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Theoretical Model based on Smart Energy Systems

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***Abstract*—All energy systems significantly contribute for the conversion of energy from one form to another in the effective means. Before attaining the production of electrical power, it contributes for the transformation of mechanical energy, chemical energy, thermal energy, potential energy, hydraulic energy having some losses of energy. All the energy in the universe is a constant. Sun is a source of energy where hydrogen atoms combined together to produce helium nucleus with the release of large amount of energy. It is the basic form of all energy in the universe. Sun is at a very distance from the earth. All other forms of energy are a small portion of energy released from the sun and are a function of time. Solar energy cannot reach out earth without losses. Therefore in all equations of power transmission, certain parametric correlations are to be found out with time as a function. If we think and set ideas to derive equations of power and energy, it can be very effective in working models. This research paper is intended to convey the idea of smart energy systems where these resolution for correlations can be incorporated and attain good productivity. These smart energy systems can energize effective power transmission in the best possible way. Here the correlation is a theoretical model equation consisting of independent and dependant variables.**

***Index Terms*— Correlation, Energy systems, Power, Productivity, Resolution, Smart energy system, Solar energy.**

I. INTRODUCTION

Energy is being converted from one system to another in all energy systems. This particular energy which is being transferred and converted consists of mechanical energy, electrical energy, chemical energy, heat energy, kinetic energy, potential energy, hydraulic energy etc. All energy in this universe is a constant. By the working of engines and machines, energy is being converted into another type of energy. Sometimes in a system, energy is being degraded or in other ways it may be upgraded. Energy is being upgraded to work energy in all heat engines. When energy is being degraded, this degradation of energy can be regarded as entropy. The net heat content of a system is called as enthalpy. According to the first law of thermodynamics; energy can neither be created nor destroyed; it can only be changed from one form to another. It is denoted by the equation

$$\Delta E=\Delta U+P\Delta V$$

Work done per unit time is being called as power. When energy is being distributed from one system to another system, power is also being transmitted. The unit of power is watt or Nm/s. The unit of energy is Nm.
The energy systems particularly dealt here consist of

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1. Turbines
2. Gear drives
3. Cooling systems
4. Heat engines
5. Generator
6. Compressor
7. Acoustic systems
8. Heat pipes
9. Heat exchanging system
10. Vibration system etc

Objectives of this research work are as follows.

1. To provide effective power transmission in energy systems.
2. To find out correlations of power transmission to reduce errors in calculations of power and energy.
3. To provide a theoretical working model in the energy systems.
4. To provide a resolution for power transmission in the design of energy systems.
5. To investigate new methodologies of power transmission by reducing losses.
6. To establish a relationship between the independent variable and dependent variables.

The world and various nations are in the process of the major energy transition created by scarcity of energy resources and higher prices of energy. The objectives of energy strategies are

1. To reduce dependence on imported petroleum oil and safeguard national interests.
2. Short term and medium term growth of conventional energy technologies for sustained economic growth.
3. Long term growth of renewable energy technologies for sustaining economic growth when non renewable are exhausted.

Smart energy systems incorporate renewable energy technologies for improving efficiency and conserving power and energy. When PV modules are being assisted for power transmission, it is very important to improve the efficiency of PV system. Efficiency of PV module is 15-18%. MPPT or Maximum power point tracker is a system to improve the efficiency of PV module. MPPT is a power electronic system having a control circuit. It consists of a DC chopper to have variable DC from a fixed DC. The control circuit is used to control the output voltage by controlling duty cycle of DC-DC converter. It stabilizes the voltage for proper operation of load or charging of battery bank irrespective of weather conditions and temperature. Smart MPPTs can use advanced technologies like nano-technology, VLSI technology, ANNs and fuzzy logic controllers. This paper presents the systematic study that analyzes the problems and realization of converting the present energy system into a 100 % renewable energy system using a smart energy systems approach. As the smart grid concept, which takes a sole focus on the electrical energy sector, smart energy systems include the entire energy system in its perspectives to identify the suitable energy infrastructure designs and operational strategies for the future.

The typical smart grid sole focus on the electricity sector often leads to the conclusion that transmission and distribution lines, increased electricity demands and electrical storage systems are the primary sources to deal with the integration of flexible renewable sources. However, the nature of wind energy and similar sources has the consequence that these measures are neither having very high efficiency nor economical. The most efficient and economical cost solutions are to be found when the electricity sector is combined with the heating, cooling and the transportation sector. Moreover, the combination of electricity and gas sector may play an important role in the design of future renewable energy systems. This research paper illustrates why electricity smart grid network should be seen as part of overall smart energy systems and emphasizes the inclusion of flexible combined heat and power production in the electricity balancing and grid stabilization methods. After all, it highlights how to design and model future sustainable smart energy systems.

In recent years, a number of new terms and definitions of sub-energy systems and infrastructures have been introduced to define new paradigms in the design of future energy systems such as smart grid (Massoud and Wollenberg, 2005), 4th generation district heating (Lund et al., 2014), Vehicle-2- Grid (Lund and Kempton, 2008) and power to gas (Gahleitner, 2013). All these infrastructures are essential new contributions and represent an important shift in paradigm in. However, the design of future renewable energy strategies are sub-systems and sub-infrastructures which cannot be understood or analyzed if not properly placed in the context of the overall energy system. Anyhow, they are not always well defined or are defined differently by different institutions. The issue of sub- energy systems versus overall energy systems is carefully analyzed in (Lund, 2014; Connolly et al., 2013) and are here taken as the concept of smart energy systems. As opposed to, for instance, the smart grid concept, which takes a sole focus on the electricity sector, smart energy systems include

the entire energy system in its approach to identifying suitable energy infrastructure designs and operation strategies. One point is that in order to do a proper analysis of any smart grid system, one has to define the overall energy system in which the infrastructure should operate. Another important point is that different sub-sectors influence one another and has to take an influence into consideration if the best solutions are to be found out. Nowadays, the design of the energy system is based on fossil fuels. This makes the energy system very flexible and reliable since huge amounts of energy can be stored in liquid, gaseous, and solid form with the help of fossil fuels. This means that energy can be provided when it is in demand, but there can be suitable fossil fuel storage nearby, such as a petrol tank in a car, a gas cylinder for a boiler or a coal storage facility for a power plant. Hence, fossil fuels are useful to the society with a lot of flexibility; fossil fuels are able to store large amounts of energy so it is available whenever it is required. But in the future this flexibility may be limited.

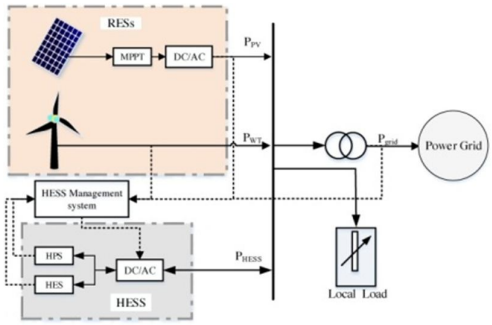

Figure 1: Energy system using MPPT

II. Smart Energy Systems

A future energy system will depend on renewable energy sources such as wind, solar power or biogas. These sources of energy cannot be stored in large amounts but the energy from the sun, wind or bio mass can be captured and used immediately. It is the main technological challenge for the energy systems. Then we can raise questions such as;

1. How can be a future energy system based on renewable energy?
2. Can it operate with flexibility?
3. Can it provide large amounts of energy as in fossil fuels?
4. Can it utilize a sustainable level of resources?

The solutions for this can find out new forms of flexibility within the energy system and utilizes the renewable technologies in an effective manner. It is being called as a smart energy system.

A smart energy system has new forms of flexibility primarily in its conversion stage. This is achieved by a more inter connected approach than simple linear approach in today's energy systems. It has combined electrical energy sector, thermal sector and transportation sector.

This flexibility can compensate for the lack of flexibility from renewable sources such as wind and solar. It uses technologies such as smart electricity grids to connect electricity demand and heat pumps and electric vehicles to intermittent renewable sources such as wind and solar power. Smart thermal grids can connect electrical and heating sector. Smart gas grids are used to connect electrical, thermal and transportation sector. The liquid fuel storages can also be utilized. The future energy systems can face the challenge of meeting transportation demands without exceeding the sustainable biomass potential. A transportation system is solely based on renewable energy and some sort of biomass to supplement the direct use of electricity.

III. Power to Transport and Gas

In the future, direct use of electricity cannot cover all the transportation demands. Biomass resources are limited due to demand for food and material as well as bio diversity. It is hard to see how biomass can cover the future energy demand in the transportation sector. A transportation system on renewable energy sources requires biomass based gas or liquid fuel to implement direct use of electricity. For the sake of transportation, power can be used directly in the battery to supplement biomass which needs to be converted into either liquid or gaseous fuel. Biomass in the form of gas helps in achieving better flexibility and efficiency. In order create enough gas

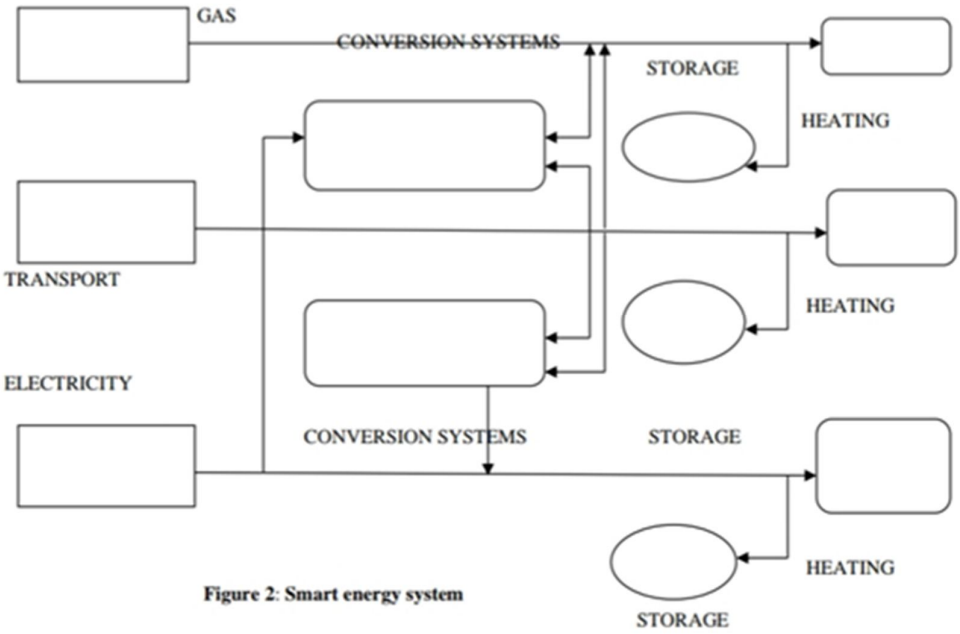

Figure 2: Smart energy system

and liquid fuel for complete renewable energy system within biomass resources; one has to boost the synthetic gas and liquid fuel from the biomass by hydrogenation.

IV. Smart Energy System Synergies

In future renewable energy systems, smart grids are the important contributors. Each individual smart grid cannot be considered as separate from the others in the energy system. Better solution arises for the implementation of smart energy system. Synergies for smart energy system include:

1. Electrical power for heating purposes makes it possible to use heat storage instead of electrical storage which is cheaper and efficient.
2. Electrical power for heating can be used for having in regulatory power market.
3. Biomass conversion to gas and liquid fuel need steam and produce low temperature heat which can be utilized by direct heating and cooling grids.
4. Biomass production need low temperature heat which can be supplied by direct heating.
5. Electrical power for gas such as hydrogenation makes it possible to use gas storage.
6. Energy saving in the space heating of buildings makes it possible to use low temperature direct heating.
7. Electrical power for transportation can be used to replace fuel and provide for electricity balancing.

V. Energy Strategies and Energy Planning

The salient features of energy planning are:

1. Conservation of fuel, energy and improve efficiency.
2. Rational policies of energy pricing.
3. Reasonable and stable policies to energy conservation and environmental balance.
4. Substitution of abundant energy sources for those which are scarce and costly.
5. Rapid development of non conventional and renewable technologies for future.

The objectives in energy strategy are:

1. To reduce the annual growth of total energy demand to 2 percent by conserving energy.
2. To reduce petroleum consumption below 10 percent.
3. To reduce petroleum imports.
4. To increase coal production and domestic crude production.
5. To improve energy efficiency of industries and other sectors.
6. To use renewable solar energy, mini hydro, bio gas etc. for rural development.
7. To use waste bio mass effectively.

8. To ensure environmental balance.

Energy management is the art and science of optimum use of energy to maximize profits and there by improve the economic competitiveness. The energy should be used efficiently, economically and optimally.

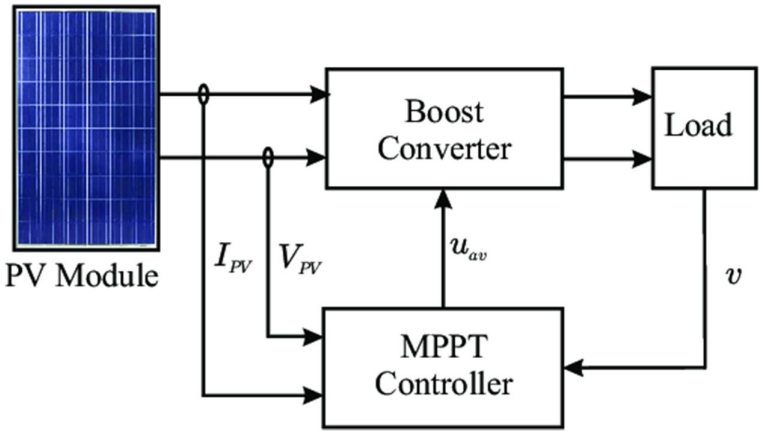

Figure: 3 Solar PV system with MPPT

The power and output voltage improves in the smart energy system with shaded cell. It increases the stored energy and enhances its output by controlling the input. The current and voltage attains an optimum value and it serves better under all conditions of deviations in the input voltage. The output voltage and current is stabilized and can save and produce more energy regardless of different working conditions. The back up from the battery bank can be high so that the smart energy system can be used for power generation under various conditions of load demand. The outputs from the simulink model of smart energy system are being verified. The variations of voltage, current and power with respect to given input are hereby produced in the figures. The voltage and current are increased initially due to renewable energy sources and after sometime this voltage and current is diminished due to the continuous working of the smart energy system. This condition changes and the increased voltage and current is restored when MPPT acts as a power bank. Therefore here losses of energy can be reduced by effective power transmission. Theoretical model equation provides the inputs such as power, work done, efficiency etc. These are functions of time and acts as a correlation to find out independent variable. This model equation can be used for predicting various performance parameters and give a resolution for improving power and efficiency and reduction of energy losses.

VI. Analysis of Smart Energy System

A novel approach of a smart energy system is being introduced here which consists of air compressor, air turbine and solar concentrators. The system was devoid of any of the fossil fuels in the form of solid, liquid or gases. The power is transmitted effectively which can be regarded as effective power transmission in the best possible ways. The fuel used here is not depleting and is easy available. It is nothing but free air which is being heated in a duct using solar concentrators. The renewable energy and renewable energy sources are here used to transmit the power effectively. The objective of this smart energy system is to generate electrical power. Apart from these energy systems, here we can have a electrical storage battery and other power sources such as solar PV array, wind mill or bio gas. It is assisted by a rectifier and inverter also. The maximum power is utilized by using a MPPT which is maximum power point tracker. It increases output voltage by controlling input voltage using DC – DC chopper. It increases the power saving capacity of electrical storage battery which can be used as a power bank. It gives continuous production of electrical power and can be used in emergency, peak load and standby power conditions. The efficiency achieved in this smart energy system is around 55%. The estimated cost for this micro electrical power production can be around Rs.110000. By utilizing very big capacity energy systems in the whole smart energy system, it can generate electrical power in an enormous way. The whole system is simple in operation and can be used with less skilled laborers. The system is also prone to avoid noise pollution. The following table consists of some of the parameters involved in the calculations of energy and power transmission in an effective manner. A theoretical model equation is being derived with the help of these parameters. Using this model equation it is easy to find out independent variable and dependent variables. The theoretical model is

perfectly fit equation model. The independent variable is efficiency and dependent variables are net work done/sec in kW and output power produced in kW.

TABLE: I

Efficiency	Net work done/sec in kw	Output power produced in kw
0.5	1.75	1.75
0.46	1.525	1.82
0.41	1.3	1.90
0.27	0.8	2.20
0.53	1.6	1.4
0.56	1.85	1.45
0.54	2.15	1.85

Statistical methods of prediction and optimization are often referred under response surface analysis. In multiple regression, we deal with data consisting of n(r+1)-tuples (xi1,xi2,….,xir, yi) where x's are assumed to be known without error while the y's are values of random variables. As in the case of one independent variable, we shall first treat the problem where the regression equation is linear, where for any given set of values x1, x2, …..,xr, for the independent variables, the mean of the distribution of y is given by

$$\beta+\beta 1x1+\beta 2x2+\ldots\ldots+\beta rxr$$

Applying the method of least squares to obtain estimates of the above coefficients, we minimize the sum of the squares of the vertical distances from the observations yi to the plane.
Symbolically, we minimize

$$\Sigma(yi-(\beta+\beta 1xi1+\beta 2xi2))^2$$

$$\Sigma y=nbo+b1\Sigma x1+b2\Sigma x2$$

$$\Sigma x1y=bo\Sigma x1+b1\Sigma x1^2+b2\Sigma x1x2$$

$$\Sigma X2y=bo\Sigma x2+b1\Sigma x1x2+b2\Sigma x2^2$$

Efficiency being y, Net work done/sec being x1 and Output power produced being x2.

$$\text{Then } \Sigma y = 3.27$$

$$\Sigma x1 = 10.975$$

$$\Sigma x2 = 12.37$$

$$\Sigma x1^2 = 18.3231$$

$$\Sigma x2^2 = 22.3099$$

$$\Sigma x1y = 5.3755$$

$$\Sigma x2y = 5.6382$$

$$\Sigma x1x2 = 18.968$$

Through regression analysis, y= b0+b1x1+b2x2
After solving the linear regression equation, b0=0.99, b1=0.09 and b2=-0.35
Thus we get the theoretical model equation as

$$y = 0.99+0.09x1-0.35x2$$

VII. CONCLUSION

An integrated study for the smart energy systems was conducted. Various factors to effectively carry out energy through the smart energy systems were discussed. Energy PLAN tool should be implemented to monitor, manage and report energy in a vast area. Energy management principles should be practiced in all industries and manufacturing units to conserve energy for the future. The strategies and plans are to be enabled in energy segments by using the principles of energy management. In every energy segment, there can have a well written energy policy. More improvement can be followed in the communication on energy matters.

RESULTS AND DISCUSSION

A well defined study is conducted in smart energy systems. Usually in all compressor-gas turbine systems, a gaseous fuel is being used for compression process and expansion process. The gaseous fuels are becoming rare in this universe due to its scarcity in the nature. Also it uses a fuel combustion system and is costlier in the working conditions. Instead of this, if air which abundantly available in the nature is used for the above conditions, it is very cheap and simple. By this method, there is considerable reduction in cost which can be

achieved in the electrical power production process. This method is simple and can easily perform with continuous working conditions. It is a very eco friendly electrical power production process. Here 10% of the power produced during the air turbine expansion process is utilized for driving the air compressor. Using MPPT, power consumption in power bank is constituted as high. It uses a dc-dc chopper to enable variable dc from fixed dc. It improves efficiency of the proposed system. The power produced during the operation of this system can be utilized for three purposes which are electricity, transportation and heating.

No research paper is yet contributed to the field of smart energy systems and gives correlations of power transmission in energy systems except this one. Here in this research paper, the compression process is adopted as isothermal compression. The temperature of air entering into the compressor remains same. This concept gives a novel approach in the study of smart energy systems.

CONFLICT OF INTEREST

I have no conflict of interest for submitting this research paper. All the content in the paper was made on behalf of me. During the preparation of this paper, I haven't included the content regarding the other persons.

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