

Concepts of Ideal Electric Energy System for Production, Distribution and Utilization

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ABSTRACT

Any system in the world can be analyzed based on two types of characteristics namely ideal characteristics and actual practical characteristics. The ideal characteristics speak about the ideal performance of the system under ideal conditions whereas the actual practical characteristics deviate from the ideal characteristics under the normal conditions. This deviation is due to many factors like the behavior of the system under normal condition, the interfaces with the environment, various limitations in inputs of the system etc. In an electrical energy system, the knowledge of ideal characteristics play an important role in design of generation, distribution, and utilization. This paper discusses the ideal conditions for production of electric energy using green technology, the ideal conditions for its distribution and ideal conditions for its utilization. The various limiting factors to reach the ideal condition are discussed and suggestions are given to improve practical systems towards hypothetical ideal system in various stages of production, distribution and utilization of electric energy. The paper identifies the characteristics of ideal electric production, ideal distribution and ideal utilization based on the “system model” of ideal power production, distribution and utilization system. The comparison chart gives the comparison between the ideal system and practical system based on the various characteristics. The discussion in this paper is limited to the energy using green technology.

Keywords : Ideal electrical system, ideal characteristics of electrical system, green technology, energy production, energy discussion, energy utilization.

I. Introduction

India is standing in the 5th position in production of electricity. However the country is not in a position to supply the electricity to 100% of requirement and those who have the facility they do not get the same facility 24×7 . One of the major factors which affect the supply is power loss. The present electrical energy system in India has three major phases called production, distribution and utilization. In the process of either production, or distribution and utilization a remarkable amount of energy is getting wasted due to the environmental conditions. For example, in a domestic electrical system a remarkable amount of energy is wasted in the form of supply chain loss. In case of electricity generation from fossil fuels 10% of the energy is lost in combustion of the fuel and rest 90% of the fuel is used to convert into steam (*Madhu Khanna et.al. 2005*). Due to the resistance of the cables 10% of the energy is lost at the transmission section. The energy loss is also due to the conversion efficiency at the ultimate end where the users are using the electric appliances. For example, the incandescent bulb is using only 2% of the electrical energy to light wasting the rest of the energy into unwanted heat. The electric efficiency in the electric plant is defined as the ratio of the useful electricity output in a specific time to the energy value of the energy source supplied to the unit in the same time period. Theoretical efficiency of converting the energy sources by verity of methods into useful energy is given in the following figure 1.

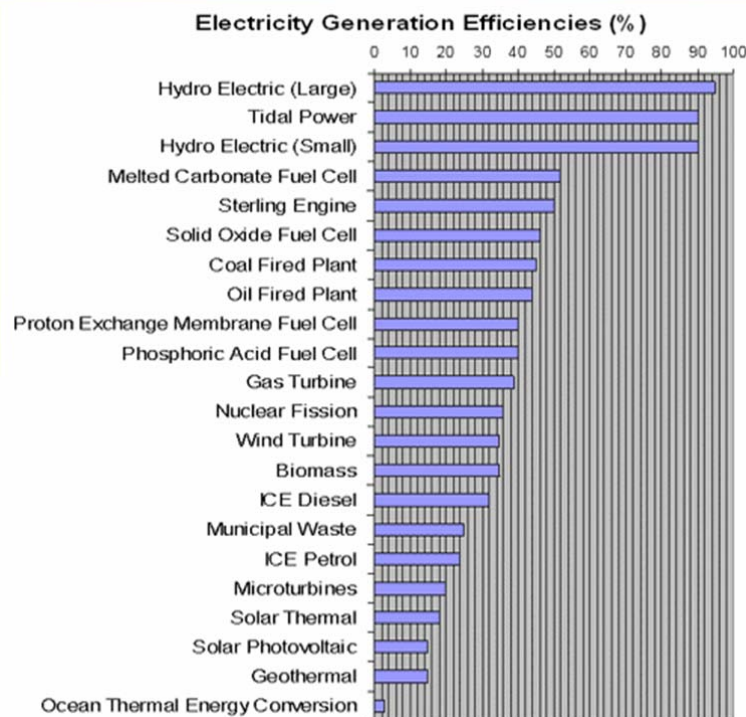


Figure 1 : The theoretical efficiency of converting various energy sources by a variety of methods into useful electrical energy (*Madhu Khanna et.al. 2005*).

The main reason for the electricity loss is the resistance offered by the conductor which is used for production, distribution and utilization. The efficiency of the electricity depends on the minimum resistance offered by the conductor. Ideally the resistance should be zero to get the most efficient zero loss of electricity either at the production center or at the distribution center or while utilization. The resistance of a conductor is defined as the amount of the opposition offer by the conductor to the flow of electric current. This law is called ohm's law.

The resistance (R) of an object is defined as the ratio of [voltage](#) across it (V) to [current](#) through it (I), while the conductance (G) is the inverse (Lambert et. al. 2010) :

$$R = \frac{V}{I}, \quad G = \frac{I}{V} = \frac{1}{R}$$

The various factors which affect the resistance of a conductor are as follows

- The environmental temperature
- The length of a conductor
- The cross sectional area of a conductor
- The material which decides the resistivity of a substance

Another reason for the power loss is the improper maintenance of the equipments which are used in the production section. The mechanical devices used at the power production section need routine greasing and proper maintenance. Various connectors, cables, and power transformers are responsible for eddy current loss (Paul Gill, 2009). The power so generated at the production section will be converted into high voltage and low current and sent to various distribution centers. There will be a power loss in the form of heat during conversion in transformers. The lengthy aluminium cables which are used to connect the production center and distribution center also contribute to the power loss.

Today almost all the distribution systems are overloaded due to the increased consumption of electricity by the consumers who are connected to the distribution system. This causes the loss of electricity due to overloading. The need of electricity in the rural area requires long aluminium HT (high tension) and LT (low tension) wires which will add to the power loss (Frank and Jack 2010). All distribution centers are open to environmental changes. This results in power loss. Aging of the connectors, aluminium cables, the connecting poles are other reasons for the electrical loss at distribution center.

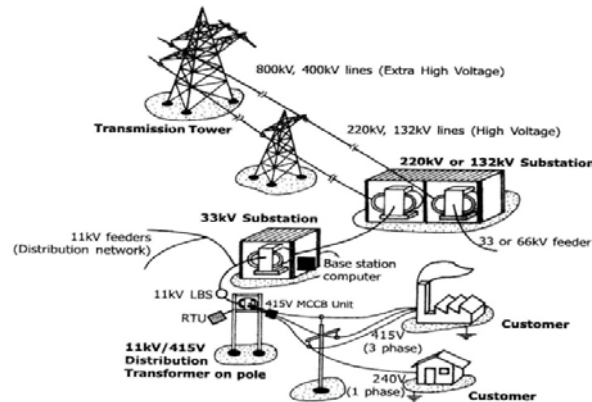


Figure 2 : Typical Power Transmission and Distribution Scenario with DA components (Frank and Jack, 2010).

The power loss at the consumer side may be due to the following reasons

- Improper wiring
- Improper earthing
- Usage of aged equipments
- Use of poor quality of equipments
- Power theft

II. Electrical System based on Ideal Technology

Technology is the branch of scientific knowledge that deals with the creation, application and use of technical means and their interrelation with human life, society, and the environment, drawing upon such subjects as engineering, applied science, pure science and industrial arts. Many technological processes generate unwanted by-products, which give rise to pollution, and deplete natural resources, to the detriment of Earth's environment. Implementations of new technology influence the culture and values of a society and often raises new ethical questions. For example, the rise of

the efficiency and effectiveness in terms of human productivity, a term originally applied only to machines is now became common traditional norms (Martin 1996).

The physical science explains the basic activity of the system. This activity which is converted into the need of the mankind is explained by the technology. The basic activity of a system is influenced by the environment. The impact of the influence of the environment is both positive as well as negative. The technology gives rise to the useful application or product to the environment as well as the unwanted waste which are called by-product to the environment. Today because of the sophisticated technology the life style has totally changed.

We have reached to a level that without this technology the life is imaginary. But at the same time the technology has serious negative aspects like the amount of the unwanted by-product to the environment which is considerably large and that it is spoiling the environment and because of this the health of the living animals in the environment is seriously affected. Thus the life style is increasing and life health is decreasing due to the technology. In connection to the electricity we are having the impact of technology in both the sides. We get electric current for industrial use or domestic use as positive impact of technology, whereas the air pollution, water pollution, life threat due to distribution channels, leakage in the current at the distribution and utilization system etc. are the negative impact of the technology.

To get an improvement from this system one should try to reach the Ideal state of the technology which maximizes the system behavior and nullifies the negative aspects (Alan Durrant, 2000). Figure 1 shows the theoretical efficiency of converting various energy sources by a variety of methods into useful electrical energy. The figure shows the practical efficiency and it is very clear that most of the energy is getting wasted without any use. The ideal state or an ideal system is a system which satisfies the ideal characteristics which means a perfect system in all the ways. The ideal behavior of the conductors, transformers, capacitors, resistors, the ideal behavior of the engines, etc. are taken as standards to reach in the practical system of production, distribution and utilization of electrical energy to minimize the waste and maximize the production, distribution and utilization. The model of the ideal electrical energy system is very important to get the improvements on the practical system. Hence we propose a model of ideal technology in the electrical system discussing the electrical energy production, distribution and utilization.

III. Ideal Electrical System Model

An ideal electrical system must include the various characteristics to fulfill the objectives to solve the problems in the energy system. Based on various characteristics the model consists of three important conditions namely input conditions, system requirements and output conditions. This model is under the influence of the environment. So the model even discusses the environmental conditions (Aithal P.S. 2015). The model is shown in the figure 3.

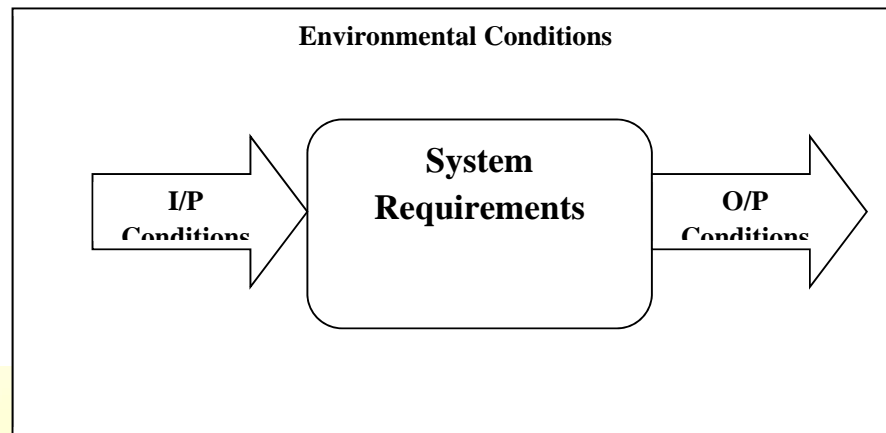


Figure 3: System model of ideal electrical system.

(1) Input conditions

The input conditions discuss the ideal characteristics of the energy system at the input side.

The input conditions have following properties :

1. Identify the fundamental nature of the input system at the production/distribution/utilization.
2. What are the differences between the practical input system with the ideal system.
3. How to reach the ideal system in the production/distribution/utilization.
4. The challenges in reaching the ideal systems.
5. The cost involved in improving towards ideal system.

(2) Output conditions

The output conditions discuss the ideal characteristics of the energy system at the output side.

The output conditions have following properties :

1. The energy system should provide complete solutions to the requirements.
2. The energy of should not be wasted in the form of heat or electromagnetic wave.
3. The energy system should completely avoid the hazardous shocks at its output.

(3) System Requirements

The system requirements concentrate on what are the system requirements to achieve the ideal output in the energy production/distribution/utility.

1. The general purpose technology to support all the processes in the production/distribution/utility.
2. Easy, simple and affordable system to support the ideal technology.
3. It should support the further new opportunities for the improvements.

4. The further new opportunities/improvements should upgrade the existing technology without replacement of the existing technology.

(4) Environmental conditions.

The impact of the new proposed ideal system on the environment are as follows :

1. Environmental cleanliness.
2. Amount of unwanted by-products from the system to the environment.
3. Adaptive to any environmental situations to achieve the goal.
4. No side effects assuring the users about the safety.

IV. Analysis of the Ideal Electrical System Characteristics

The characteristics of ideal electrical system can be explained based on the effective performance of the ideal electric source/line/output and the conditions to reach their ideal behavior. The ideal nature of the electrical energy system is discussed below based on the ideal system model shown in figure 3.

(1) Input Conditions :

1. Identify the fundamental nature of the input system at the production/distribution/utilization.

The electrical energy can be generated in several methods. The most frequently used commercial methods include thermal electricity, hydro electricity, electricity using atomic energy etc. The fundamental principle in all the above methods is the rotation of large turbine using different methods. In hydro-electricity, the turbine can be rotated using flow of water i.e. the kinetic energy is converted into rotational motion of turbine shaft. Using this method the efficiency of conversion from kinetic energy (water flow) to electrical energy is in the range of 85% to 95%. This is considered to be the most efficient method of power generation. The turbine can also be rotated using the steam generated from coal using thermal energy. In this case the efficiency in converting the heat energy to electricity is expected to be 40-45%. Even the rotation of turbine can also be done using the steam generated from controlled nuclear atomic fission. The total electric supply is expected to be 12%.

The electrical energy thus generated is given to the distribution and transmission system for distribution. Here the energy is converted into high voltage and low current at the production section and sent to different feeders located at different places. A considerable amount of energy is getting wasted in the form of heat during conversion as the conversion requires the transformers. The energy loss is expected to be around 22.5%. The energy loss at the utility end is considered to be maximum. Here more than the usage, the electrical energy is getting

wasted in the form of heat. For example, if 60W incandescent lamp is used as a light source then the real conversion of electrical energy into light is only 2% rest 98% of the energy is converted into unwanted heat whereas if 15W CFL is replaced then the conversion rate of the CFL into light is only 9% and the rest 91% is wasted into unwanted heat. Similarly most of the domestic or industrial electrical equipments are resistive equipments and they waste the energy into heat more than the actual usage.

The model below shows the methods to reach the ideal input system

- Hydro Electric plant Must use the turbine which does not waste energy in the form of heat.
- Transformer design should be done in such a way that it should not heat during voltage conversion.
- Transmission lines/load should have zero resistance.

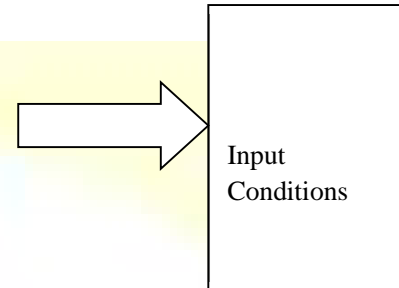


Figure 4: Input conditions to reach ideal electric production and utilization.

2. What are the differences between the practical input systems with the ideal system?

The difference between the practical electric system at production side and ideal production system is expected to be 5 to 15% in hydro electric system, 55 to 60% in thermal and atomic system.

The difference between the practical electric system at distribution side and ideal distribution system is expected to be around 22.5%. The major difference is in the utility side of the electrical energy system where in the difference between the practical electric system and ideal electrical energy system is around 90-95%.

3. How to reach the ideal system in the production/distribution/utilization.

- From the previous section it is clear that the maximum efficiency in power production is achieved in hydro electricity which is in the range of 80-95%. The range is due to the flow of water to the turbines. As the water flow is increased the efficiency can be increased. By modifying the turbine blades, junctions from the turbine to generator, minimizing the friction loss and deciding the water flow rate it may be possible to reach closer to the ideal condition.
- In thermal energy system the efficiency is around 40-45% due to the wastage of the heat into environment. In order to reach closer to the ideal system the entire heat generated should be used for steam which in turn is used for generators to generate electricity.

- In order to reach closer to the ideal system in distribution the new decentralized method of power production using renewable energy should be adopted. The transformer designs have to be improved to nullify the eddy current loss.
- In order to reach closer to the ideal system in utilization all the inductive and resistive loads have to be replaced. The inductive and resistive load are wasting electricity in terms of heat utilizing Only 2-5% of energy wasting 95-98% of energy.

4. The challenges in reaching the ideal systems.

There are various challenges which limit the system to reach the ideal system.

- a. No system or matter in the world is exhibiting the ideal behavior.
- b. Impact of environment.
- c. Aging of components.
- d. Various connections and lengthy distribution lines.

5. The cost involved in reaching the ideal system.

The materials used in the production section, distribution section and utilization section are limited by the various external properties of the environment. The materials whose behavior is found to be closer to the ideal system are considerably costlier than the regular materials used.

(2) Output Condition

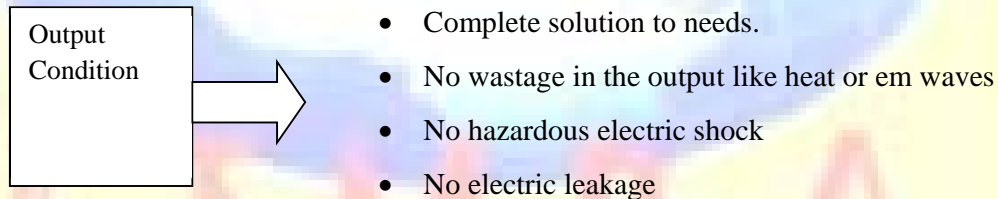


Figure 5: Output conditions to reach ideal electric production and utilization.

1. The energy system should provide complete solutions to the requirements.

The energy system produced will be considered ideal only when it is in a position to provide a complete solution to the requirements. The requirement may be as small as energy for nanotechnology, microelectronics, or as large as power electricity, industrial power requirements etc. The solution given by the system should not waste energy in any way.

2. The energy system should not be wasted in the form of heat or electromagnetic wave.

The equipments at the output system should be so selected that they should satisfy the ideal conditions in which there should not be any heat dissipation. The major output devices like lights and fans should be so designed that the complete electrical energy should be converted into either light energy or wind energy or any other required energy form without any waste.

3. The energy system should completely avoid the hazardous shocks at its output.

The ideal energy system should function in such a way that there should not be any shock wasting the energy as well as life threat. This is possible only when the current system is replaced by a new technology which supports these features.

The above mentioned output conditions are possible when the electrical energy production is decentralized and renewable energy sources are used for production so that there will be a system closer to the ideal system in production. There will not be any question of distribution. The output condition is as per the need of the individual satisfying all the output conditions.

(3) System requirements

1. The general purpose system to support all the fields in the production/distribution/utility.

The technology which supports the ideal system should be taken from the general purpose system without much of the complicated systems which involve a huge amount of money to be spent in turn the return is very small. This can be achieved using decentralized power production using green technology.

2. Easy, simple and affordable system to support the ideal system.

In order to support the ideal system, the proposed system should also be easy to install and use. The cost involved in this must be affordable.

3. It should support the further new opportunities for the improvements.

This distributed decentralized domestic system strongly supports the further new opportunities for the improvements.

4. The further new opportunities/improvements should upgrade the existing system without replacement of the existing one.

This distributed decentralized domestic system strongly supports the further new opportunities for the improvements. These improvements should not be a complete replacement of the existing system instead should be up-gradation of the existing system by adding new concepts to the present technology.

V. Comparison of ideal and practical Green energy Production, Distribution & Utilization System :

Table 1: Comparison of ideal and practical Green energy system.

S. No.	Ideal Electrical System	Practical Green Electrical System
1	Efficiency is 100% at production stage	Efficiency is 35% at production stage [mpoweruk 2015]
2	Resistive losses at distribution stage 0%	Resistive losses at distribution stage 10% [mpoweruk 2015]

3	Waste in the form of heat at the output is 0	Maximum loss of electrical energy in the output in the form of heat which is equal to 98% [mpoweruk 2015]
4	The resistivity of the cable which supplies the electricity from source to destination is 0 irrespective of length	The resistivity of the cable which supplies the electricity from source to destination varies from 5% to 20% depending on the length average being 7% to 8% [mpoweruk 2015]
5	The capacity factor is 100%	The capacity factor is less than 40% [mpoweruk 2015]
6	The load factor is 100%	The load factor is around 60% [mpoweruk 2015]

The advantages, benefits, constraints and disadvantages of practical green electrical energy system are listed below:

(a) Advantages:

- Environmental friendly source of production
- This system can be directly connected to the public storage grid in such a way that during green energy production grid can access the energy from green source otherwise it can access the energy from public storage grid.
- Distributed energy production avoids the distribution power loss.
- Uses of LED lights and TV and other latest technology can minimize the power loss at the output load

(b) Benefits:

- The customer can decide the nature of green energy which he is going to install.
- The customer can technically plan the design for the production, distribution and utilization.
- The customer can either enhance or reduce the green energy (production/distribution/utilization)

(c) Constraints:

- Financial constraints- huge amount has to be invested at the beginning for incorporating this green energy. However our government is encouraging the public to invest more and more on green energy.
- Technical constraints- Lack of technical knowledge by the public limits the installation of green energy.
- Geographical constraints- The place where the green energy is to be installed is a major challenge. The constraints like area, availability of sun light, bio waste

management etc. The geographical position which means longitude and latitude of the place is another constraint.

- Use of nanotechnology- The present industry has its own limitation in using nano technology in the energy system.

(d) Disadvantages:

- It is a challenge in increasing the efficiency of green energy system.
- No one can reach zero resistivity at the room temperature to utilize the energy to 100%
- The dissipation of heat at the load cannot be nullified.
- Negative impact of environment on green energy production/distribution/utilization cannot be nullified.

VI. Conclusions

The major challenges in reaching the ideal electrical energy system in either production or distribution or utilization is reaching zero resistance offered by various devices. The effect of the resistance is responsible for heat generation which not only wastes the energy to the maximum extent but also the life of the devices will go down. But it is very much possible to reduce the resistance and improve the efficiency thereby can reach closer to the ideal system by adopting the following suggestions.

1. Since it is very difficult to achieve zero resistance either in the production section or in the distribution and utilization, decentralized energy production system using green electrical system is strongly recommended.
2. Since heat dissipation is due to the flow of current in the conductor it is recommended to have a very small amount of current by increasing the voltage is recommended.
3. This paper recommends the production of equipment like fan, lights and any other domestic appliances which operate in high voltage and low current to reduce the heat generation.

4. Since decentralized production and management of energy system using green technology is suggested, the constant maintenance activities required to reduce power loss.

All the above mentioned conclusions lead closer to ideal electrical energy system.

References :

- [1] Madhu Khanna, Kusum Mundra, Aman Ullah (2005), *Parametric and Semi-Parametric Estimation of the Effect of Firm Attributes on Efficiency: Electricity Generating Industry in India*. *Journal of International Trade and Economic Development*, pp 419–436.
- [2] Lambert M. Surhone, Miriam T. Timpledon, Susan F. Marseken (2010) *Ohm's Law: Ohm's Acoustic Law, Electrical Network, Electric Current, Voltage, Electrical Resistance, Ampere, Ohm, Current Density, Drude Model, Classical and Quantum Conductivity*, Betascript Publishing, 2010
- [3] Paul Gill (2009), *Electrical Power Equipment Maintenance and Testing*, Second Edition, CRC Press.
- [4] Frank Delea, Jack Casazza (2010) *Understanding Electric Power Systems*, Second edition, WILEY Publications.
- [5] Martin F.G. (1996) Ideal and real systems: A study of notions of control in undergraduates who design robots. In Y. Kafai and M. Resnick (Eds.), *Constructionism in Practice: Rethinking the Roles of Technology in Learning*. pp. 297-322, Mahwah, NJ: Lawrence Erlbaum, 1996.
- [6] Alan Durrant, (2000) “Quantum physics of Matter”, CRC Publications. ISBN-13: 978-0750307215
- [7] Aithal P.S., and Shubhrajyotsna Aithal, (2015) *Ideal Technology Concept & its Realization Opportunity using Nanotechnology*, *International Journal of Application or Innovation in Engineering & Management (IJAIEM)*, Volume 4, Issue 2, pp. 153 – 164.
- [8] http://www.mpoweruk.com/energy_efficiency.htm