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Empowering Smart Cities with Energy Supply Models

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Abstract: Alternative sources of energy are being trailed in the world today due to declining availability of fossil fuels and other non-renewable. Solar energy provides a favorable perseverance to this exploration as it is a less polluting which can easily be transformed into photovoltaic energy systems. The unsustainable use of energy sources and an increasing dependence on fossil fuels are also triggering environmental deprivation at local (land degradation), regional (air, water, and soil pollution) and global levels (greenhouse gas emissions offering to climate change). At the same time, use of renewable drives to safeguard the power supply are hosting up new visions for economic efficiency along with reductions of greenhouse gas and local pollution. Exemplary approaches for a solar energy resource have been developed and validated to the economic productivity. These also offer inputs towards energy interventions to reduce carbon emissions and to provide a qualified tool as a guide for governments, business, experts and financing organizations. It is intended to bridge owing knowledge gaps on suitable energy supply models for cities. It proposes a valuable support for preparation of future projects for the forthcoming urban renewable energy supply. The energy supply models (ESM) accumulates the characteristics of model-specific advantages, problems and success factors in the urban scenarios.

Keywords: *Carbon Emissions; Photovoltaic Systems; Solar Energy; Supply Models.*

1. INTRODUCTION

Energy systems have become an abandoned priority[1]. About millions of people are stagnant incapable of benefiting from modern energy services, as fuel used by them is generally is of meager quality, and energy is used inefficiently; the power supply is unreliable and access is limited[2]. This not only has an adverse effect on economic productivity, more importantly, it also affects people's quality of life having a strong impact on the environment[3]. The requirement of consistent and reasonable energy supply is very crucial for developing countries for sustained economic development to safeguard poverty. Providing access to electricity in a country like India is most challenging time. Energy supply models (ESM) aims to provide the required system of energy supply with characteristic model-specific problems and factors under different circumstances. Smart concepts propose to support people with enabled access to modern services for development[4]. Likewise, the concept of the *'smart cities'* substantiates the modern energy access for education, health, food security, productive enterprise, environment and participatory democracy to advance energy access[5].

Significant reduction in solar photovoltaic (PV) panels costs and light-emitting diode (LED) lighting, together with innovative sponsoring models have meant solar home systems [6] very accessible to user community. Key restrictions on growth rate for further escalations lies in access to operational capital for the small and medium enterprises involved in this field. Encouraging developments in the home-based and mini-grid approaches are productive usage of energy systems for home-based approaches serving surrounding, more dispersed communities (a *'hub-and-spoke'* model). Financing costs for mini-grids can be punitive as lenders often perceive risks to be high[7]. The funding bodies and governments may extend support to reduce the risk of investment for ceiling down the interest rates. Publically concerned 'impact investors' can offer lower interest rates than commercial. These impact investors may appropriately build a relationship with entrepreneurs similar to venture capital funders in which they continue to support the entrepreneur as their business progresses through various stages of growth[8]. A sympathetic policy and regulatory framework is needed for financiers to make a plea for less red tape and more breathing space in relation to taxation regimes to get their businesses off the ground[9]. If the knowledge about crucial desires and certain obstacles to the propagation prototypes for electrification spreads, mistakes to be avoided for future projects, whereas encouraging strategies, adapted to the special conditions in the respective countries, may be given preference for the similar upcoming projects[10]. Although, to address energy needs, several efforts have been made both by governmental organizations and non-governmental organizations in the form of national programs in spite of the existence of these programs.

2. LITERATURE REVIEW

The approaches of the related policies are essential to prevent energy from getting mixed up with biomass energy and renewable energy for all energy systems, then the goal for energy systems sustainable development. Energy systems, therefore, must advance economic growth that is economically efficient, need-oriented and equitable, self-reliant and empowering, and environmentally sound[11]. The stress on equity means that energy systems must promote poverty alleviation involving improvement of the living conditions of the poor[12]. Researchers over the world have indicated that the adoption of modern energy technologies is required for the counterparts. Therefore, pressure has increased to plan for strategies to accelerate the transition towards the recent technologies[13]. In order to efficiently plan any new model, the ground truth realities need to be recognized and understood. The prime requirement is to understand the requirement of near future energy demands, available resources and mechanism of energy supply to include these constraints into the actual energy supply model. It will help to reduce the dependence to the majority of people on inefficient energy resources'. More effort is required to improve approaches to assess the outcomes of energy schemes in respect of economic development benefits[14]. The absence of the structure assessment systems is acting as a hurdle to investors supporting the various energy supply models. Also, there is a confusing array of funding schemes, and funders often seem to compete rather than to cooperate. In India, the off-grid solar photovoltaic (PV) market has three major segments: captive power plants (where the majority of generation is consumed at the source), telecom towers, and rural electrification. The market potential for these PV segments has created an off-grid solar market in India forecasted to install more than 1 GW per year by 2016[15]. The energy requirement of the nation is also expected to increase due to the introduction of various development schemes like smart city, make in India, skill development etc needs the energy to run the industry. And till now there are no such energy supply models existing to assist the issues arising pertaining to energy supply. Therefore some preliminary work on the energy supply models especially in context to the solar energy system is pre-requisite of the forthcoming smart cities in India. The present work offers a platform for crafting a user-friendly ecosystem to design, develop and addressing the energy issues.

3. METHODOLOGY AND CONCEPTUAL FRAMEWORK

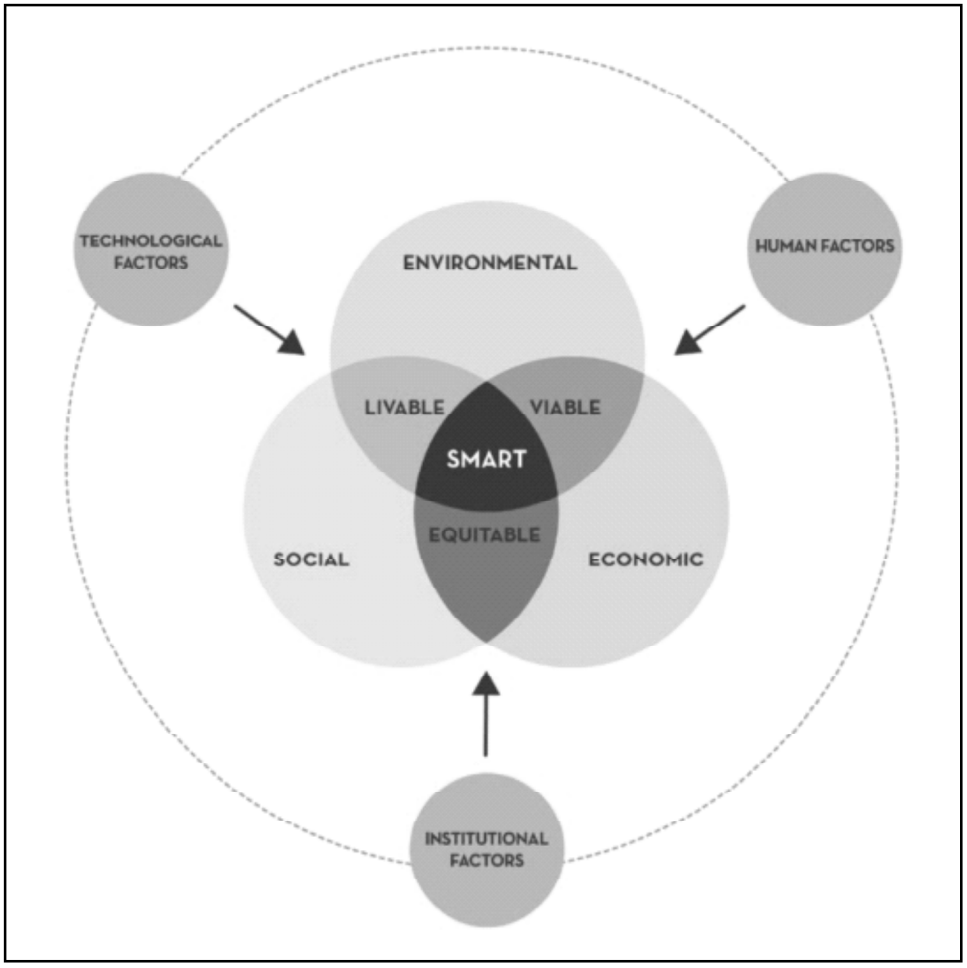
Precisely energy supply models (ESM) deals with subject matter of a qualified instruments/policies/regulations as a guide for governments, business, and financing organization's dealing with renewable energy systems.

These models expect to bridge the remaining knowledge gaps on suitable models for market-based energy supply. Providing uninterrupted access to the required energy for any sector is vital to run the business efficiently and it is also a major challenge due to unavailability of any optimal framework resolving this issues raised to the imbalance between demand and supply along with the economic aspects. The present work emphasizes on following aspects:

1. To improve and exhibit model approaches for energy supply.
2. To raise economic productivity and contributing to the sustainable improvement in living conditions to suffice the energy requirements of people.
3. To provide inputs for interventions on energy issues to reduce carbon emissions.

3.1. Major Components of Any Smart Ecosystem

The following figure 1 identifies setup for smart cities ecosystem (SME).It explains the livable, viable, equitable framework for better understanding. It is intended to achieve sustainable development to increase the quality of life of its citizens and improve the efficiency of the existing & new infrastructure. The usage of information and communication technologies (ICT) supports as a backbone to achieve its objectives.



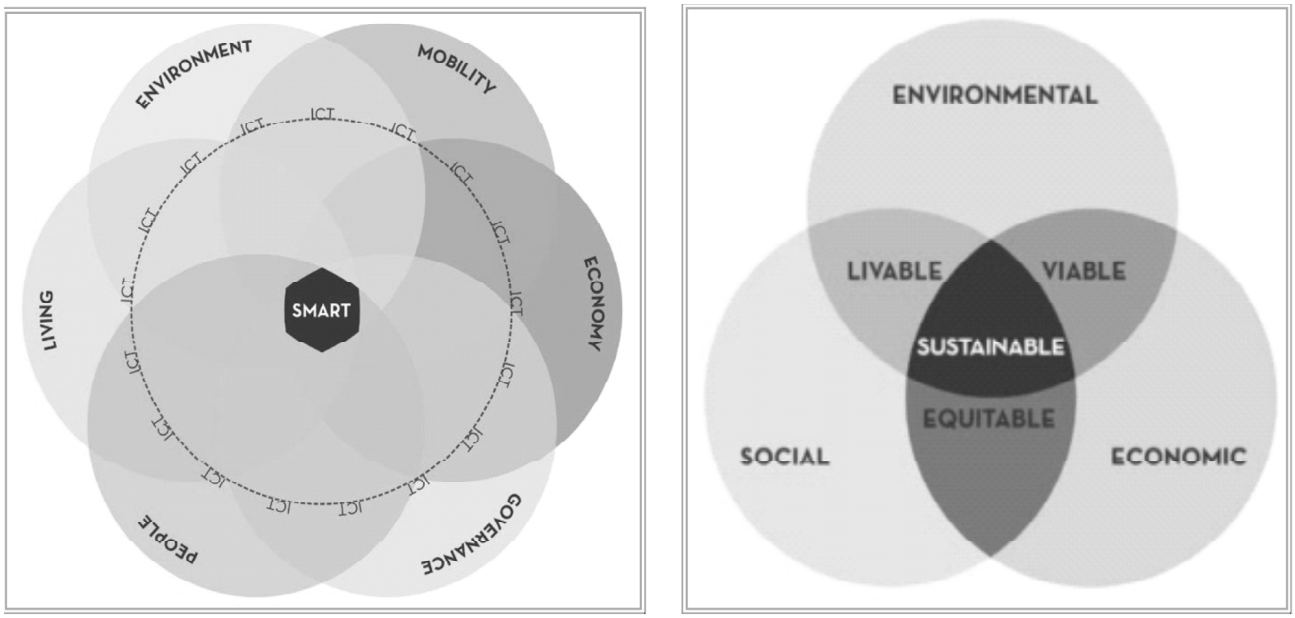
Source: European Investment Bank Institute

Figure 1: System of Smart Cities Ecosystem

3.2. Smart Cities Concepts

A smart city is an urban development concept encompassing the integration of multiple information and communication technology (ICT) and Internet of Things (IoT) solutions in a secure platform to manage a city's resources through an ingenious information system. The objective of developing any smart city is to improve the quality of life through urban informatics and technology to meet the dwellers' requirements. The usage of sensors integrated with real-time monitoring systems allows the administrators to collect the data from citizens for further processing and analysis purpose. These helps to augment quality, performance, and interactivity of urban services, to decrease costs of the resource. Other terms that have been used for analogous concepts are cyberville, digital city, electronic communities, flexibility, information city, intelligent city, knowledge-based city, MESH city, telicity, teletopia, Ubiquitous city, wired city.

Smart cities groups the visions of leading scientists, thinkers across the globe to raise the people living standard from the existing conditions. A *Smart City* connects human capital, social capital and ICT infrastructure to resolve the public issues to achieve sustainable development for improving the quality of life. Prospective users of modern energy systems particularly of renewable technologies, e.g., micro-hydro and photovoltaic are hardly consulted when it comes to planning & improvement of local infrastructure to make final decisions.



Source: European Investment Bank Institute

Figure 2: (a) Components of Smart Cities (b) Sustainable Development Model

3.3. Scope of Energy Supply Models

Prospective or forthcoming users of modern energy systems *(i.e. renewable technologies, e.g., micro-hydro and photovoltaic)* are barely consulted during the planning & improvement of local infrastructure. In the case of India, it has been argued that renewable energy technology was promoted as a panacea for the country's energy problems but very fewer attempts have been made to design any framework to address the concerns. The various existing energy supply models adopted for these purposes includes:

1. ***Cash & Carry Energy Supply Model***

   a) In this scheme, customers buy an individual power supply system on a cash basis.

b) The ownership is directly transferred after the payment and the customer is responsible for installing, operating, and maintaining the system.

c) Thus, the cash and carry business only comprises a sales infrastructure.

A fundamental advantage of cash & carry is less capital requirement for undertaking business due to minimal infrastructure requirement. The system provider does not need to pre-finance the hardware. This means, that the system provider's financial risk is rather low.

2. ***Installment Credit Energy Supply Model***

a) The technical and the financial flow are separate, although interlinked.

b) This means, that a technical intermediary (the system provider) who is responsible for the technical service like provision of the hardware, installation, operation and maintenance, and a financial intermediary (commonly a microfinance institution), who is responsible for credit disbursement and collection business, are involved.

c) The customer pays an individual power supply system with a credit channeled from the financial institution to the system provider.

3. ***Finance Leasing (Hire Purchase) Energy Supply Model***

a) Customer leases the system on payment for regular leasing fees;

b) System provides ownership during leasing period;

c) ownership title transferred with payment of residual amount;

d) system provider installs the system;

e) customer responsible for O&M;

f) typical system provider is NGOs, dealers, intermediaries in "aid" projects.

4. ***Fee-for-Service***

a) The customer pays regular service fees for electric service through individual or power systems;

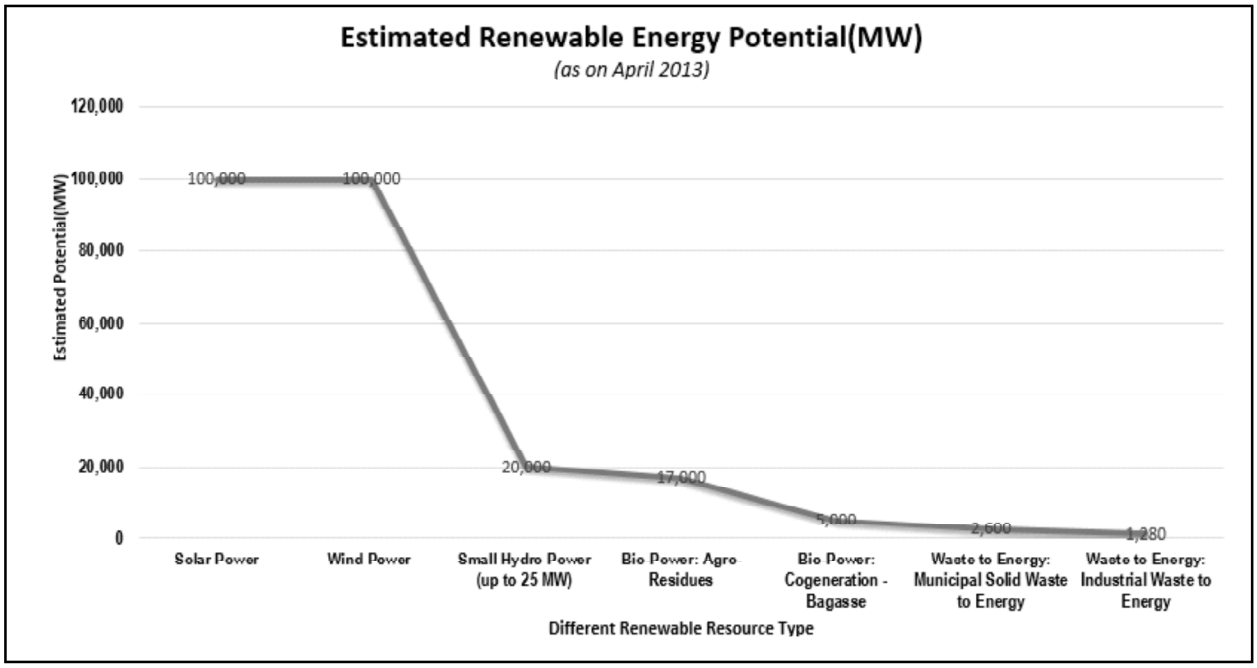
b) the service provider is the owner of the system and is responsible for installation and O&M;

c) typical service providers: dealers, service companies (e.g. utility).

4. RESULTS, META-ANALYSIS, AND DISCUSSIONS

Energy intervention programs have gained its prominence in governmental policies and development agendas for improving prevailing livelihoods conditions and to protect local environment & resources. In spite of the increasing indications of small- scale renewable energy systems over traditional aiming towards sustainability, the introduction, and transmission of the new energy systems has also suffered due to the ineffectiveness in terms of slow construction, limited utilization, and high risks of being idled or abandoned by the adopters. While there were substantial studies for resolving the issues and challenges of energy planning but only a few scholars have contributed for the processes and efficacy of the energy planning. In developing countries, the renewable energy technologies (RETs) offers a wider prospect for self-reliant energy supply systems at national and local levels along with improved economic, ecological, social, and security benefits.

More or less very meager amount of RET supply models has been implemented in developing countries like as India, Nepal, and China[16]. In developing countries, household energy is mainly obtained from natural sources. Since a very small part of commercial energy was involved in energy use, its supply has not been



Source:www.data.gov.in

Figure 3: Estimated Renewable Energy Potential of India (in MW)

considered in national energy programs. And this, in turn, resulted in a negative influence on commercial energy supply and use, as also on the improvement of economy and living standard. Population increase and excessive exploitation of local resource caused serious ecological environmental degradation.

In partial support of the earlier arguments, the above figure 3 illuminates that the estimated renewable energy potential in India, which implies that solar power and wind power had contributed to maximum generation potential to cope with the current as well forthcoming energy demands. This also echoes that, nowadays the small hydropower and Bio-Power are also becoming prominent sources of the energy generation, which may extend the current trends of energy supply. In the face of challenges of population, resource and environment at the turn of the century in the most of the countries are seeking the solution for synchronizing the development of society, resource, and environment to work out towards policies for sustainable energy resource and environment. Therefore, it is necessary to provide solutions to energy problems and to integrate energy supply with the national energy programs.

4. CONCLUSION

The pattern of energy resources utilizations in the developing countries are rapidly transforming and transiting towards global climate change issues. Therefore energy supply acted as a complicated phenomenon which needed to transcend from the modest to the best technology. The present deliberated models may serve as one of the business models for energy supply which is economically viable for maximum investment available from a various funding/financing organizations. None of the present-day energy models has potential to suffice the issues concerning to the energy systems and economies of the developing countries. Hence, an extrapolation is well requisite made for modeling of the energy systems and economies of developing countries. An inclusive model may act as a boon to address issues equally to incorporate the main characteristics of developing countries into the main model and keeping the constraints of technical restrictions, data inconsistencies, and purposes of the models and the complexity of the system in the consideration. This will encourage to understand the influence

of different parameters on the increasing global energy requirement. The current energy supply models intend to suffice the requirements of energy for the upcoming smart cities in India. It will also enable us to understand the energy models in precise details to explore the future of the global and regional energy requirements, locations and the effects of energy use on the human and natural environment.

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