS

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Survey on Different Meta-Heuristic Technique for VANET

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Abstract

The combinations of these values of the parameter are large. Thus, the main goal of our work is to discover best com
heuristic technique. Meta-heuristic is designed to find, generate or select to a heuristic that may provide a sufficientl
techniques by using PSO (particle swarm optimization), TLBO (teacher learning-based optimization), MO(magnetic C
parameters. The parameters are AE2ED, PDR, NRL and these parameters had been analyzed under the above-given t
different Metaheuristic techniques.

Keywords: AOMDV, PSO, TLBO, MO, OLSR, VANET, Optimizat ion of Value of Parameters, Quality of service, cMOG.

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Secured Biometric Template Matching by Using Linear Discriminant Analysis

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encoded fingerprints and matched the fingerprints to the data set by using LDA. Simulated model was found to measure the accurate percentage results of biometric templates.

Keywords

Biometric template Logistic Mapped Encryption Algorithm
Linear Discriminant Analysis (LDA)

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Abstract

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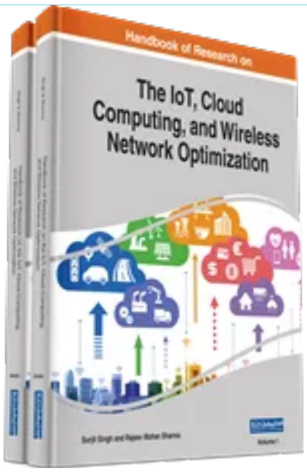

Cognitive Radio Networks: A Comprehensive Review

Nitin Gupta (Netaji Subhas Institute of Technology, India), Sanjay Kumar Dhurandher (Netaji Subhas Institute of Technology, India) and Bhoopendra Kumar (KIET Group of Institutions, India)

Source Title: Handbook of Research on the IoT, Cloud Computing, and Wireless Network Optimization (/book/handbook-research-iot-cloud-computing/206185)

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The radio spectrum is witnessing a major paradigm shift from fixed spectrum assignment policy to the dynamic spectrum access, which will completely change the way radio spectrum is managed. This step is required to greatly reduce the load on limited spectrum resources, which is being enforced by the exponential growth of wireless services. This is only feasible due to the capabilities of the cognitive radio, which will provide a new paradigm in wireless communication by exploiting the existing unused spectrum bands opportunistically. The chapter provides insight into recent developments in the area of cognitive radio networks with the main focus on review of the spectrum management, which consists of four main challenges: sensing of selected spectrum band, decision about sensed spectrum, sharing of spectrum among many users, and spectrum handoff. Further, sharing of target channel after a channel handoff is analyzed using game theory to get a different perspective on the existing medium access techniques.

Chapter Preview

Top

Introduction

Radio spectrum plays a major role in vital technological innovations in wireless communications, but it is also very important for the economic growth of a country *(Bhattarai, Park, Gao, Bian, & Lehr, 2016)*.With the advent of various emerging wireless products, the usage of limited spectrum has grown exponentially in the recent years. *Zhou et al.(2017)* stated in their work that in the next few years, it is expected that global mobile data traffic will grow up to 49 EB/ month, which is nearly a seven times increase over year 2016. *Kumar et al. (2018)* reveals the trend in growth of mobile data traffic as shown in Figure 1.

Figure 1. Trend in growth of mobile data traffic
978-1-5225-7335-7.ch021.f01(https://igiprodst.blob.core.windows.net:443/source-content/9781522573357_206185/978-1-5225-7335-7.ch021.f01.png?sv=2015-12-11&sr=c&sig=K0laF2PeJN1r36VAUQ1uiPbVqenm51fv48L3IL66mDE%3D&se=2019-11-14T22%3A31%3A08Z&sp=r)
Therefore, it will become extremely difficult to satisfy the ever increasing demand through the current fixed spectrum assignment policy in which spectrum band is exclusively used for the particular applications and it has also led to under-utilization of a significant portion of the spectrum (like TV bands). It is almost impractical to find new frequency spectrum bands from the already in adequate spectrum resources to improve overall system capacity. To tackle the above challenges, a paradigm change is required in which spectrum is shared with more flexibility and dynamically among all categories of users. *(Federal Communications Commission [FCC], 2003)* has proposed to enable any unlicensed user to use the licensed frequency band such that no interference to the primary license holders is ensured. The solution to this problem is implemented by the use of cognitive radio by making dynamic spectrum access possible *(Kumar, Dhurandher, & Woungang, 2018)*. Further, an eminent example of wireless standard that benefits from the recent developments in the area of cognitive radio is the IEEE 802.22 Wireless Regional Area Networks standard. In the rest of the chapter, an introduction to the cognitive radio networks, their application and then wireless regional area networks is provided in detail followed by game theoretic analysis of post handoff target channel sharing by the SUs. The last section draws the conclusion.

Top

Cognitive Radio

The concept of cognitive radio was proposed by (*Mitola, 2000)*. Cognitive radio techniques present the ability to utilize or share the spectrum band in an opportunistic manner. The under-utilization of spectrum is described in cognitive radio networks as a spectrum hole (*Haykin, 2005)*.As shown in Figure 2 (*Akyildiz et al.,2009)*, a spectrum hole is a band of frequencies which is assigned to a licensed user, but, not being utilized by that user at a particular time and specific geographic location.

Figure 2. Concept of spectrum holes
978-1-5225-7335-7.ch021.f02(https://igiprodst.blob.core.windows.net:443/source-content/9781522573357_206185/978-1-5225-7335-7.ch021.f02.png?sv=2015-12-11&sr=c&sig=K0laF2PeJN1r36VAUQ1uiPbVqenm51fv48L3IL66mDE%3D&se=2019-11-14T22%3A31%3A08Z&sp=r)
Cognitive radio is the technology that enables the efficient use of spectrum holes. *Akyildiz et al. (2006)* formally define the cognitive radio as follows:

A *"Cognitive Radio" is a radio which is capable of interacting with the surrounding environment and based upon it's learning, it can change it's operating parameters (e.g. frequency, transmission power, modulation technique etc.) in real time to effectively utilize the spectrum band.*

According to this definition two main characteristics of the cognitive radio can be defined as *(Haykin, 2005;Thomas et al., 2007)*:

Key Terms in this Chapter

Spectrum Handoff (/dictionary/spectrum-handoff/72490): It is a process of pausing the ongoing transmission by the secondary user whenever a primary user reclaims its licensed channel and gets triggered to switch to some new target channel for resuming its transmission.

Spectrum Sensing (/dictionary/spectrum-sensing/43597): It is the process of observing the frequency bands by the unlicensed users and sensing any activity of a licensed user, which helps in detecting the spectrum holes.

Target Channel Sharing (/dictionary/target-channel-sharing/72491): It is the situation where multiple users want to share a single channel and a secondary user has selected this channel as a target for spectrum handoff.

Game Theory (/dictionary/game-theory/11839): It is the study of mathematical models involving conflict and cooperation between intelligent but rational or selfish decision-makers.

Geo-Location Database (/dictionary/geo-location-database/72489): It stores the information about protected TV and low power devices operations in the area along with other IEEE802.22 operations.

Cognitive Radio (/dictionary/cognitive-radio/4248): A radio which is capable of interacting with the surrounding environment, and based upon its learning, it can change its operating parameters (e.g., frequency, transmission power, modulation technique, etc.) in real time to effectively utilize the unused part of the spectrum band.

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Abstract

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Computer vision Human activity recognition Random forest

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Contract Theory Based Incentive Mechanism Design Approaches in Cognitive Radio Networks: A Survey

Publisher: IEEE

Nitin Gupta ; Sanjay Kumar Dhurandher ; Bhoopendra Kumar **All Authors**

Abstract: Through the previous decade, an ever increasing demand of wireless radio spectrum has been observed due to expeditious use of various wireless applications and devices. H... **View more**

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Abstract:
Through the previous decade, an ever increasing demand of wireless radio spectrum has been observed due to expeditious use of various wireless applications and devices. However, current fixed radio spectrum policy holds up the efficient use of radio spectrum due to which large part of the spectrum remain under-utilized. This requires a complete

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Contents

I. Introduction

The unprecedented essential technological revolutions in the area of wireless communications that we are witnessing today is majorly due to the radio spectrum and, also make a positive impact on the economic growth of a country [1], [2]. The advancement in wireless technology has allowed seamless connectivity across various wireless devices. The enhanced Quality of Experience and Quality of Service provided by the service providers has seen exponential growth in mobile data traffic and it is predicted that by 2020, there will be approximately ten times increase in the data traffic globally as compared to the year 2015 [3], [4]. Therefore, it has now become exceedingly hard to meet the increasing spectrum re-quirment through the current fixed spectrum assignment policy where spectrum channels are particularly used by licensed users only for the exclusive applications which also led to wastage of a considerable spectrum channels like TV bands [5]. Practically it is not possible to obtain new frequency bands from the already inadequate spectrum resources to enhance overall capacity of the wireless system. This fact has inspired the development of various wireless technologies, like exposure of millimeter wave spectrum [6], femtocells [7], [8], multi-input multi-output systems (MIMO) [9], and dynamic spectrum access with the help of cognitive radio technology [10]. To address these challenges, the “Federal Communications Commission (FCC)” has recently proposed to allow interference less use of the licensed spectrum to the primary license holders by the unlicensed users [11]. By making dynamic spectrum access possible with the help of cognitive radio, FCC has intended to achieve the solution to this problem [12]. Next,

Quantitative structure-activity relationship (QSAR) is an important drug design approach to understand the relationship between the chemical structure and their biological activity. The book describes brief introduction to hepatitis C virus (HCV), life cycle, identified targets and current progress towards development of anti-HCV agents. 2D and 3D-QSAR studies for anti-HCV compounds from different categories targeting NS5B polymerase have been incorporated. Some of the selected categories are nucleoside and non-nucleosides.

Vaishali M Patil

Satya Prakash Gupta

Neeraj Masand

Hepatitis C Virus: QSAR Studies on Polymerase Inhibitors

Dr. Vaishali M. Patil has academic and industry experience of 15 years. Her research interests are synthetic chemistry, computational chemistry, QSAR and their application for drug discovery. She has excellent research publications and some reviews to her credit in esteemed journals and few chapters in Elsevier, Nova, and Springer published books.

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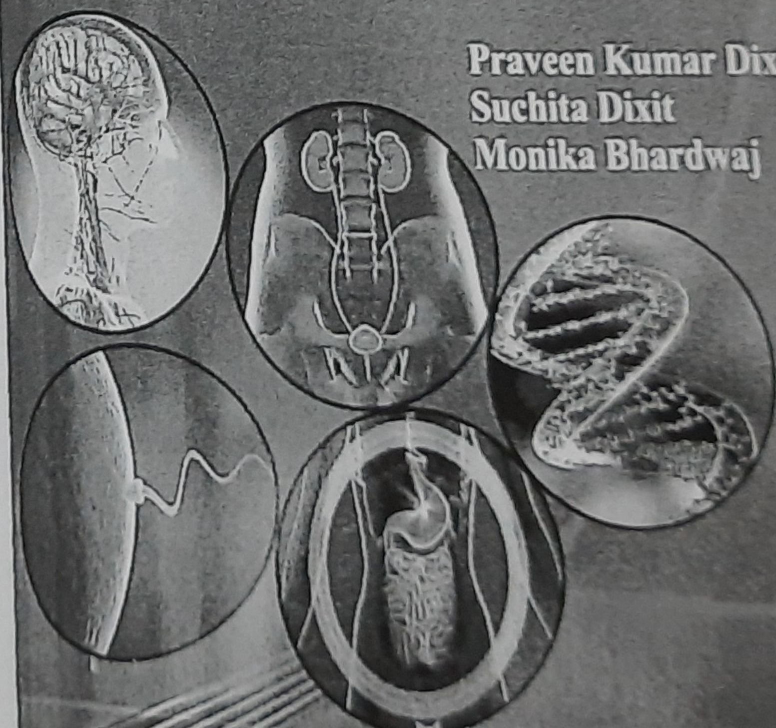

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Drug Discovery and its principles are of critical importance in human health care and the need for new drugs is also increasing. Computational approaches for discovery and optimization of drug leads have grown in their effectiveness with regard to biological events and molecular interactions that define a target for therapeutic intervention. The most direct computer aided drug design application area in correlation model construction is Quantitative structure activity relationship (QSAR) analysis. Central to the construction of QSARs is the maximum extraction of information from data sets which are highly oversubscribed, that is, for which the number of independent variables is much greater than the number of dependent variables as used in the applications of Comparative molecular field analysis (CoMFA). Drug discovery is the broad area of study of new drugs discovered based on the various strategies of designing the drugs especially with computer applications, their receptor interactions through docking strategy, QSAR studies, Concept on Rational drug design, Pharmacophore based mapping, Target identification and validation, Lead identification and optimization.

Author: Prof. Dr. K. Nagarajan is presently working as Professor & Additional Head of the Department in KIET School of Pharmacy, Ghaziabad. He has completed M. Pharm. from Birla Institute of Technology, Ranchi and Ph. D from Jadavpur University, Kolkata. Co-author: Prof. Dr. Ramesh B. Bodla is presently working as Professor in DIPSAR, New Delhi.

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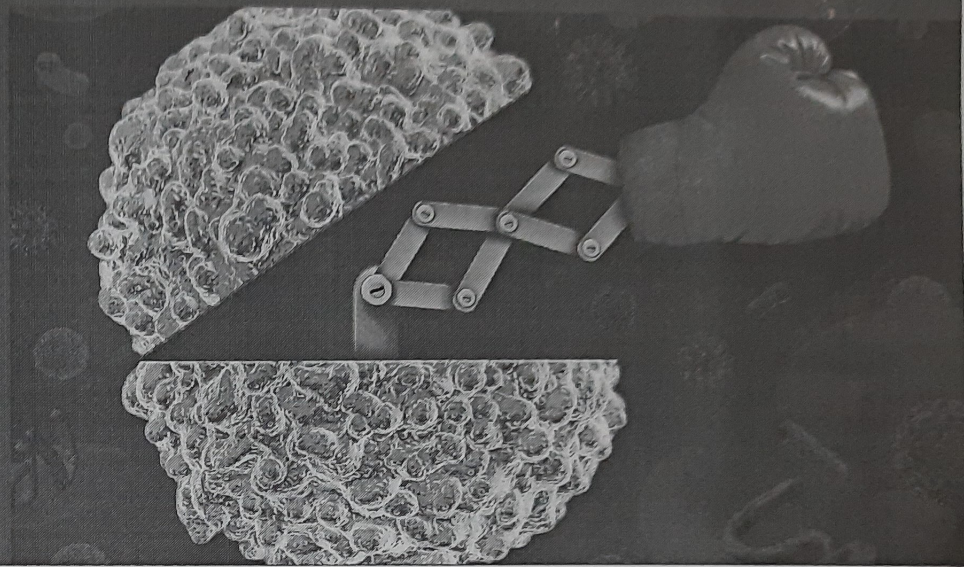

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Fundamental Principles Of Drug Discovery

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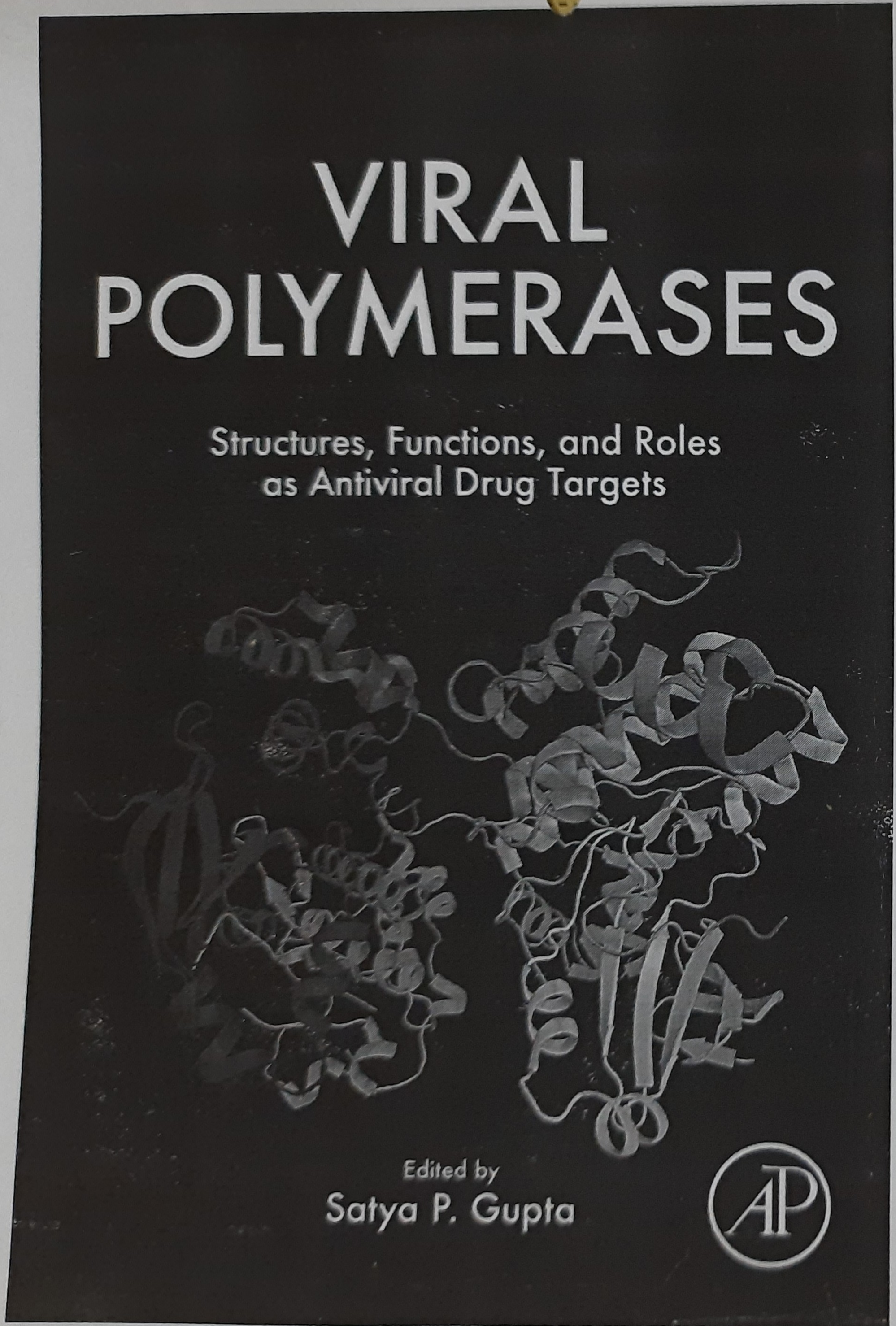

VIRAL POLYMERASES

Viral Polymerases
Structures, Functions and Roles as Antiviral Drug Targets
2019, Pages 387-428

Chapter 14 - Dengue Virus Polymerase: A Crucial Target for Antiviral Drug Discovery

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https://doi.org/10.1016/B978-0-12-815422-9.00014-0

Abstract

The dengue virus (DENV) is the most prevalent mosquito-borne viral pathogen. Four DENV serotypes have been identified and majority of them are developed into life-threatening dengue hemorrhage fever (DHF) and dengue shock syndrome (DSS). It is a growing global health concern and requires specific antiviral drugs and vaccines. DENV NS5 protein is comprised of N-terminal methyltransferase (MTase) and a C-terminal RNA-dependent RNA polymerase (RdRP) domain. They catalyze 5′-RNA capping/methylation and RNA synthesis during viral genome replication. The reported X-ray structures of NS5 suggest coordinated activity of MTase and NS5 residues as a dimer during viral genome replication. Some insights into the dynamics and mechanism of DENV entry and infectivity through atomistic-level modeling and molecular dynamics, identifying key amino acids and regions that facilitate entry and fusion of DENV into cell membrane have been summarized. Direct evidence support the hypothesis for the presence of allosteric pockets as target for antiviral drug development. An overview of the target-based approaches to develop therapeutics against DENV infection is presented that may be helpful in screening and development of inhibitors directed against the DENV polymerase.

Keywords

Falviviridae; DENV RdRP; nucleoside inhibitors; nonnucleoside inhibitors; atomistic-level modeling; molecular dynamics

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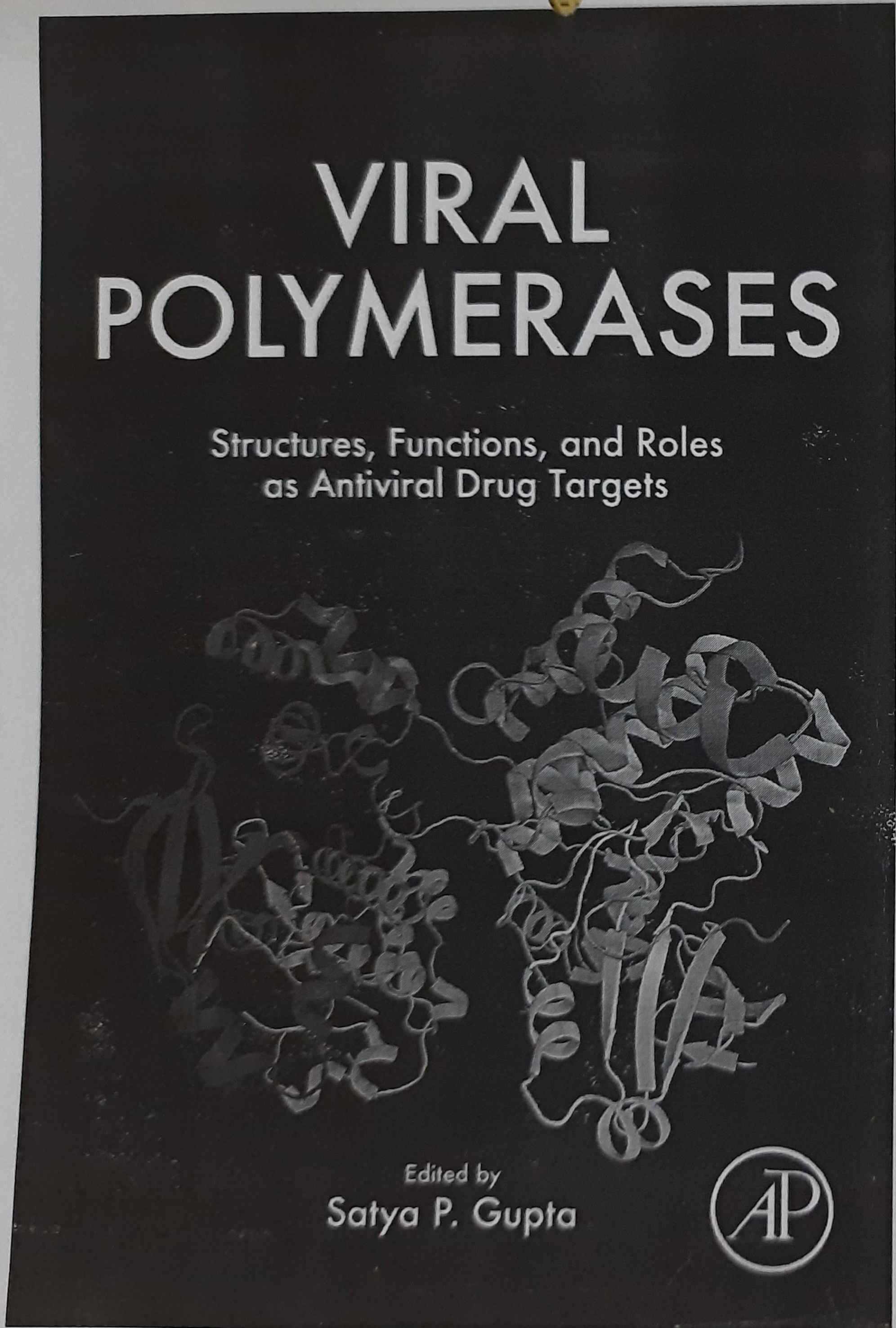

VIRAL POLYMERASES

Viral Polymerases
Structures, Functions and Roles as Antiviral Drug Targets
2019, Pages 357-385

Chapter 13 - Zika Virus Polymerase: Structure, Function, and Inhibitors

Vaishali M. Patil [1], Neeraj Masand [2], Satya P. Gupta [3]

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https://doi.org/10.1016/B978-0-12-815422-9.00013-9

Abstract

Among the human infections transmitted by mosquito, Zika virus (ZIKV) infection has potential as worldwide pandemic. ZIKV infection can spread from person to person vertically from mother to fetus or through sexual contact and thus differs from other pathogenic flaviviruses. ZIKV infection is asymptomatic and has been strongly associated with neurological sequelae (Guillain–Barre syndrome), meningoencephaitis, and myelitis. During pregnancy ZIKV infection may cause dreaded complications leading to fetal abnormalities and death. Currently no specific therapies or vaccines are approved for prevention and treatment of ZIKV infection. ZIKV structure has been revealed that shows remarkable similarities with those of other flaviviruses. Inhibition of viral MT activity and/or RNA synthesis can be developed for inhibiting ZIKV replication. Various ZIKV proteins complexed with inhibitors could aid in accelerating the drug discovery process. The consequences of ZIKV mutations suggest the urgent need for viral inhibitors with higher specificity and potency. Rationalized approaches are fundamental in the discovery of potent inhibitors to mask the virus as well as its destruction. The advent of in silico drug design allows rapid screening of potential leads and reduces the consumption of time and resources. Various optimized and proven screening techniques and their results in the discovery of potential inhibitors of ZIKV methyltransferase (MTase) and RNA-dependent RNA polymerase (RdRP) have been elaborated.

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Keywords

Zika virus; flavivirus; protein-structure function; ZIKV polymerase; nucleoside analogs

VIRAL POLYMERASES

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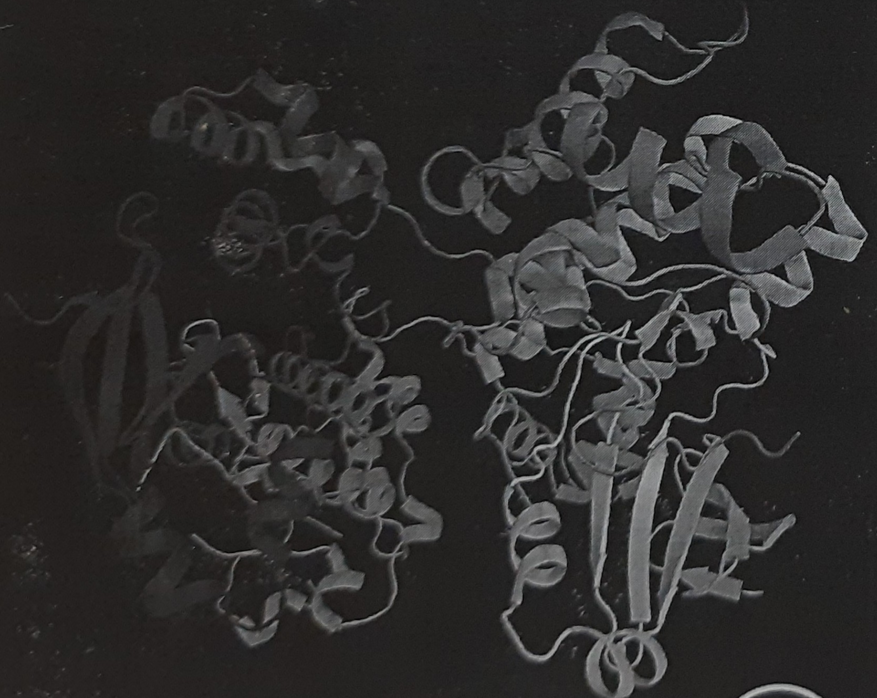

Edited by
Satya P. Gupta

VIRAL POLYMERASES

Studies in Natural Products Chemistry
Volume 59, 2018, Pages 401-430

Chapter 12 - Anticancer Potential of Flavonoids: Chemistry, Biological Activities, and Future Perspectives

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https://doi.org/10.1016/B978-0-444-64179-3.00012-8

Abstract

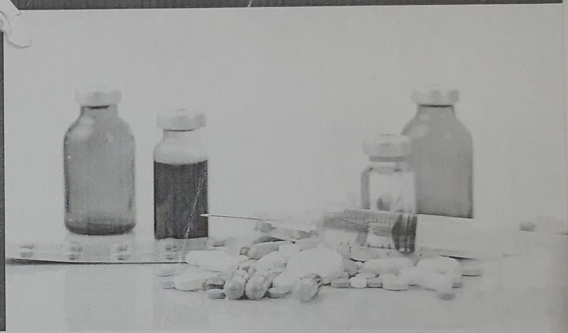
The polyphenolic flavonoids are found ubiquitously in plants. Flavonoids are nontoxic and possess a remarkable spectrum of biological activities such as antiallergic, antiinflammatory, antioxidant, antimutagenic, anticarcinogenic, and modulation of enzymatic activities. Some of the reported flavonoids are able to influence the deregulated processes during cancer development. Thus, flavonoids have beneficial effects on health and have the potential for the development of possible chemoprotective therapeutic agents for the treatment of cancer. Some dietary flavonoids have antitumor activity during in vivo studies and also repress angiogenesis. In vitro studies conclude the potential of flavonoid-induced modulation of kinases with apoptosis, vascularization, cell differentiation, cell proliferation, etc. The results obtained from the laboratory and epidemiological studies have confirmed the potential of flavonoids and have stimulated the development of flavonoids. Most of the available chemotherapeutic agents have a major obstacle as they do not spare normal cells and the development of multidrug resistance. The promising results stimulate the development of flavonoids and their synthetic analogs for cancer prevention and chemotherapy. This chapter covers the structural characteristics of flavonoids, their role in cancer treatment and prevention in in vitro cell lines and in vivo murine models, and the human clinical trials.

Keywords

Anticancer agents; Flavonoids; Mechanism of action; Flavonoid subclasses

July, 2018

This book presents a comprehensive overview of systematic procedure for establishing and validating an IVIVC. It describes development of IVIVC as a tool that can help to save time and cost during and after the development of an extended release formulations. It also discusses the biopharmaceutical, pharmacokinetics and mathematical aspects to design ER products.



Ashu Mittal
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Mathematical Approaches to Extended Release Products

Dr. Ashu Mittal received his B.Pharm degree from University of Rajasthan, M.Pharm from Government college of Pharmacy, Karad, MS. and Ph.D from Uttar Pradesh Technical University. He has supervised over 45 post graduate students. Dr. Ashu Mittal has over forty publications to his credit in foreign/international journals of high scientific impact.

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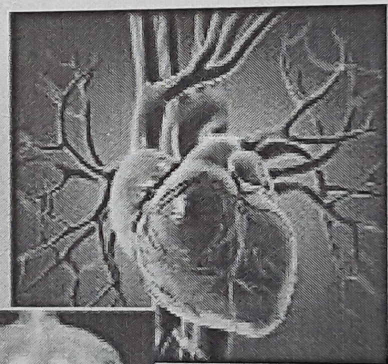

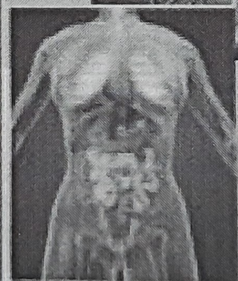

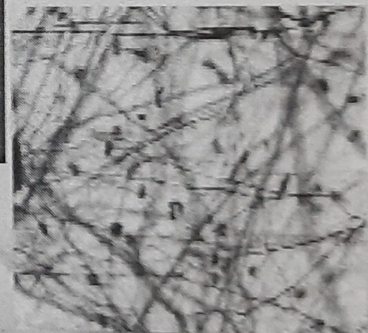

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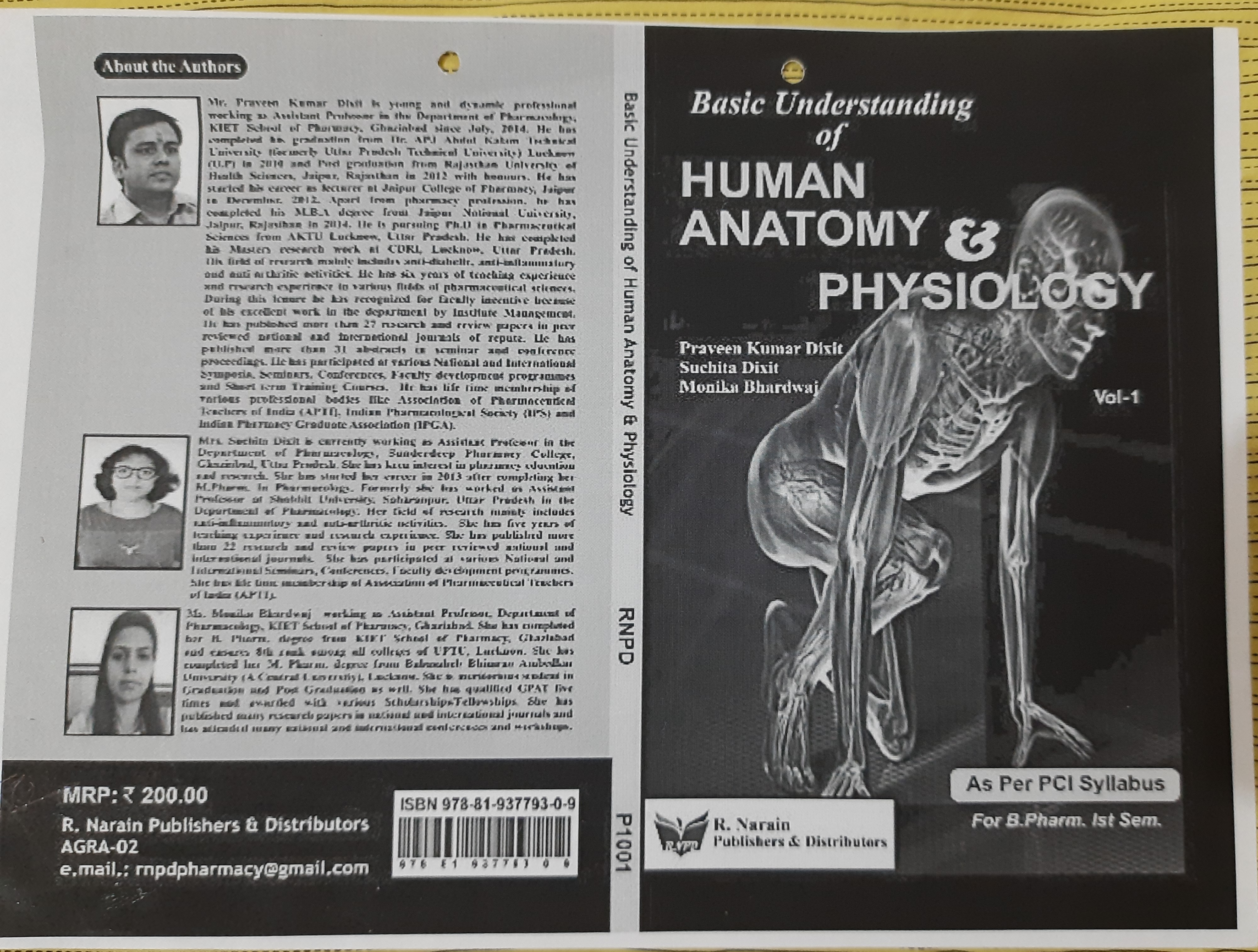

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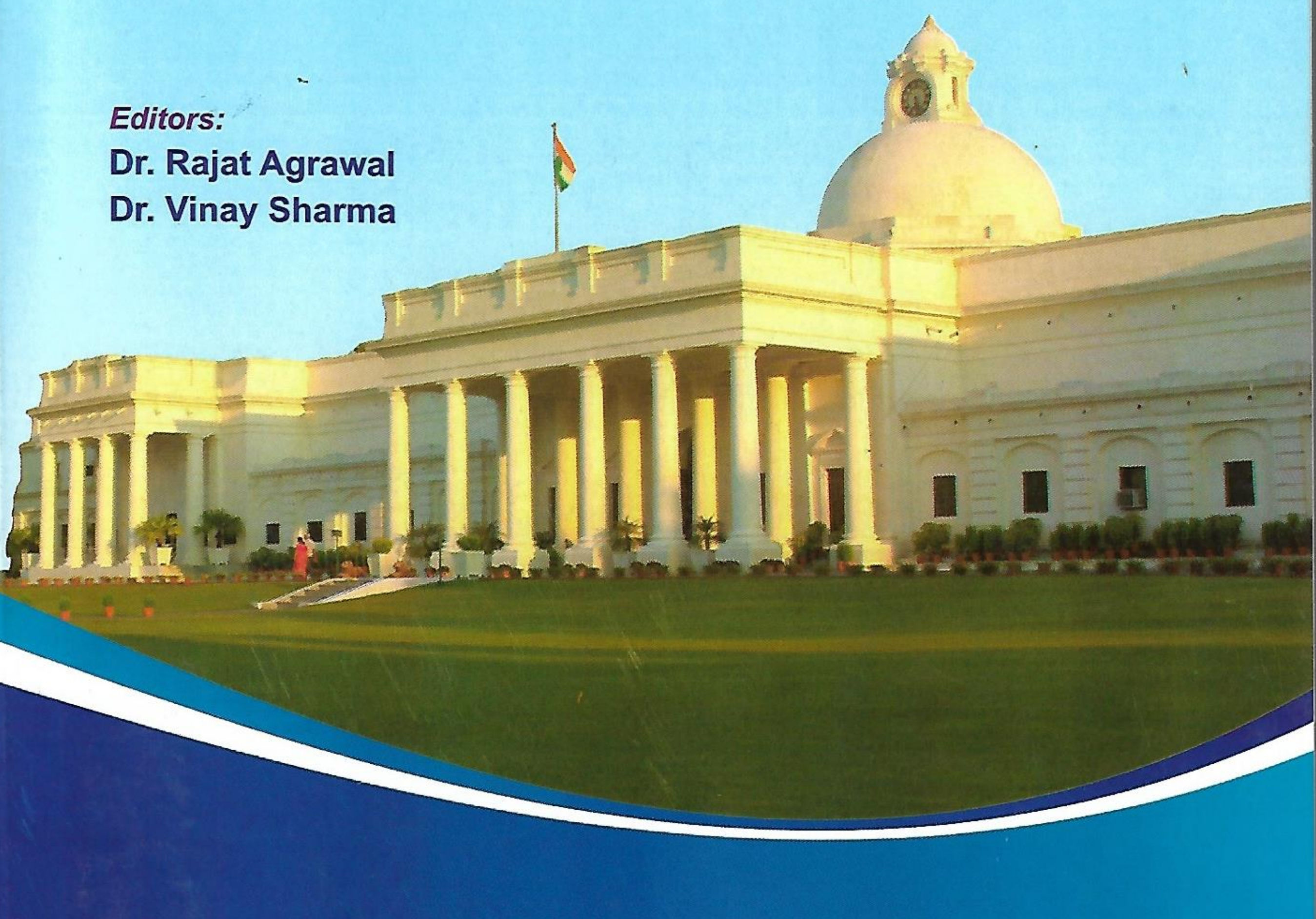

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ROLE OF TECHNOLOGY BUSINESS INCUBATORS (TBIs) IN SETTING UP OF STARTUPs: A STUDY OF TBI-KIET, GHAZIABAD

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ABSTRACT

The development of India depends on the technological development of the nation. The technical Startups are boon in this endeavor. These startups are considered to be a solution for generating capital, creating employment and launching new products and services through unique ideas. Hence developing the spirit of entrepreneurship among the young has become vital. In encouraging entrepreneurship in academic institutions, seeking leadership with these characteristics is essential. The need for Academic Technology Business Incubators (TBIs) has been recognized the world over for initiating technology led and knowledge driven enterprises. In this paper, it is intended to analyze the need and role of TBIs in development of India especially for TBI-KIET.

Keywords: *Entrepreneurship, Startups, Academic TBIs, Entrepreneurial education, TBI-KIET.*

INTRODUCTION

The requirement for TBI has been documented the world over for initiating technology driven and knowledge driven organizations. Past crams also show that such incubators help not only in the growth of technology based new enterprises but also in improving their endurance rate to a large extent i.e. upto 40 percent (earlier 30 per cent to over 70 per cent[a]). The TBIs besides providing a host of services to new enterprises (and also to existing SMEs in the region) also facilitate an environment affable for their survival and growth. The indispensable feature of a TBI is that the tenant companies leave the incubator space within 2-3 years. TBIs also make easy, speedy commercialization of research outputs[b]. There are nearly 4000 incubators of various categories operational in the World. In USA, there are more than 1000 incubators including about 200 Internet incubators. Europe has nearly 1000 incubators including 300 in Germany. Among the developing countries, China has shown exponential growth in the incubators and over a period of ten years has set up almost 400 incubators. Korea too, is reported to have about 300 Incubators, while Japan, Malaysia and Singapore are catching up it in speed. High-technology incubators have been particularly successful in U.S., Israel, and China. In Central and Eastern Europe, where entrepreneurial movements have traditionally been very low, incubators are sought to play an important role in instigating entrepreneurial activities[c]. In the developing economies like India, each TBI evolves its model based on the need, its strength and the thrust area of the technology. The TBI model usually provides the following:

- Assist in preparation of business plans.

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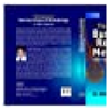
[a] http://www.nstedb.com
[b] http://www.nstedb.com/institutional/tbi.htm
[c] http://www.fao.org/docrep/W6882e/w6882e02.htm



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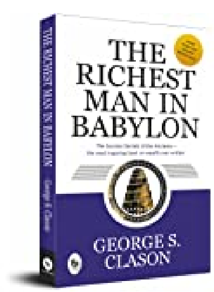

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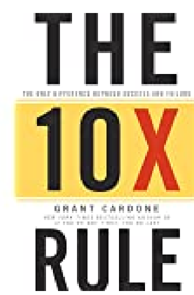

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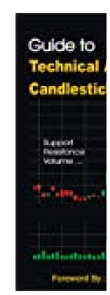

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A Qualitative Analysis of Secured Handover Management Schemes for Mobile IPv6 Enabled Networks

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Arun Kumar Tripathi ; Surendra Kumar Tripathi All Authors

Abstract: Development in wireless technologies permits IPv6 enabled handheld mobile devices to access the Internet ubiquitously. An IP-address is required to identify the mobile ho... **View more**

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Abstract:
Development in wireless technologies permits IPv6 enabled handheld mobile devices to access the Internet ubiquitously. An IP-address is required to identify the mobile host on the Internet. Mobile IPv6 (MIPv6) scheme enables a mobile host to migrate from one subnet to another without changing its exiting IP-address. For IPv6 based mobility, Internet Engineering Task Force (IETF) proposed standard Mobile IPv6 as first mobility management scheme. It provides a powerful and flexible way to handle handover management. Standard MIPv6 is a host-based global mobility management scheme and endure from basic issues such as signaling overhead, handover latency and packet loss. Subsequently, IETF has standardized localized network-based Mobility Management schemes to overcome problems associated with global host-based mobility management schemes named as Proxy Mobile IPv6 (PMIPv6). It reduces handover latency and packet loss compared to host-based mobility management schemes considerably, yet, suffers from security issues. Later on, researchers proposed secured-PMIPv6 protocols for authentication of mobile as well as network devices within

Automating Outcome Based Education for the Attainment of Course and Program Outcomes

Publisher: IEEE

Akash Rajak ; Ajay Kumar Shrivastava ; Divya Prakash Shrivastava **All Authors**

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Published in: 2018 Fifth HCT Information Technology Trends (ITT)

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Detection of Tuberculosis based on Multiple Parameters using ANFIS

Publisher: IEEE Cite This PDF

Ajay Kumar Shrivastava ; Akash Rajak ; Shashank Bardwaj **All Authors**

Abstract: Tuberculosis is being a big disease in the world due to which large numbers o deaths occur. Adaptive Neuro Fuzzy Inference System (ANFIS), which is a type of hybrid of n... **View more**

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Tuberculosis is being a big disease in the world due to which large numbers of deaths occur. Adaptive Neuro Fuzzy Inference System (ANFIS), which is a type of hybrid of neural network and fuzzy logic and is based on fuzzy inference system, has been presented in this paper for an intelligent system for a simulation for the disease which will be helpful for diagnosing the stages of the pulmonary tuberculosis based on various input parameters.

Published in: 2018 3rd International Innovative Applications of Computational Intelligence on Power, Energy and Controls with their Impact on Humanity (CIPECH)

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Ambient Communications and Computer Systems pp 265-271 | Cite as

- Adesh Kumar Pandey (1)
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1. KIET Group of Institutions, , Ghaziabad, India

Conference paper
First Online: 31 March 2019

Part of the Advances in Intelligent Systems and Computing book series (AISC, volume 904)

Abstract

Road safety is very important in our day to day life. Every year thousands of accidents happen during the driving of vehicles. For many accidents, reasons are not identified. There is need of device for recording vehicle evidences when the person is on the way and safe the people from malicious activities i.e. accidents, kidnapping etc. The system having acquisition system on the board is designed to monitor and record the vehicle speed, video recording, acceleration, steering input etc. This device is robust due to its design and work in different temperatures also. This device helps in investigations of road accidents, vehicle theft and kidnappings etc. Initially this system is fabricated in car.

Keywords

Raspberry Data acquisition system Arduino

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SMS Advisory System for Medical Assistance by using Neuro Fuzzy System

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Ankit Verma ; Gaurav Agarwal ; Shashank Bhardwaj **All Authors**

Abstract

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Cancer is a disease which causes increasing of human death rate in each year. Normally cancer can occur anywhere in human body. A major class of problems in medical sciences involves the diagnosis of disease based upon various tests performed upon patient. When several tests are involved the ultimate diagnosis may be difficult to obtain, even for medical expertise because of lot of different parameters obtained from the subject to be diagnosed. This has given rise, over the past few decades, to computerized diagnostic tools, intended to aid physicians in making sense out of the confusion of data. Clinical oncologists create diagnostic selections concerning cancer patient supported by past skilled experiences and information, intelligent techniques area unit probably the sole category of automatic technique powerful enough to emulate the expert's selection because of their stable behavior within the presence of noise in preciseness and uncertainty, the ANN and ANFIS techniques may doubtless get higher results than classical ways.

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Genetic algorithms in computer aided design

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Uttar Pradesh, India.

Abstract

Design is a complex engineering activity, in which computers are more and more involved. The design task can often be seen as an optimization problem in which the parameters or the structure describing the best quality design are sought.

Genetic algorithms constitute a class of search algorithms especially suited to solving complex optimization problems. In addition to parameter optimization, genetic algorithms are also suggested for solving problems in creative design, such as combining components in a novel, creative way.

Genetic algorithms transpose the notions of evolution in Nature to computers and imitate natural evolution. Basically, they find solution(s) to a problem by maintaining a population of possible solutions according to the 'survival of the fittest' principle. We present here the main features of genetic algorithms and several ways in which they can solve difficult design problems. We briefly introduce the basic notions of genetic algorithms, namely, representation, genetic operators, fitness evaluation, and selection. We discuss several advanced genetic algorithms that have proved to be efficient in solving difficult design problems. We then give an overview of applications of genetic algorithms to different domains of engineering design.

Keywords: CAD; Genetic algorithms; Optimization; Geometric design; Conceptual design; Mechanism design

1. Introduction

Design is an engineering activity for creating new technical structures characterized by new parameters, aimed at satisfying predefined technical requirements. As does any process, it consists of several phases, which differ in details such as depth of the design, kind of input data, design strategy and procedures, and results: e.g. consider the differences between conceptual design and detail design. In spite of the great variety of design tasks, the design steps can often be interpreted as solving optimization problems. In this case a structure and/or a set of parameters is sought, which results in the best value of some attribute character-izing the quality of the design.

Classical (analytical or numerical) methods for calculat-ing the extrema of a function have been applied to engineering computations for a long time. While they perform well in many cases of everyday design practice they may fail in more complex design situations. In real design problems the number of design parameters can be very large, and their influence on the value to be optimized (the goal function) can be very complicated, having a strongly non-linear character. The goal function usually has many local extrema, whereas the designer is interested in the global extremum. Such problems cannot be handled by classical methods (e.g. gradient methods) at all, or they only compute local extrema. In these complex cases stochastic optimization techniques including evolutionary algorithms such as genetic algorithms may offer solutions to the problem; they may find a design near to the global optimum within reasonable time and computational costs.

Different variants of gradient methods start from a single point in the search space (a solution to the design problem), and search for a better solution in the direction of the gradient of the goal function (this method is also called hill climbing). If the new point has a better value of the goal function, it becomes the current point and the process is repeated. The method is efficient, because it requires just a few evaluations of potential solutions, which may be crucial in complex engineering problems. However, gradient methods have several difficulties. The basic problem is that gradient methods find only a local optimum, and no information is available on how good it is compared to the global one. Moreover, the local optimum found depends on the starting point; to improve results the computation is usually repeated for a number of starting points. The goal function must be smooth, and a procedure is needed to compute gradients (analytically, or at least numerically). In real design problems—with complicated or possibly discontinuous goal functions, and discrete variables— these conditions are in general not straightforward to fulfill.

Some of the disadvantages of the gradient method can be eliminated by the simulated annealing method, which is a stochastic search method. Here a new solution is obtained by perturbing the current solution. If the goal function of the new solution is better than that of the previous solution, then it is accepted. It is also possible, however, for the method to accept a solution, which produces a worse value of the goal function. The probability of accepting a worse solution is reflected in the temperature of the system. The temperature is gradually lowered as the search proceeds through an annealing process (e.g. following Boltzmann's law), thus allowing acceptance of worse solutions with greater probability at the beginning and with smaller probability later. From a practical point of view, the advantage of simulated annealing is that there is a good chance of finding the global optimum and that the solution does not depend on the starting point. It is clear, however, that simulated annealing requires higher computational effort than the gradient method.

Genetic algorithms strongly differ in conception from other

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search methods, including traditional optimization methods and other stochastic search methods. The basic difference is that while other methods always process single points in the search space, genetic algorithms maintain a population of potential solutions.

Genetic algorithms constitute a class of search methods especially suited for solving complex optimization problems [6,8,36,44]. Search algorithms in general consist of systematically walking through the search space of possible solutions until an acceptable solution is found. Genetic algorithms transpose the notions of natural evolution to the world of computers, and imitate natural evolution. They were initially introduced by John Holland [44] for explain-ing the adaptive processes of natural systems and for creating new artificial systems that work on similar bases. In Nature new organisms adapted to their environment develop through evolution. Genetic algorithms evolve solutions to the given problem in a similar way. They maintain a collection of solutions—a population of individuals—and so perform a multidirectional search. The individuals are represented by chromosomes composed of genes. Genetic algorithms operate on the chromosomes, which represent the inheritable properties of the individuals. By analogy with Nature, through selection the fit individuals—potential solutions to the optimization problem—live to reproduce,

Table 1
The correspondence of terms between natural and artificial evolution

Nature	Evolutionary computation
Individual	Solution to a problem
Population	Collection of solutions
Fitness	Quality of a solution
Chromosome	Representation of a solution
Gene	Part of representation of a solution
Crossover	Binary search operator
Mutation	Unary search operator
Reproduction	Reuse of solutions
Selection	Keeping good subsolutions

and the weak individuals, which are not so fit, die off. New individuals are created from one or two parents by mutation and crossover, respectively (unary and binary operators). They replace old individuals in the population and they are usually similar to their parents. In other words, in a new generation there will appear individuals that resemble the fit individuals from the previous generation. The individuals survive if they are fitted to the given environment.

In Table 1 we present the analogy of terms between Nature and artificial evolutionary systems in general.

2. Genetic algorithms at work

Evolution is an emergent property of artificial evolution-ary systems. The computer is only told to (1) maintain a population of solutions, (2) allow the fitter individuals to reproduce, and (3) let the less fit individuals die off. The new individuals inherit the properties of their parents, and the fitter ones survive for the next generation. The final solutions will be much better than their ancestors from the first generation.

This evolution is directed by fitness. The evolutionary search is conducted towards better regions of the search space on the basis of the fitness measure. Each solution in a population is evaluated based on how well it solves the given problem. Correspondingly, each member of the population is assigned a fitness value.

Genetic algorithms use a separate search space and solution space. The search space is the space of coded solutions, i.e. genotypes or chromosomes consisting of genes. More exactly, a genotype may consist of several chromosomes, but in most practical applications genotypes are made of one chromosome. The solution space is the space of actual solutions, i.e. phenotypes. Any genotype must be transformed into the corresponding phenotype before its fitness is evaluated.

2.1. The outline of a genetic algorithm (GA)

When solving a problem using genetic algorithms, first a proper representation and fitness measure must be designed

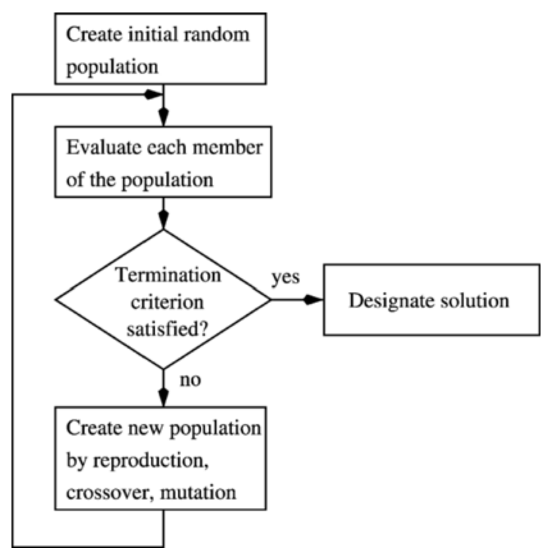

Figure. 1. Genetic algorithm flowchart

Many representations are possible, and will work. Some are better than the others, however. Devising the termination criterion should be the next step. The termination criterion usually allows at most some predefined number of iterations and verifies whether an acceptable solution has been found. The genetic algorithm then works as follows (also shown in Figure. 1):

1. The initial population is filled with individuals that are generally created at random. Sometimes, the individuals in the initial population are the solutions found by some method determined by the problem domain. In this case, the scope of the genetic algorithm is to obtain more accurate solutions.
2. Each individual in the current population is evaluated using the fitness measure.

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3. If the termination criterion is met, the best solution is returned.
4. From the current population individuals are selected based on the previously computed fitness values. A new population is formed by applying the genetic operators (reproduction, crossover, mutation) to these individuals. The selected individuals are called parents and the resulting individuals offspring. Implementations of genetic algorithms differ in the way of constructing the new population. Some implementations extend the current population by adding the new individuals and then create the new population by omitting the least fit individuals. Other implementations create a separate population of new individuals by applying the genetic operators. Moreover, there are GAs that do not use generations at all, but continuous replacement.

Actions starting from step 2 are repeated until the termination criterion is satisfied. An iteration is called generation The above process transposes the natural process of evolution into algorithmic terms. To predict the GAs' behavior, it would be useful to have a mathematical characterization of how they work. Unfortunately, it is very difficult—if not impossible—to predict how a stochastic search method like GAs will perform on a specific problem in a complex, highly non-linear domain. However, there are theoretical results highlighting why and how GAs work for idealized settings.

Theoretical work shows that already evolved good parts of solutions (building blocks, or so-called schemata) can be transferred to subsequent generations through crossover [36, 44]. In a genetic algorithm, schemata of small size and with performance better than average appear at exponentially increasing rates in consecutive generations. The so-called schema theorem states that good schemata are expected to gain precedence throughout evolution at an exponential rate.

When applying GAs to more complex design problems, a complete theoretical analysis is not possible, and in such cases ingenious GA design ideas in the choice of representation and operators are needed to ensure evolution toward good solutions.

2.2. Representation

When designing a genetic algorithm for a given problem, choosing the representation (i.e. constructing the chromo-some) is the first step. Generally, for the same problem one can imagine a number of possible representations, ranging from very simple representations to more complicated ones. Despite using the same underlying principles of inheritance and evolution, the results obtained with the different representations can be very different. Some representations can successfully lead to good solutions, while others fail to converge or take too much time to complete. The reason is that the representation together with the recombination operators bound the exploration of the search space to certain regions. In some situations it is desirable to explore as much of the search space as possible. In other situations, when many restrictions on the acceptable solution are imposed, it is preferable to explore only the regions of the search space that correspond—at least partly—to these restrictions. Also, different representations reparameterize the search space, making it easier or harder to search.

A common representation used in simple genetic algorithms is the fixed length bit string. In the case of more complex problems a more sophisticated representation might lead to better results. In some cases the problem consists of function optimization over one or more real valued parameters. In such situations, real valued strings can lead faster to the desired solutions, if the genetic operators are also properly designed.

In solving complex design problems, e.g. in the case of shape design, when the task is to find a complicated shape that corresponds to some criteria, a two or three dimensional representation is often much more successful.

In other cases, variable length representations may be chosen, when the genetic algorithm finds the appropriate length of the chromosome and its content at the same time.

A general experience is that incorporating knowledge specific to the problem domain into the representation helps to guide the evolutionary process towards good solutions. However, there is no exact recipe for choosing the right representation for each problem. One always has to make a trade-off. On one hand, with simple representations, the genetic algorithm might spend too much time exploring irrelevant regions of the search space. On the other hand, when incorporating too much domain knowledge, the resulting offspring might get too far from their parents without ever reaching equilibrium (see Section 2.6).

2.3. Genetic operators

In each generation, the genetic operators are applied to selected individuals from the current population in order to create a new population. Generally, the three main genetic operators of reproduction, crossover and mutation are employed. By using different probabilities for applying these operators, the speed of convergence can be controlled. Crossover and mutation operators must be carefully designed, since their choice highly contributes to the performance of the whole genetic algorithm.

Reproduction. A part of the new population can be created by simply copying without change selected individuals from the present population. This gives the possibility of survival for already developed fit solutions.

Crossover. New individuals are generally created as offspring of two parents (as such, crossover being a binary operator). One or more so-called crossover points are selected (usually at random) within the chromosome of each parent, at the same place in each. The parts delimited by the crossover points are then interchanged between the parents, as shown in Fig. 2. The individuals resulting in this way are the offspring. Beyond one point and multiple point crossover, there exist more sophisticated crossover types. The so-called knowledge-augmented crossover operator constructs offspring from the parents by making use of domain knowledge related to the given problem. In a representation consisting of numerical values, the so-called

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arithmetic crossover generates offspring as a component-wise linear combination of the parents.

In later phases of evolution it is more desirable to keep fit individuals intact, so it is a good idea to use an adaptively changing crossover rate: higher rates in early phases and a lower rate at the end of the genetic algorithm. Sometimes it is also helpful to use several different types of crossover at different stages of evolution.

Mutation. A new individual is created by making modifications to one selected individual. The modifications can consist of changing one or more values in the representation or in adding/deleting parts of the representation. In genetic algorithms mutation is a source of variability, and is applied in addition to crossover and reproduction.

At different stages of evolution, one may use different mutation operators. At the beginning mutation operators resulting in bigger jumps in the search space might be preferred. Later on, when the solution is close by, a mutation operator leading to slighter shifts in the search space could be favored.

2.4. Fitness assignment

The probability of survival of any individual is determined by its fitness: through evolution the fitter individuals overtake the less fit ones. In order to evolve good solutions, the fitness assigned to a solution must directly reflect its 'goodness', i.e. the fitness function must indicate how well a solution fulfills the requirements of the given problem.

Fitness assignment can be performed in several different ways:

† We define a fitness function and incorporate it in the genetic algorithm. When evaluating any individual, this fitness function is computed for the individual.

† Fitness evaluation is performed by dedicated separate analysis software. In such cases evaluation can be time-consuming, thus slowing down the whole evolutionary algorithm.

† Sometimes there is no explicit fitness function, but a human evaluator assigns a fitness value to the solutions presented to him/her.

† Fitness can be assigned by comparing the individuals in the current population. For example, if the problem is about game-playing, and a solution corresponds to a game-playing strategy, its fitness depends on the number of other solutions in the population that are defeated by it.

2.5. Selection methods

Only selected individuals of a population are allowed to have offspring. Selection is based on fitness: individuals with better fitness values are picked more frequently than individuals with worse fitness values. We present here the most commonly used selection schemes.

Fitness-proportional selection. When using this selection method, a solution has a probability of selection directly proportional to its fitness. The mechanism that allows fitness proportional selection is similar to a roulette wheel that is partitioned into slices. Each individual has a share directly proportional to its fitness. When the roulette wheel is rotated, an individual has a chance of being selected corresponding to its share.

Ranked selection. The problem of fitness-proportional selection is that it is directly based on fitness. In most cases, we cannot define an accurate measure of goodness of a solution, so the assigned fitness value does not express exactly the quality of a solution. Still, an individual with better fitness value is a better individual. In rank based selection, the individuals are ordered according to their fitness. The individuals are then selected with a probability based on some linear function of their rank.

Tournament selection. In tournament selection, a set of n individuals are chosen from the population at random. Then the best of the pool is selected. For n ¼ 1, the method is equivalent to random selection. The higher is the value of n, the more directed the selection is towards better individuals.

2.6. Constraints in GAs

Design problems usually contain constraints. In many cases the constraints can be expressed as well-defined intervals for the design parameters, but sometimes it is quite difficult to specify them (e.g. forbidden regions in robot path design). A key question in applying genetic algorithms to design is the handling of design constraints. Several techniques have been developed to introduce constraint handling into different components of GAs.

A popular method of constraint satisfaction in GAs is to reject individuals that violate constraints, i.e. the infeasible individuals. Infeasible individuals can be represented and can appear as the result of the genetic operators but are not admitted to the new generation. This method may work when the feasible region of the search space (i.e. the region

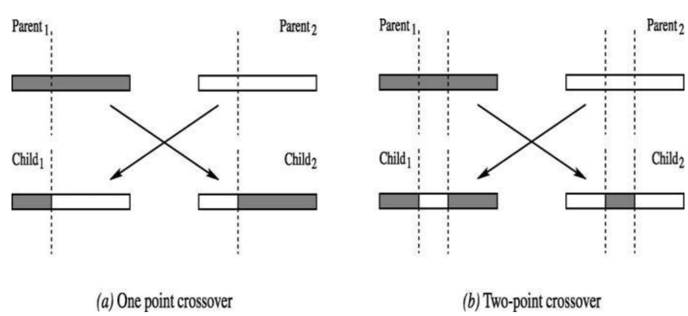

Figure. 2. Different types of crossover.

containing the individuals that satisfy all the constraints) is convex and reasonably large. However, if the initial population consists of infeasible individuals only, they could be repaired instead of being rejected. Repair of infeasible

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individuals in a population is a popular approach, especially in the case of problems where it is relatively easy to repair an infeasible individual. The disadvantage of this method is that for each problem a specific repair algorithm must be devised. Meanwhile, evaluation can be tuned in such a way that individuals slightly violating the constraints are still accepted.

A frequently applied technique for handling constraints is to introduce a penalty into the fitness function. Individuals that do not fulfill the constraints are given penalties that depend on the extent of violating the constraints. Selection is based on a weighted sum of fitness and penalty. Thus, the infeasible individuals participate in the genetic process, as they are still considered capable of delivering useful offspring. However, careful adjustment of the penalty weight is needed. If the penalty weight is too low, 'very' infeasible individuals could be preferred to slightly less fit but much more feasible individuals. On the other hand, application of high penalty weight may push promising individuals out of the population, and the process may converge to feasible but unfit individuals. There is a general view that GAs with variable penalty weights work better than GAs with a fixed penalty weight. For instance, in many cases a good strategy is to start with relaxed constraints, i.e. low penalty weights, and then continue with strengthened constraints, i.e. higher penalty weights, as the GA proceeds, thus ensuring a path to promising solutions.

A more reliable approach is to incorporate all constraints into the genetic representation, i.e. to devise a representation which does not allow any individual to violate any constraints. While in the case of simple constraints this may work, for more complex cases it may be very tricky or impossible. Additionally, incorporating too much problem specific knowledge into the representation largely limits the size of the search space and may require the careful definition of specific crossover and mutation operators.

2.7. Advanced genetic algorithms

Genetic algorithms work well for many practical problems. In their application to complex design problems, however, simple GAs may converge slowly, evaluations may be computationally intensive, or GAs may fail because of convergence to an unacceptable local optimum. Con-siderable research effort has been made to improve the efficiency of GAs, which has resulted in advanced genetic algorithms. We mention the most important extensions shown to be advantageous in the application of genetic algorithms to design problems. An overview of other useful extensions is given by Bentley [8]. according to how close they are to other individuals in the population. The fitness of each individual is worsened by its neighbors in the search space: the more and the closer neighbors an individual has, the worse its fitness becomes. As a result, the population does not converge as a whole, but convergence takes place within neighborhoods of the optima—the so-called niches.

The notion of species was defined for GAs: similar individuals form a species, and the technique of implement-ing species is called speciation. When mating can take place only between individuals of the same species and is disallowed for individuals of different species, the specia-tion method is mating restriction [27].

Using parallel (even simulated) GAs is another possi-bility for maintaining diversity, more precisely for finding multiple solutions. The use of several independent sub-populations increases the chances of finding several different optima. Migration between subpopulations helps diversity maintenance during the run.

2.8. Other evolutionary algorithms

Genetic algorithms constitute the most popular method—having the greatest number of applications—of evolutionary computation. Here we give only brief defi-nitions of other evolutionary methods, whose detailed comparative description and fields of application can be found in Refs. [4,8].

Evolutionary programming was created by Lawrence Fogel [30] for generating machine intelligence. Evolution-ary programming works directly on the variables of the problem and uses only inheritance from one parent: it creates new individuals only by mutation. Intelligent behavior was viewed as the ability to predict the environment and to give proper response so as to reach a certain goal. Initially, evolutionary programming was applied to the evolution of finite state machines.

Evolution strategies were developed by Ingo Rechenberg. Evolution strategies represent individuals as real valued vectors and also create new individuals by mutation only. In contrast to evolutionary programming, evolution strategies select the parents for a new generation deterministically.

Genetic programming is a relatively new development initiated by Nichael Cramer and John Koza [24,53]. Genetic programming operates on computer programs represented in various forms—trees, sequential structures or graphs—by using modified genetic operators.

3. Genetic algorithms in design

Engineering design is aimed at creating artifacts (products) that satisfy well-defined human needs or change the environment around us.

Expectations and requirements concerning the product are described in design specifications. The design process can be seen as the transformation of the specifications into design descriptions. The design description must contain sufficient information (numerical, graphical, symbolic) for manufacturing the product. Functionality and manufactur-ability impose constraints on the structure and parameters of the product. Thus, design—as an intelligent activity—can be characterized as a goal oriented, constrained, decision making process [34]. Engineering design typically involves exploration and learning. While exploration is needed to identify what kinds of structures and variables are appro-priate to fulfill the requirements, learning attempts to use experience gained from previous design processes and from emerging solutions.

A considerable effort has been made to model the design process [47]. Although the basic aim is to provide a solid basis for building computer programs to automatize—or at least assist—the design process, modeling has contributed to a better understanding of what design is.

The information flow model [3] concentrates on communication of information and data during design in sequential stages with fixed feedback. The model reflects the organization of activities required to solve a design task, but says almost nothing about the role of knowledge used in design. In spite of the apparent simplification, this model is currently used for building CAD systems, and for integrat-ing them with CAPP and CAM systems.

The cognitive model tries to describe reasoning, inten-tions, problem solving and decision making processes of the designer during design. Although this kind of model provides deeper understanding of the intellectual process during design, it is very difficult to transform into computational terms.

Design can be conceived as a search for a suitable or optimal construction, where the term search is used in a technical sense. A search problem consists of a desired state (goal state), a search space and a search process. In design the goal state represents the characteristics of the final design. The goal state is consistent and complete: its characteristics are non-conflicting and fully specify the final design. The search space is the set of all designs characterized by all possible (or allowable) values of the design parameters. The search process (deterministic or heuristic) consists of searching for the goal state in the search space, in this case searching for the optimal design in the space of all designs.

A comprehensive bibliography on 'Artificial Intelligence in Design' is maintained by Brown [13].

3.1. Routine design

In many design situations the relationship between the functional requirements and the structure or form needed to satisfy those requirements is known. In this case—referred to as routine design—the parameters allowing variation in the design are also known. The design task consists of defining appropriate values for the parameters, which frequently means searching for their optimal values.

The concepts of routine design can be directly mapped to genetic algorithms: the parameters are encoded as genes that form chromosomes, which are evolved by the genetic algorithm. There is a close relation—usually a one to one mapping—between the chromosomes (genotype) and the parameters (phenotype). Addition and deletion of genes (parameters) is generally not performed during evolution.

In routine design, the search space is fully determined by the structure and range of the design parameters. The fitness function evaluates all states, and the goal state is determined by the optimum of the fitness function. The search space is defined by the chromosomes, and the search process is the artificial evolution.

The high efficiency of applying GAs to parameter optimization can be explained by the intensive exploration and exploitation of the search space through selection, crossover and mutation.

3.2. Creative design

Creativity is a concept that is hard to define. We mostly associate the attribute 'creative' to a human [9] for doing something that results in a creative product or performing something in a creative way.

For a long time there has been a general view that computers cannot be creative. Pioneering work on using computers for creative architectural design was done by Stiny and Mitchell, and Frazer [9,32]. An early application of artificial intelligence to the design of simple mechanical devices is the 'EDISON' system described by Dyer, Flower and Hodges [28], which is another attempt to make computers creative.

It is only recently that so-called creative evolutionary systems have been developed. They are defined by Bentley and Corne [9] as evolutionary systems that possess one or both of the following features:

1. They aid human creativity;
2. They solve problems that only creative people could solve.

In systems that aid human creativity selection is guided by the user. When the user is asked to rank the individuals in a population, he/she actually plays the role of a fitness evaluator, which is good and bad at the same time:

† good, because there is no need to define a fitness function, and premature convergence can be avoided through the user enforcing alternatives;

† bad, because the system is very slow due to the limited speed of rating and interaction. In general, the user cannot cope with very large populations, and the user may judge the same individual differently at different stages.

Examples of such systems are evolutionary art systems. Most of these systems evolve aesthetic images, and require human guidance in selecting the more beautiful ones. Evolutionary art systems are very popular, and are available as art packages

Systems that generate creative results (i.e. solve problems that only creative people could solve) provide solutions automatically. The evolutionary techniques are applied non-traditionally: only the tools for constructing the solution are made available to the system, possible solutions are not [9]. One way of doing this is to relax constraints in order to explore more potential solutions [9]. In a traditional GA system, only good parametrization leads to good solutions. By allowing modification of the represen-tation, we could expect the GA system to be able to solve problems beyond optimization. According to Boden [11], creativity can be achieved by finding some new solution that could not have been defined by a representation (but Boden believes that computers will never be able to do so).

In the new approach, the parameters do not represent the solution itself, but the components from which the solution is constructed. The genetic representation consists of a set of rules for the construction of a solution. These rules are mapped into a solution through so-called embryogeny [9]. The phenotype is then evaluated for fitness either with human guidance or automatically, by a fitness function. Embryogenies are used for exploring the search space, as they allow the construction of solutions from components, contrary to genetic optimization where the parameters of a fixed system are optimized.

There are few systems generating creative results. Bentley and Wakefield [10] propose an automatic creative design system for optical prisms. Funes and Pollack [33] use artificial evolution to generate 2D and 3D Lego structures that accomplish certain objectives. The obtained structures are feasible and completely different from human-designed structures. Taura and Nagasaka use different represen-tations for genotype, embryogeny and phenotype for configuration design of a satellite. They adopt a so-called adaptive-growth-type shape representation: the actual shape is determined by the interaction between the generational rules and the environment.

Goldberg [38] explains how to design and implement innovative genetic algorithms based on understanding human innovation.

We expect that as the advantages of creative evolution are better understood, the number of such applications will increase.

4. Genetic algorithm applications to design

Genetic algorithms are being applied to many areas of engineering design in mechanical engineering, electrical engineering, aerospace engineering, architecture and civil engineering, etc. It is practically impossible to give

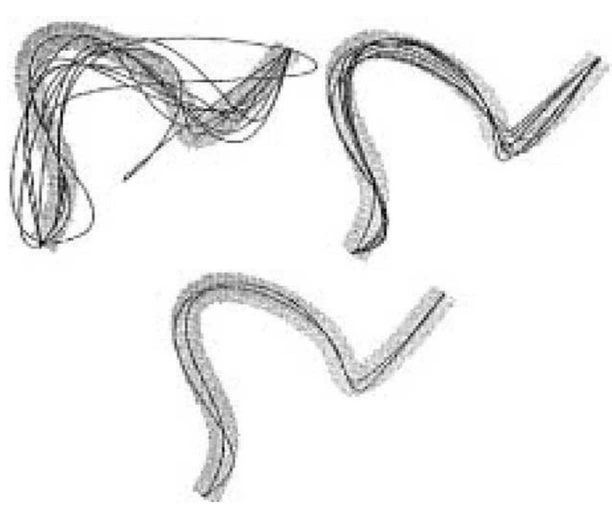

Figure. 3. Evolution history of the population.

consequences; genetic operators and selection methods must be capable of handling these structures, which means that readily available GA software packages cannot be used in shape design without modification.

Shapes with complex geometrical properties can be represented by two or three-dimensional grids of control points of Be´zier, B-spline, NURBS surfaces or volumes. Following the discussion for curves, a grid structure of control points may be suitable for genetic representation. Simple genetic codes are not applicable directly to these structures, and new genetic operators must also be developed. For example, crossover operating on grids of the same size can be defined by first randomly selecting subgrids at the same position in the two individuals and then exchanging them in the offspring. A frequently occurring problem is the appearance of self-intersecting grids, which may result in self-intersecting shapes. To avoid this, intersecting grids may be locally deformed or they may be strongly penalized in the fitness calculation. Variants of the control point representations can also be used as genetic representation of shapes. For example, Wataba and Okino [95] use the free form deformation lattice (deformation of a grid of Be´zier control points) introduced by Sederberg and Parry [84] as shape chromosomes, and solve a minimum weight design problem with constraint conditions, and limitation of maximum stress.

In many practical shape optimization problems, evalu-ation of the fitness function for a given set of shape parameters is computationally demanding; it frequently requires the solution of non-linear state equations in two or three dimensions. Genetic algorithms, however, can be easily parallelized (see Section 2.7.2): after individuals of the current population have been created, evaluation of their fitness can be computed in parallel. In this setting a master – slave distribution of the work is efficient. In more complex cases, more sophisticated ways of distributing computations may be needed, e.g. distribution among several levels of computational hierarchy. Ma¨kinen et al. [58] use a master-slave process, Marco and Lanteri [60] a two level strategy for the parallelization of the GA.

4.2.2. Cell GA

An alternative way of representing the shape of an object to be optimized is to subdivide the design space into small rectangular domains (pixels in 2D, voxels in 3D), and assign them a binary full value (1) for material or empty value (0) for void (see Fig. 4), or integers for different materials. This kind of cellular representation has the advantage that any shape can be represented with a certain accuracy, which can be increased by increasing the resolution. At the same time, the cellular representation can be mapped directly into a two or three-dimensional binary genetic representation, result-ing in a two or three-dimensional array chromosome. By applying this representation, domain specific knowledge and geometric constraints can easily be built into the genetic process. It has a great advantage from the point of view of shape optimization, and also compared to a parametric GA, that the structure and topology of the object need not be fixed in advance, but arise through the optimization process. As a result, a properly designed genetic process can work in an extended search space and give better results. However, unwanted small holes may appear in the final shape, and lack of smoothness of the boundary may not be acceptable in certain engineering problems.

When a genetic algorithm for shape optimization is designed based on two or three dimensional arrays as a

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genetic representation, specific two or three dimensional crossover operators must be developed. One practical solution—a direct generalization of one point crossover— is first to select randomly a point in the middle of the array. Then complementary parts of the parents' chromosomes in blocks determined by the selected point are used to form the chromosomes of the children (see Fig. 5). For this type of genetic representation, fitness evaluation is more compli-cated and time consuming than in the case of a simple sequential genetic code. Typically, planar or spatial distribution of geometrical or physical quantities need to

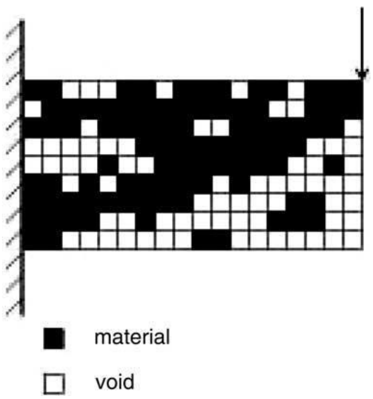

Figure. 4. The cell representation of a cantilever

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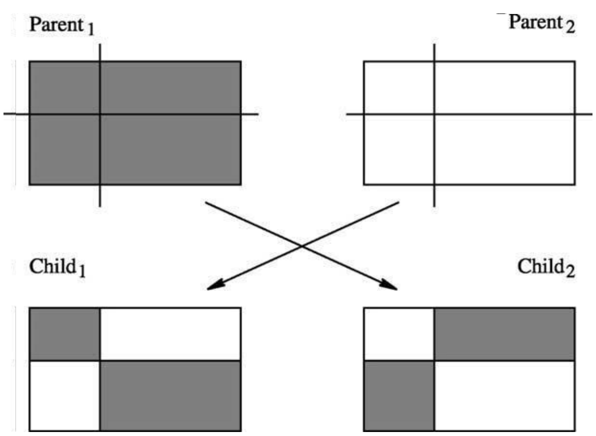

Figure. 5. The diagonal crossover for 2D arrays.

be evaluated, often by using demanding analysis programs (e.g. finite element programs).

Baron et al. [5] study the shape optimization of a beam and an annulus. Instead of finetuning various parameters of the GA, they focus on the development of new operators in an attempt to eliminate some of the weaknesses of the cellular representation. For example in order to reduce the number of small holes, they apply a smoothness operator; the most common value for cells in a rectangular region with random position is applied to all the cells in that region. They also use an n-dimensional crossover operator which swaps rectangular areas with randomly selected size and location in the array. It is rather interesting that the design produced by the cell representation compares well with that produced by a parametric GA; however, the cell GA requires more time to find a solution. This can be explained by the fact that, when using a cell representation, the GA has to search a much larger space with fewer constraints.

Duda and Jakiela [27] describe a speciating genetic algorithm for shape optimization. The speciation is based on a sharing function computed from the distance in the genotype and phenotype space. Using statistical cluster analysis, this measure allows the quantification of the extent to which a population is speciated. The sharing function is also used for mating restriction during evolution. As a result of the genetic process, the speciated final population contains not only one solution, but good designs with different topology and shape. The method has been shown to be efficient for solving planar strain problems based on cell shape representation and finite element methods for structural analysis.

Two-dimensional cell (pixel) representation is also used for shape optimization by Kane and Schoenauer [51]. The inadequacy of one dimensional (bitstring) representation is emphasized and an evolutionary choice made among different two dimensional genetic operators.

Chapman and Jakiela [17] apply cell representation for the geometric and topological design of truss structures having a maximum stiffness-to-volume ratio. In order to obtain realistic structures a connectivity analysis is performed; all material elements in the topology which are not connected to another one through an edge are set to void. Chen and Rajan consider simultaneous sizing, shape and topology optimization of structural framed systems subject to static and dynamic loads. Raich and Ghaboussi develop an implicit redundant representation genetic algorithm, which allows the representation of a variable number of location independent parameters. In this way the fixed parameter limitations of usual genetic algorithms can be overcome.

A special type of cell representation called cell division model is introduced by Taura et al.. The shape of a free form object is represented by dots (cells) on the surface of a sphere; the distance between a point on the surface of the free-form object and the center of the sphere is proportional to the local density of cells on the sphere. Shape evolves through a series of cell divisions, which are governed by a set of rules. These rules indirectly hold the features of the shapes, and are encoded as bit strings. A GA is applied for adaptive generation of new rules and for testing the effectiveness of existing ones. The whole mechanism resembles the early development of a living creature. In nature, cell divisions divide the fertilized egg (a single cell) into a population of smaller cells, which form the early embryo. Shape features of the evolving multicellular system are determined by rules of cell division. Although the complexity and accuracy of shapes which can be handled by the model is questionable, first experiments show that shape features can be represented, held, combined and manipu-lated by the method, which is useful and especially valuable in the early phase of design.

4.3. Data fitting

Fitting of continuous curves and surfaces to discrete data points is often needed in a number of engineering endeavors. There are well-established fitting methods (usually variants of the least-squares technique), but they perform well only if several parameters are defined in advance, e.g. for spline fitting, the process is computation-ally feasible (linear) if the degree, knot distribution, and parametrization of the data points are given and fixed for the computation. In practical situations, however, these are not known to the designer. Currently there is no better way than to start with some values and gradually improve them. Complicated and cumbersome methods are in use to find good initial values and refine them during a repeated fitting process. At the same time, the above parameters strongly influence the quality of the fit, because they determine the structure and the basic geometric properties of the approximating function. If they are not defined properly, either the accuracy will be poor or the shape quality will not be satisfactory. The complicated and strongly non-linear interdependence of the parameters and their influence on the fitting process is hard to keep under control, but is relatively easy to include into a GA. Successful experiments have

emerges. Buckley et al. [15] report on applying GAs for positioning a snake manipulator in a gas duct for inspection and repair work in nuclear reactors. With a simple GA they experienced premature convergence, and the GA population quickly converged to sub-optimal solutions. The loss of diversity in the simple GA was due to the fact that most of the encoded parameters were strongly dependent on others. Much better, but still not optimal results were obtained when rank-based selection, diversity promoting techniques and domain knowledge were used. They used a so-called incest prevention scheme that allows mating only between dissimilar individuals. The incorporation of knowledge related to the kinematics of the snake manipulator reduced the search space and resulted in improved performance.

Nearchou and Aspragathos formulate the collision-free path planning problem as a constrained optimization problem. They use a fitness function based on positioning error and assign a fitness value of zero to any path with collisions. The decision whether a path is collision-free is made with the help of a method based on convex hulls. The solutions guarantee obstacle avoidance and their positioning error is also acceptable.

Rana and Zalzala tackle the problem of path planning for two robot manipulators which act as dynamic obstacles for each other. The paths are represented as strings of via-points through which the robots have to pass. Fitness is calculated as a weighted sum of penalties for path lengths, uneven distribution of via-points and collisions. They also consider a safety distance between the two robots at any time instant.

5. Conclusion

Evolutionary methods such as genetic algorithms have increasingly been applied in engineering in the past decade. Basically, genetic algorithms have been considered as tools for optimization and parameter tuning in engineering design.

Although the algorithmic implementation of artificial evolution is much simplified compared to real natural evolution, GAs are capable of solving surprisingly complex design problems. Genetic algorithms conduct a search through the space of potential solutions to the problem. They provide a balance between two search strategies— exploration and exploitation—: they explore the search space and in the mean time exploit the good features of already found promising solutions. GAs perform an independent sampling on a large population of design solutions, then select members of the population, i.e. highly fit designs, for survival, and create new designs by crossover (combination of building blocks from different individuals) and by mutation. Crossover ensures the inheritance and dominance of valuable features, whereas mutation intro-duces variability. Together with the selection mechanism, they drive the artificial evolution process towards generat-ing better and better solutions.

The strength of genetic algorithms in design can be attributed to several factors. They are flexible and can be adapted to different design problems. Realization of GA procedures results in robust and stable algorithms and computer codes. Complexity of a problem can be handled by their ability to work with many parameters simul-taneously in a search space of complicated structure. In design applications it is very important that there is a built-in tendency to find global optima. GAs can also be used beyond parameter optimization, for creative design.

Due to the nature of design problems, the application of GAs is not always as straightforward and successful as it would seem. For instance, evaluation of the quality of the solutions (i.e. the fitness function) during the genetic process can be computationally very demanding (e.g. requiring finite element analysis software). Great efforts have been made towards reducing the number of evaluations needed before the final solution is reached. This has resulted in advanced and improved genetic algorithms, such as parallel and distributed GAs.

Genetic algorithms imitate the very basic properties and fundamental mechanisms of natural evolution. Natural evolution, however, possesses complicated structures and complex, well regulated and fine-tuned mechanisms. Although our current knowledge about evolution is rather limited, we can expect that ideas learned from studying evolution will be extensively used to solve complex engineering problems. Promising results have been obtained in all fields of evolutionary computation. More complex biological structures and mechanisms (e.g. brain, viruses, and immune system) can also be incorporated into computational systems in order to support complex intellectual activities, like design. A great challenge for future research is to understand the functioning of these systems and to transpose abstracted ideas into computer aided design systems.

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OPTIMIZATION OF INVENTORY BY SUPPLIER SELECTION USING TOPSIS METHOD IN PISTON AND RING INDUSTRY

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Abstract

As every industry needs to run parallel with the market demands to win most extraordinary advantages in which inventory management and demand forcasting of inventories accept an essential part. In view of which inventories and inventory optimization will be blended in like way and modified. For any industry to work profitably the trust between the supplier and buyer is a verifiable prerequisite. The idea of supply chains has as of late attracted significant consideration worldwide economy. This supply-side attention clarifies the accomplishment of the recently blasted economy in numerous regions under the immense worldwide opposition after the decay of old framework. This paper will at first discuss the basic definitions of supply chain management, inventory management and inventory optimization techniques. Inventory optimization should be planed to the point that the stream between them is continually smooth and versatile as demonstrated by the need of the client. After examination of the inventory network of the industry genuine attributes are picked. TOPSIS Method is actualized on the data achieved.TOPSIS procedure is utilized for determining the supplier's estimations. The positioning of the suppliers according to those attributes are derived with the objective that best inventory optimization is attained. The technique used has distinctive applications be it in day-to-day issues to complex present day issues. Thus, the aim of this paper is to decide the appropriate supplier giving the maximum consumer trustworthiness for the criteria recognized in the supply chain.

Keywords: Supply Chain Management, Inventory Management; Inventory Optimization; Multi-Criteria Decision Making; TOPSIS Method; Supplier Selection

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1. Introduction

In the ebb and flow circumstance supply chain management acknowledge an important centrality and calls for certified research thought, as associations are tried with finding ways to deal with meet routinely rising customer wants at a sensible cost. To do thusly, a manufacturer must request out which parts of their supply chain are not engaged, grasp which customer needs are not being met, develop change goals, and rapidly execute basic upgrades. Makers were the drivers of the store organize - managing the pace at which things were created and circled. Today, customers are settling on significant choices, and makers are scrambling to meet customer demands for decisions/styles/features, energetic demand fulfillment, and fast movement.

Inventory Management is a trying issue area in store network management. Associations require inventories in dispersion focuses with a particular true objective to fulfill client ask for, meanwhile these inventories have holding costs and this is set save that can be lost. In this way, the endeavor of stock organization is to find the measure of inventories that will fulfill the demand, keeping up a vital separation from over-burdens.

Lean Manufacturing framework has risen as a vital region of research in Indian setting. Diminishment in lead time enhances the efficiency. Here the variables influencing the lead time are distinguished. This examination has built up an endeavor to create basic model of factors, essential to execute by Interpretive Structural Modeling way to deal with decide the key elements which influence the lead time.

In the engaged business state of the 21st century, affiliations must answer quickly and unquestionably to client's solicitations. The choice of suppliers and their assessment are getting the chance to be extremely troublesome. Surveying suppliers and picking one of them are jumbled assignments in view of the way that diverse criteria or objectives must be considered in the essential initiative process. In this paper, we proposed a supplier assurance investigation considering Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method. TOPSIS framework is used for discovering the supplier's examinations.

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2. Supply Chain Management

Savage competition in the present worldwide markets the presentation of items with shorter life cycles, and the increased desires for customers have constrained business undertakings to put resources into, and concentrate consideration on, their supply chains. This, together with proceeding with propels in interchanges and transportation innovations (e.g., versatile correspondence, Internet, and medium-term conveyance), has roused the consistent development of supply chain and of the methods to oversee it viably. In a run of the supply chain management, raw materials are obtained and things are created at least one production lines, delivered to distribution centers for middle of the road stockpiling, and after that sent to retailers or clients. Subsequently, to lessen cost and enhance benefit levels, successful supply chain must consider the collaborations at the different levels in the supply chain.

3. Multi-criterion Decision Making

Multi-Criteria Decision Analysis, or MCDA, is an important technique that we can apply to numerous mind-boggling choices. It is most pertinent to taking care of issues that are portrayed as a decision among choices. It has every one of the attributes of a valuable choice help apparatus.

MCDA IS USEFUL FOR:

- Dividing the decision into smaller, more understandable part
- Analyzing each part
- Integrating the parts to produce a meaningful solution

3.1 Steps of MCDM

A decision-making process involves the following steps to be followed:

- Identify objective of decision-making process
- Selection of the Criteria/Factors
- Selection of the Alternatives
- Selection of the weighing methods
- Method of Collection
- Decision based on the Aggregation result

4. TOPSIS Method

TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) was developed by Hwang and Yoon in 1980 as an alternative to the ELECTRE method and can be considered as one of its most widely accepted variantsThe essential idea of this strategy is that the chose option ought to have the briefest separation from the perfect arrangement and the most remote separation from the negative-perfect arrangement in some geometrical sense.

The TOPSIS technique accept that each measure has a propensity of monotonically expanding or diminishing utility. Thusly, it is anything but difficult to characterize the perfect and negative-perfect arrangements. The Euclidean separation approach was proposed to assess the relative closeness of the other options to the perfect arrangement. In this way, the inclination request of the options can be determined by a progression of correlations of theserelative distances. The TOPSIS method first converts the various criteria dimensions into non-dimensional criteria as was the case with the ELECTRE method.

However, it is sensible to expect here that for the advantage criteria, the leader needs to have a most extreme incentive among the options. For the cost criteria, the chief needs to have a base an incentive among the options. By and large, A+ shows the most ideal option or the perfect arrangement. Additionally, elective A- demonstrates the minimum ideal option or the negative perfect arrangement.

4.1 TOPSIS Process

TOPSIS process was presented by Yoon and Hwang and was evaluated by surveyors and distinctive administrators. As large number of potential accessible merchants in the present advertising condition, a full ANP choice process ends up unreasonable now and again. To stay away from an irrationally huge number of match insightful correlations, we pick TOPSIS as the positioning procedure in light of its idea's instance of utilization. Additionally, ANP is embraced basically for the securing of the weights of criteria.

This method considers three types of attributes or criteria:

1. Qualitative benefit attributes / criteria

2. Quantitative benefit attributes
3. Cost attributes or criteria

In this method two artificial alternatives are hypothesized:

- Ideal alternative: the one which has the best level for all attributes considered.
- Negative ideal alternative: the one which has the worst attribute values.

First, a general TOPSIS process with six activities is listed below:

ACTIVITY: 1) Establish a decision matrix for the ranking. The structure of the matrix can be expressed as follows:

$$D = \begin{array}{c|cccc} & B_1 & B_2 & \dots & B_n \\ \hline A_1 & P_{11} & P_{12} & \dots & P_{1n} \\ \vdots & \dots & \dots & \dots & \dots \\ A_n & P_{m1} & P_{m2} & & P_{mn} \end{array} \quad (1)$$

Where A_i denotes the alternatives i, i = 1…., m; B_j represents j^{th}attribute or criterion, j = 1…., n, related to i^{th}alternative; $P_{ij}$is a crisp value indicating the performance rating of each alternative A_i with respect to each criterion B_j.

ACTIVITY: 2) Calculate the normalized decision matrix Q= [Sij].

The normalized value Sij is calculated as;

$$s_{ij} = \frac{P_{ij}}{\sqrt{\Sigma_{j=1}^{n} (P_{ij})^2}} \quad (2)$$

i = 1 ……n; j= 1…..m

ACTIVITY: 3) Calculate the weighted normalized decision matrix by multiplying the normalized decision matrix by its associated weights. The weighted normalized value

V_{ij} is calculated as:

$$V_{ij} = W_{ij}.S_{ij} ,$$

j=1…….n; i=1….. m; (3)

Where wj represents the weight of the j^{th}attribute or criterion.

ACTIVITY: 4) Determine the PIS and NIS, respectively:

$V^+ = \{v_1^+..v_n^+\} = \{(\text{Max } v_{ij} \text{ I } j \text{ c } J), (\text{Min } v_{ij} \text{ I } j \in J')\}$

$V^- = \{v_1^- v_n^-\} = \{(\text{Min } v_{ij} \text{ I } j \in J), (\text{Max } v_{ij} \text{I } j \in J')\}$

Where J is associated with the position criteria and J' is associated with the negative criteria.

ACTIVITY: 5) Calculate the separation measures using the m-dimensional Euclidean distance. The separation measure Ei^+ of each alternative from the PIS is given as:

$$E_i^+ = \sqrt{\Sigma^n_{j=1} (V_{ij} - V_j^+)^2}$$

i = 1…….m (4)

Similarly the separation measure Ei^- of each alternative from the NIS is as follows:

$$E_i^- = \sqrt{\Sigma^n_{j=1} (V_{ij} - V_j^-)^2}$$

i = 1…….m (5)

ACTIVITY: 6) Calculate the relative closeness to the idea solution and rank the alternatives in descending order. The relative closeness of the alternative A_i with respect to PIS V^+ can be expressed as:

$$H_i^* = E_i^- / E_i^+ + E_i^- \quad (6)$$

Where the index value of H_i^* lies between 0 and 1. The larger the index value, the better the performance of the alternative

5. Application of TOPSIS for supplier selection in Piston and Ring Industry

A number of problems arise during the manufacturing stage and premanufacturing stage at the plant. No prescribed technique is being implement at the plant for inventory management as well as inventory optimization. This has led to a number of problems such as increased cycle time, increased lead time, over-stocking, non-uniform motion of inventory oh manufacturing line, increase in rejection rate, etc. leading to loss to the company in terms of reputation as well as monetary funds. While performing research and visiting the industry, we were able to collect crucial information for better optimization of inventory management of the industry and found that supplier selection was very much needed as most of the attributes which needed improvement were on the supplier’s end.

The industry provided us with a couple of attributes on which they needed improvement and some attributes have been selected by us through rigorous research and observation at the industry during the visits. A detailed study of all the attributes has been done keeping in mind the requirements of the industry and proper technique for optimization has been applied. TOPSIS has been implemented for the optimization of supplier selection as well as the attributes.

5.1 Selected Attributes

The following are the selected attributes:

- Material Quality
- On-time Delivery
- Ordering Cost
- Product Price
- Financial Stability
- Delivery lead-time
- Technical Capability
- Transportation Cost
- Rejection of defective product
- Production Facilities and Capacity

Table 1. **Selecting criteria for supplier evaluation and Weight**

Code	Criteria	Weight
D1	Material Quality	0.21
D2	On time Delivery	0.08
D3	Ordering Cost	0.07
D4	Product Price	0.16
D5	Financial Stability	0.10
D6	Delivery lead-time	0.09
D7	Technical Capability	0.06
D8	Transportation Cost	0.04
D9	Rejection of defective product	0.08
D10	Production facilities and capacity	0.11

STEP-1: FORMULATION OF DECISION MATRIX

Establish a decision matrix for the ranking. TOPSIS uses all outcomes (x_{ij}) in a decision matrix to develop a compromise rank. The viable alternatives of the decision process are A_1, A_2,..., An. The structure of the decision matrix denoted by

X= (x_{ij}) n x mcan be expressed as follows:
x is the outcome of i^{th} alternative with respect to j^{th} criteria.

	Suppliers			
Criteria	**1**	**2**	**3**	**4**
D1 (%)	94	93	96	90
D2 (%)	90	95	93	91
D3 (Rs.)	130	150	142	140
D4 (Rs.)	2700	3500	3200	3000
D5 (Grad.)	4	3	6	3
D6 (Days)	12	15	14	10
D7 (%)	45	52	37	40
D8 (Rs.)	655	472	560	700
D9 (%)	0.01	0.03	0.01	0.02
D10 (Grad.)	5	4	6	7

W= (w_1, w_2, w_3,…, w_j,…, w_m) is the relative weight vector about the criteria, and $w_j$represents the weight of the j^{th} attribute and $\sum_{j=1}^{m} wj = 1$

Table2. Supplier's information (Decision Matrix)

STEP-2: CALCULATING THE NORMALIZED DECISION MATRIX

Now, normalize the decision matrix using the equation:

$$r_{ij} = \frac{w_{ij}}{\sqrt{\sum_{k=1}^{n} w_{ij}}}$$

where,i= 1,2,3,…n and j=1,2,3,…,m

Table 3. Normalized Matrix

	Suppliers			
Criteria	**1**	**2**	**3**	**4**
D1 (%)	0.51	0.5	0.51	0.48
D2 (%)	0.48	0.52	0.51	0.49
D3 (Rs.)	0.46	0.53	0.51	0.49
D4 (Rs.)	0.45	0.56	0.49	0.53
D5 (Grad.)	0.56	0.35	0.68	0.34
D6 (Days)	0.46	0.58	0.59	0.39
D7 (%)	0.52	0.59	0.42	0.45
D8 (Rs.)	0.53	0.39	0.46	0.58
D9 (%)	0.47	0.7	0.29	0.47
D10 (Grad.)	0.44	0.65	0.53	0.62

STEP-3: CALCULATING THE WEIGHTED NORMALIZED DECISION MATRIX

The weighted normalized decision matrix is formed using the following formula:

$V_{ij} = W_{ij} * S_{ij}$

where, i= 1,2,3,…n and j=1,2,3,…,m

Table 4. Weighted normalized decision matrix

	Suppliers			
Criteria	**1**	**2**	**3**	**4**
D1 (%)	0.1020	0.1000	0.1020	0.0960
D2 (%)	0.0391	0.0416	0.0409	0.0392
D3 (Rs.)	0.0329	0.0370	0.0358	0.0343
D4 (Rs.)	0.0676	0.0840	0.0721	0.0560
D5 (Grad.)	0.0558	0.0341	0.0680	0.0340
D6 (Days)	0.0423	0.0522	0.0485	0.0351
D7 (%)	0.0363	0.0412	0.0303	0.0315
D8 (Rs.)	0.2700	0.0196	0.0231	0.0290
D9 (%)	0.0377	0.0569	0.0191	0.3760
D10 (Grad.)	0.0495	0.0397	0.0583	0.0681

STEP-4: DETERMINE THE POSITIVE IDEAL SOLUTION (PIS) AND NEGATIVE IDEAL SOLUTION (NIS)

$V^+ = \{v_1^+ \ldots v_n^+\} = \{(\text{Max } v_{ij} \text{ I } j \text{ c } J), (\text{Min } v_{ij} \text{ I } j \text{ € } J')\}$

V^+ ={.1020, .0416, .0370, .0840, .0680, .0522, .0412, .0290, .0569 .0397}

$V^- = \{v_1^- v_n^-\} = \{(\text{Min } v_{ij} \text{ I } j \text{ € } J), (\text{Max } v_{ij} \text{I } j \text{ € } J')\}$

V^- = {.0960, .0392, .0329, .0560, .0340, .0351, .0303, .0196, .0191, .0681}

STEP-5: CALCULATING POSITIVE SEPARATION MEASURE AND NEGATIVE SEPARATION MEASURE

1. **POSITIVE SEPARATION MEASURE**

   $E_i^+ = \sqrt{\Sigma^n_{j=1} (V_{ij} - V_j^+)^2}$, i = 1…….m

Table 5. Positive separation measure of Suppliers

Suppliers	E_i^+
1	0.0321
2	0.0354
3	0.0461
4	0.0533

2. **NEGATIVE SEPARATION MEASURE**

   $E_i^- = \sqrt{\Sigma^n_{j=1} (V_{ij} - V_j^-)^2}$,i = 1…….m

Table 6. Negative separation measure of Suppliers

Suppliers	E_i^-
1	0.0366
2	0.0543
3	0.0387
4	0.0219

STEP-6: CALCULATING THE RELATIVE CLOSENESS COEFFICIENT

$$H_i^* = E_i^- / E_i^+ + E_i^-$$

Table 7. Relative Closeness Coefficient of Suppliers

Supplier	Closeness Coefficient	Rank
Supplier 1	0.535	2
Supplier 2	0.607	1
Supplier 3	0.455	3
Supplier 4	0.291	4

RESULT

Therefore, the relative closeness coefficients are determined, and four suppliers are ranked. Obtained results have been mentioned in Table-7. Thus, supplier 2 has the best score amongst the 4 suppliers. So supplier 2 will be best for the company

Conclusion

The study discussed that how to select the best supplier in supplier selection problems when decision makers set the target value of each criterion. Although many approaches can solve the problem, the study proposed a method and a procedure to extend the TOPSIS method to solve the problem. The main advantages of using TOPSIS method are "TOPSIS logic is rational and understandable", "The computation processes are straightforward", "The concept permits the pursuit of best alternatives criterion depicted in a simple mathematical" and "The importance weights are incorporated comparison procedures". Due to this, decision making for selection of suitable supplier is of special importance. Acquired results from numerical example determine that this model could be used for decision making optimization in supplier selection.

For a manufacturing industry it is very important to do work with good coordination between management and supplier. By this approach it is clear that supplier selection for an industry involves multiple criteria which show important role in selection of suppliers. Using TOPSIS Method provides a useful approach for manufacturing industries for selecting the suitable supplier for them. Here Supplier 2 is the best one for the company in terms of the attributes selected.

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Analyzing problems and optimization of supply chain in different industries using SAW and TOPSIS methods

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Abstract

Due to high level competition in market, effective supply chain management has become a potentially important tool for gaining and effective competitive advantage and refining organizational performance, because the competition is not only amongst companies but also between supply chains. Supply chain plays a significant role in company's performance. Companies are challenged to explore ways to meet the customer demands and satisfaction at a manageable cost. To achieve this, business must find which parts of supply chain process are competitive and can be optimized with budget constraints meeting customer demands. In any unit it is mandatory to produce a high quality product with minimal budget successfully. Selection of a suitable supplier is equally important due to budget constraints. There are various methods for making the optimize result. In this research paper collecting the data from different industries and optimize the result by selecting TOPSIS and SAW methods for the solution of this problem. In this technique the decision is made by comparing each alternative with the ideal solution, hence delivering the best results.

Keywords: Supply chain, TOPSIS, SAW, Attributes/criteria.

1. Introduction

A supply chain is a unified network of all input data useful for production through the correct channel, it can be individuals, organizations, resources, activities and technologies related to the production and sale of a product or service. The supply chain starts with the delivery of the raw materials (raw materials) from the supplier to the producer and ends with the delivery of the finished product or service (product) to the final consumer / consumer. Supply chain coordination plays an important role in integrating the various actors in any supply chain, which leads to an increase in its efficiency. There are numerous mechanisms by which supply chain partners can coordinate with each other [1]. SCM controls every point of contact for a company's product or service, from initial creation to final sale. With so many places in the supply chain that can increase value by increasing efficiency or losing value by increasing costs, an adequate supply chain management system can increase revenues, reduce costs and affect a company's profits.

In a typical supply chain, the raw materials are purchased and the products are produced in one or more factories, sent to warehouses for intermediate storage and then sent to retailers or buyers. Therefore, in order to reduce costs and increase efficiency, effective levels of service, satisfaction and supply chain strategies must take into account the interaction at various levels in the supply chain.

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2. Importance of supply chain

As we know, an effective supply chain is very important for any organization. Supply chain strategies are now an important force for business organizations. Effective market coverage, a roadmap, the availability of products and their usefulness in any place where there is a key to revenue recognition depends on the effectiveness of the expanded supply chain strategy [14]. Any error that the product is not available at the right time can lead to a decline in interest and demand from the customer, which can be disastrous. The design and management of the transport network is essential to support sales and marketing strategies.

Inventory control and inventory visibility are two very important elements in all successful operations. Because these are factors that influence the cost that directly affect the total budget figures. Inventory means cost and is a resource for a company. Every company has a standard value for inventory turnover that is optimal for a company. Stock turnover refers to cases where the stock was sold and replaced within twelve months.

The status of stock turnover is related to the health of the company. In the global scenario, the final inventory of goods is carried out at many sites and distribution centers managed by third parties. A lot of inventory will also be in sequence in transport, except for inventory with distribution points and retailers.

3. Problems in supply chain management

In today's difficult conditions, SCM is faced with various problems in various sectors, health sectors and institutions. Industries are becoming increasingly aware of the fact that their ability to gain a competitive advantage in companies can take place through the supply chain.

If we consider the case of companies that operate globally, supply chain strategies increase operational efficiency and affect both the bottom line and the main flow. Unlike technology or other key areas that affect sales / business, the supply chain is always in a dynamic mode [10].

Supply chain project managers have many times encountered many problems and challenges that must be overcome throughout the project. They make every effort to minimize these problems. In this research, we will discuss some practical problems and obstacles encountered in implementing and implementing global supply chain projects.

3.1 Project Scale and Span of Control

There are so many projects distributed globally with the participation of many countries and places where all areas must be launched in the same time frame. Project managers will be in one country and physically the project managers will not be able to continue working in all places and concentrate on all the sites. Without a doubt, project teams are trained at the regional level of the country.

However, if the development, planning and control of the project are carried out by an office, a person or a group, the remaining members of the project group will become executors, which will lead to a decrease in energy and concentration.

Supply chain projects include technology, including infrastructure, in addition to software. They also include diversified logistics, including warehouse, transportation and transportation, etc.
The degree of control over the implementation of the project is important in the case of logistics projects and service providers that involve different channels and external and internal agencies. At

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best, project managers can focus on implementing a project in a country, depending on the number of sites and logistics components involved. If the project involves the creation of a distribution center or warehouse, there are more and more reasons why the implementation should be limited to the country level

3.2 Technology

Adopting the right technology and implementation often encounters obstacles in implementing global supply chain projects. Each country has a specific supply chain and all projects implement common processes that must be followed in all countries and regions and include the use of technology to manage these processes. There are so many technological problems in the project:

3.2.1 Technological solutions

In most industries, it turns out that their supply chains are not managed by a single application or a series of applications, but that in every place and country obsolete systems or separate systems will be implemented for the management of individual local logistics activities. After implementation, it becomes difficult to isolate such applications and transfer them to a common platform, without which common processes and standardization cannot be implemented in different places.

Secondly, any software solution must be configured in accordance with local and country site requirements. A solution is not suitable for everyone. Although the solution may work in a country with large volumes and sizes of supply chain networks and warehouses, the same software may not be suitable for deployment in a small country with a single location.

3.2.2 Cost of Technology absorption

The introduction of various technologies requires IT teams to travel to all places, to personalize. It can be based on some software, trains the public and stabilizes the sites after it has been viewed. The implementation cost could be high. Once again, not all countries may be able to bear the costs of this implementation.

3.3 Availability of technological infrastructures

The availability of technological infrastructures is different in different countries and within the country. Internet connectivity and its network may not be the same in all places, which can hinder the implementation of applications based on Internet technologies and artificial smart technologies. In general, if the project is implemented globally, the problems of Local infrastructure in many countries are still not resolved given the suitability of the implementation IT platform.

3.4 The possibility of internal and external resources

Supply chain projects involve multiple offices and departments and cross-functional teams within the organization. It includes several departments for the operation of various operations. In addition, they also include various external agencies and internal agencies that manage logistics.

The availability of quality resources both inside and outside in all places is crucial for the implementation of the project and is often a problem that can delay implementation and training.

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4. Methodology:

As discussed earlier SCM has different problems and for getting out these problems we can optimize our results by taking different alternatives/criteria. There are so many different type of optimization technique for getting better result. Multi criteria decision making technique is used to get the beneficial results, In this research paper we are collecting data from three different industries and optimizing results of supplier selection, vendor and product order etc. by using SAW and TOPSIS [5,7] optimization methods and discuss how they affect our supply chain.

5. OPTIMIZATION METHODS

a) TOPSIS method
b) SAW method
c) ANP method
d) AHP method

In this research paper for optimizing the results by taking different alternatives/criteria we are using SAW and TOPSIS method and comparing the results on the basis of these two optimization methods.

6. Analysis:

COMPANY 1

SAW (Simple Additive Weighing)

Table1.1

Criteria	Weight	V1	V2	V3	V4	V5
Weight	15	70	70	40	65	50
Defectives	15	45	40	30	50	40
Quality	25	65	45	35	50	40
Time	15	75	55	35	60	45
Cost	20	50	60	40	60	40
Transportation	10	55	40	30	50	35
Weighted Score	100	60.25	52	35.5	55.75	41.75

Vendor Order:- V1, V4, V2, V5, V3

TOPSIS METHOD

Table 1.2

Vendor	Wt (kg)	Defectives (%)	Quality (Rating)	Time (Rating)	Cost (Rs/kg)	Transportation Cost (Rs/kg)
V1	5000	5.0	Very Good	Very Good	200	5
V2	3500	5.5	Good	Very Good	250	2
V3	4500	7.0	Moderate	Good	150	3
V4	6000	4.5	Very Good	Moderate	275	7
V5	5500	6.0	Very Good	Moderate	245	4

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Decision Matrix

Table 1.3

Vendor	Weight (kg)	Defectives (%)	Quality (Rating)	Time (Rating)	Cost (Rs/kg)	Transportation Cost (Rs/kg)
V1	5000	5.0	9	9	200	5
V2	3500	5.5	7	9	250	2
V3	4500	7.0	5	7	150	3
V4	6000	4.5	9	5	275	7
V5	5500	6.0	9	5	245	4

N.M. Table 1.4

Vendor	Weight	Defectives	Quality	Time	Cost	Transportation Cost
V1	0.4495	0.3947	0.5571	0.5571	0.3917	0.4927
V2	0.3146	0.4341	0.4333	0.5571	0.4898	0.1917
V3	0.4045	0.5525	0.3095	0.3095	0.2938	0.2956
V4	0.5393	0.3552	0.5571	0.4333	0.5386	0.6897
V5	0.4944	0.4736	0.4333	0.4333	0.4799	0.3941

Table1.5

S. No.	Weight (20%)	Defectives (25%)	Quality (30%)	Time (10%)	Cost (20%)	Transportation Cost (10%)
V1	0.0899	0.0987	0.1671	0.0557	0.0783	0.0493
V2	0.0692	0.1085	0.1299	0.0557	0.0974	0.0197
V3	0.0809	0.1381	0.0929	0.0433	0.0588	0.0296
V4	0.1076	0.0888	0.1671	0.0310	0.1077	0.0690
V5	0.0999	0.1184	0.1299	0.0310	0.0960	0.0394

Ideal Solution

Negative Ideal Solution

Separation Measures

S1*=0.0422 S1-=0.0986
S2*=0.0571 S2-=0.0827
S3*=0.0928 S3-=0.0693
S4*=0.0697 S4-=0.0891
S5*=0.0747 S5-=0.0532

Relative Closeness

C1*=0.7003
C2*=0.5916
C3*=0.4275
C4*=0.5611
C5*=0.4159

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Vendor Order: V1, V2, V4, V3, V5

SAW (Simple Additive Weighing)

Table 1.6

Criteria	Weight	P1	P2	P3	P4	P5
Delivery	10	75	70	85	65	90
Order	15	70	60	70	55	85
Defectives	30	75	50	75	50	60
Sales Price	30	70	75	60	75	75
Transportation	15	60	70	75	65	80
Weighted Score	100	70.5	64	70.75	62	74.25

Product Order:- P5, P3, P1, P2, P4

TOPSIS METHOD

Table 1.7

Product	Delivery (Rating)	Order (Quantity)	Defectives (%)	Sales Price (per piece)	Transportation Cost (Rs/Piece)
P1	Very Good	10,000	3.0	500	5
P2	Good	15,000	4.0	450	9
P3	Moderate	12,000	2.0	775	6
P4	Good	14,000	3.0	550	8
P5	Good	18,000	2.5	650	7

Decision Matrix

Table 1.8

Product	Delivery (Rating)	Order (Quantity)	Defectives (%)	Sales Price (per piece)	Transportation Cost (Rs/Piece)
P1	9	10,000	3.0	500	5
P2	7	15,000	4.0	450	9
P3	5	12,000	2.0	775	6
P4	7	14,000	3.0	550	8
P5	7	18,000	2.5	650	7

Normalized Matrix

Procedure is followed as above.

Weightage Matrix

Table 1.9

Product	Delivery (10%)	Order (20%)	Defectives (30%)	Sales Price (30%)	Transportation Cost (20%)
P1	0.0566	0.0636	0.1353	0.1127	0.0626
P2	0.0440	0.0954	0.1804	0.1013	0.1127
P3	0.0341	0.0637	0.0902	0.1744	0.0751
P4	0.0440	0.0890	0.1353	0.1236	0.1002
P5	0.0440	0.1145	0.1127	0.1463	0.0877

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Ideal Solution

Negative Ideal Solution

Separation Measures

S1*=0.0918	S1-=0.0729
S2*=0.1285	S2-=0.0998
S3*=0.0581	S3-=0.0591
S4*=0.0827	S4-=0.0591
S5*=0.0462	S5-=0.0999

Relative Closeness

C1*=0.4426
C2*=0.4371
C3*=0.5043

C4*=0.4168
C5*=0.6838

Customer Order: C5, C3, C1, C2, C4

COMPANY 2

SAW (Simple Additive Weighing)

Table 2.1

Criteria	Weight	P1	P2	P3	P4
Cost	40	45	90	80	30
Defectives	30	50	95	80	60
Availability of Raw Materials	30	85	70	85	50
Weighted Score	100	58.5	85.5	81.5	45

Product Order:- P2, P3, P1, P4

TOPSIS METHOD

Table 2.2

Product	Cost (Per Piece- Rs)	Defectives (%)	Availability of Raw Material (Rating)
P1	10	5	Very High
P2	13	3	High
P3	12	4	Very High
P4	11	4.5	Average

Decision Matrix

Table 2.3

Product	Cost (Per Piece- Rs)	Defectives (%)	Availability of Raw Material (Rating)
P1	10	5	9
P2	13	3	7
P3	12	4	9
P4	11	4.5	5

Normalized Matrix

Table 2.4

Product	Cost (Per Piece- Rs)	Defectives (%)	Availability of Raw Material (Rating)
P1	0.4323	0.5965	0.5859
P2	0.5626	0.3579	0.4557
P3	0.5193	0.4772	0.5859
P4	0.4790	0.5369	0.3255

Weightage Matrix

Table 2.5

Product	Cost (Per Piece- Rs)	Defectives (%)	Availability of Raw Material (Rating)
P1	0.1729	0.1789	0.1758
P2	0.2550	0.1074	0.1367
P3	0.2077	0.1432	0.1758
P4	0.1916	0.1611	0.0977

Ideal Solution

Negative Ideal Solution

Separation Measures

S1*=0.1089 S1-=0.0781
S2*=0.0391 S2-=0.1156
S3*=0.0593 S3-=0.0927
S4*=0.1116 S4-=0.0292

Relative Closeness

C1*=0.4176
C2*=0.7473
C3*=0.6098
C4*=0.2074

Product Order: P2, P3, P1, P4

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7. Conclusion

From the above mentioned calculations and results these are the following conclusions:

It is observed for company 1 that by considering various attributes like weight, defectives, quality, time, cost and transportation cost vendor V1 is the best vendor considering both SAW and TOPSIS. SAW emphasis on weightage of criteria while TOPSIS focuses on its distance from ideal solution as well, hence giving the comparative results between vendors. Similarly for products, product P5 has best rating according to both the techniques.

It can also be depicted for company 2 that considering cost, defectives and availability of raw materials as attributes, product P2 is the best rated product amongst the four choices on application of both TOPSIS and SAW. So it is recommended to company selecting any parameter like vendor or product after optimization.

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