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A Review on Social Impact of International Interconnection of Power Grid

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Abstract
The world development depends on the minds of innovative Engineers from the past to the future generation. The technology has revolutionized human life which was considered as a nightmare. Engineers have always been the most recognized people in addressing the issues of diversified fields like sanitation, energy, infrastructure, communication, automotive, human welfare and many more. Energy plays an important role in everyone's life. The prosperity and wealth of a Country is decided by the strength of generation and utilization of Electrical energy. Engineers are focused in revolutionizing the energy system and create a smarter world by interconnecting the power Grid internationally which will upgrade the society, establish a friendly rapport between the neighboring Countries and reduce the energy pricing. International Grid interconnection will be the modest way to transfer power between one Country and another Country. This paper reviews on the social impacts / aspects of the International Interconnection of Grid and also the issues associated on the development of the Interconnection of power Grid like Technical, Economic and Finance ,Legal, Environmental and Political. The development of new technology has many pros and cons, it is up to the society to utilize the technology in the improvement of human welfare.
Keywords: Energy, International Grid Interconnection, Social impacts, Technical, Economic and Finance, Legal , Environmental, Political

INTRODUCTION

Electricity plays an Integral role in the life of mankind. Energy serves as the main criteria in deciding the economic activity and prosperity of a Country which in turn delivers the wealth of society benefits and high quality of lifestyle. About 1.2 billion of people in India do not have access to electricity, 2.8 billion have to still rely on wood or other biomass to cook and light up their homes. About 80 percent of those without access to modern energy live in rural areas. Although 1.7 billion people gained access to electricity between 1990 and 2010, this is only slightly ahead of population growth of 1.6 billion over the same period[4]. As the natural resources for generating electricity by conventional methods are depleting, it is impossible to rely only on it. The population growth is increasing at a faster rate, so the generation of electricity has to be increased by using alternative methods like generating it from various Renewable Energy Resources – Solar energy and Wind energy to meet the 100 percent access target by 2030. In India, utilization of renewable energy resources which is the modern energy generation is only 18 percent of the global energy mix. Dr.Frei quoted that "Access to secure, clean, and affordable energy is fundamental to improving the lives of people across the world. The goals of Sustainable Energy for All are important and we must seize this opportunity to make a better future."[3]

As the energy demand is increasing very rapidly due to the advancement of technology and changing lifestyle of man, globally it is a challenging issue for the Scientists of how to meet the energy demand and also reduce the Carbon–di-oxide emissions produced from the Conventional methods of energy generation. The global energy and environmental challenges cannot be solved through a local ,regional or even a national approach .

***Fig. 1*:Internatinal Grid Interconnection**
(Source: Global Status Report, Renewables 2014)

It requires a global outlook, a broader network which is international interconnection of power grids. International power grid interconnections provides sharing of power generation resources by linking the power grids of two or more adjoining Countries. The international integration can help to contribute towards the process of development of the Sustainable resources and also to increase the security and the reliability of supply of electricity as well as societal benefits such as education, employment generation, health care, better services and reduced capital investment .Many Countries are implementing energy policies for developing the renewable resources(RES) and even in India, the government is providing subsidiary for the implementation of RES for the consumers.

The major global shift of Grid Interconnection cannot be easily developed as there are many impacts (both positive and negative) to be dealt which are categorized as technical, economic and financial, legal, social, environmental and political issues and challenges that has to be accounted before the arrangements for International Grid Interconnection.

IMPACTS OF INTERNATIONAL GRID INTERCONNECTION

THE IMPACTS AND ISSUES THAT ARISE CONCERNING WHEN INTEGRATING POWER GRIDS ARE

A Technology

International interconnection of Grid is technically very complex and also risky which requires a high degree of technical compatibility and operational coordination which grows in cost and complexity as the interconnection becomes broader and wider. Extensive joint planning, Computer modeling and exchanging of Information between the Interconnection systems and many other technical changes required should be properly specified. Technically and operationally, there are many differences in the Institutional and Administrative features of power systems of different Countries [1].

The technical benefits of Grid interconnections are[1]

- Reliable and sharing of reserves
- Systems can improve the poor load factor
- Diversity of generation mix and supply security
- Economic exchange
- Environmental dispatch and new plant siting
- Coordination of maintenance schedules

Finally, the Interconnections are designed in such a way to provide power to consumers economically, efficiently, safely, reliably, and with minimal environmental impacts.

B Economic and Financial

The primary reason for developing an International Grid interconnection between countries is to reduce the overall combined economic costs of supplying electricity services in the interconnected countries. Energy trading between nations offers significant economic benefits.Pricing of traded electricity requires careful consideration and negotiation if all parties are to be benefitted. The economic and financial structures which includes the economic costs and benefits should be priorly planned before expensive interconnections can begin operation.

An appropriate incentive structure was developed to align the economic and regulatory policies with energy-efficiency and environmental goal needed to be tailored to each member economy [12]. The potential economic benefits of interconnected countries considered either individually or together include fuel costs avoided by the interconnection, avoided generation capacity costs, avoided operating costs, and avoided costs for transmission system improvements. Large amount of savings can be obtained in these elements because the operation of the interconnected system can be coordinated to optimize the use of resources on both systems to

meet the loads on both systems. There are two ways of Income from power sales, direct and indirect. In addition to the direct benefits and costs of the power systems to the connected countries, international grid interconnections also offer the potential for indirect economic benefits and costs related to the employment impacts associated with the construction of power plants and power lines, the impacts of improved power supply on local and national economies, and the impacts of net savings on power supplies.

The "E7" Group of Utilities describes some of the economic benefits of interconnection as follows:

"The pooling of resources and the interconnection of isolated electric power systems allow optimum use of available resources. They will be instrumental in achieving reductions in the operating cost of the generation mix, increasing the generation capacity margin and, conversely, reducing the need for investment in peak capacity. Lower production costs and/or lower investments in generation, achieved through the interconnection of electric power systems should have an impact on rates to the customers' advantage. Improved electric power systems reliability will foster an increase in quality of service and a reduction in power interruptions that too often lead to productivity losses in the commercial and industrial sectors, affecting average regional manufacturing costs and, finally, the national gross domestic product (GDP). Pooling electricity resources is crucial if the electric power systems are to fully contribute to sustainable development."[1]

The analyses of the economics of power trade across all Countries in a Grid interconnection project need to be a part of both short- and long-term electricity sector planning by the Engineers [1][17]

C Legal

International grid interconnections can be very complex legal undertakings which involves different national, sub-national, and even international parties to the agreements required for planning, building, and operating power lines used to buy and sell electricity across the borders. Binding legal agreements among countries and others involved, as well as the negotiation processes that produce the agreements, has to be transparent and enforceable. To draft, review, enforce, adhere to and, in the event of a disagreement, adjudicate contract issues national legal capacity is very essential. Some of the key types of legal agreements needed to provide The frameworks for international grid interconnections for which legal agreements has to be provided include power purchase and pricing agreements, agreements on siting of power lines and related infrastructure, agreements on power line operation and operation authorities, agreements on power line security, agreements on the environmental performance of the interconnection, agreements on liability for power line failure, and agreements for the orderly, fair, and open selection of contractors to build and/or finance and/or operate and maintain interconnection infrastructure. Long term legal framework has to be structured which ensures trust between the partners(Countries) for international flow of electric power, funds to pay for electricity received, as well as structuring straightforward and transparent dealings between the trading countries and the public and/or private institutions that support grid interconnections In order to identify the parties responsible for paying for grid interconnection infrastructure, for the power itself, and for the costs of operating the infrastructure a legal framework is necessary. The complexity of international grid interconnection systems includes the physical systems themselves, the institutional arrangements necessary to make them work, agreements are needed to codify the rights and responsibilities of the parties relative to each other. Some of the potential "parties" in legal agreements related to grid interconnections involved are given below:

(a) National governments/ministries
(b) Sub-national governments and agencies
(c) National utilities
(d) Private utilities, buyers, or sellers
(e) Private construction and/or maintenance contractors and subcontractors
(f) National or multi-national transmission consortia
(g) Multi-national banks and other financial institutions

During negotiating and complying the international agreements required to build and operate an interconnection can also serve to build confidence in a country's legal system and to provide a source of experience in international-standard legal system operations[1].

D Social

The Social impact is the most sensitive and important feature to be analyzed during the International grid interconnection. Communities worldwide has to join together leaving behind different race, religion, color, poor/rich, etc to integrate the grid so that everyone can have access to a reliable, stable and energy at economical price.

Fig. 2: International Integration
(Source: http://english.vov.vn)

The analysis made by Anna Mengolini and Julija Vasiljevska shows that the two points most frequently referred to as critical are the uncertainties regarding the use of different motivational factors, and the lack of trust by consumers .The motivational factors which are commonly concerned in Interconnection of Grids are which is shown in the Figure 3 [15]

(a) Environmental concerns,
(b)Reduction of control over electricity bills
(c) Better comfort

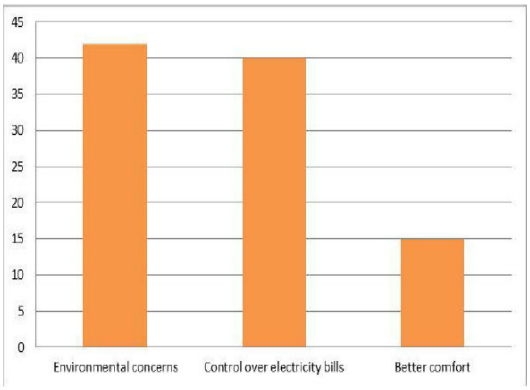

Fig. 3*: *Motivational factors for Consumers
(Source: JRC Scientific and Policy Reports)

Jackson (2005) argues that sustainable consumption and consumer behavior are key issues to the impact that society has on the environment. However, he acknowledges the challenges and difficulties of changing consumption behaviors' and motivating consumers. Consumers are mostly locked into unsustainable consumption patterns influenced by routines, social norms and expectations, as well as incentive structures, institutional barriers and restricted choice. Jackson (2005) argues that consumers are guided as much by social norms and the behavior and opinions of people around them as by personal choice. The distinction of three kinds of acceptance (Huijts,2012) that can be applied in Interconnection of Grid is shown in the Figure 4 [15]

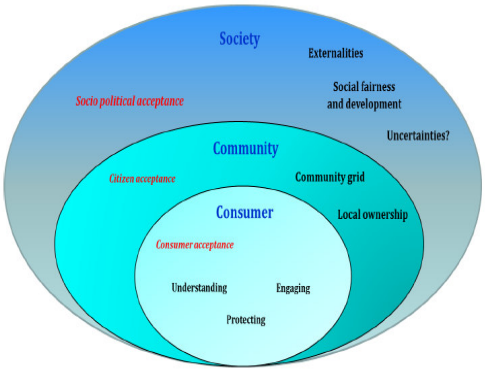

Fig. 4: A Social dimension on International Interconnection of Grid.
(Source: JRC Scientific and Policy Reports)

Societal Benefits like job creation, community development can be increased due the Grid Interconnection which is shown in the Figure 5

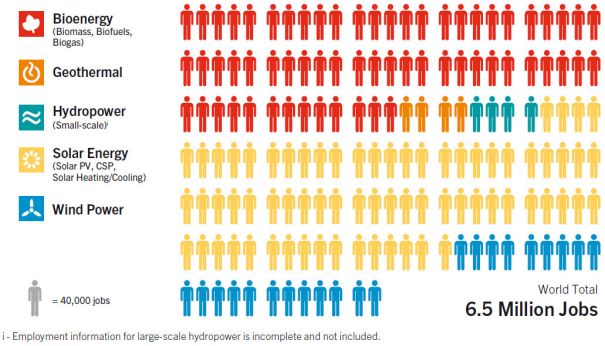

***Fig. 5*: Jobs in Renewable Energy - International Grid Interconnection**
(Source: Global Status Report, Renewables 2014)

In India, the Central Transmission Utility has committed to achieve the goal of Sustainable Development. It has integrated environmental and social management procedures into its corporate operations by enunciating Environmental and Social Policy and Procedures (ESPP) like other Countries. Massive plantations in sub-stations where large acres of land is being afforested . A separate fund is also earmarked for this purpose whenever it is feasible[4]

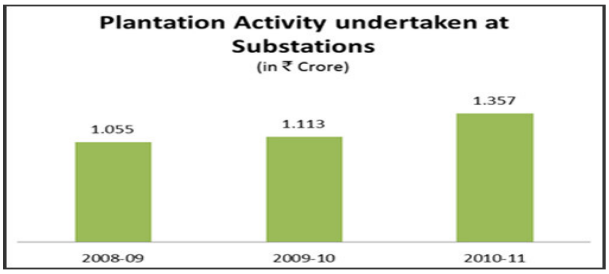

Fig. 6: Plantation Activity undertaken at Substations
(Source:POWERGRID of India)

It provides Resettlement and Rehabilitation assistance within the social entitlement framework and various community developments works in villages adjoining the substation which share its local resources, an example is shown in the Figure 7

Fig. 7: Rehabilitation assistance
(Source:POWERGRID of India)

International grid interconnection projects may yield significant social benefits to some or many groups in the nations participating in the projects [15].

E Environmental

Global warming phenomenon has to be taken very seriously as it affects the weather patterns, leading to more droughts, flooding and melting of world's ice caps and glaciers leading to the increase in sea level. The continuous research and debate by the Scientists and Industrialists on the causes of global warming has not ended up for centuries. There are many panels discussing on the climatic change which has suggested that global warming is mainly due to the human activities. The percentage releasing of greenhouse gases and the use of aerosols is in particular affecting in warming up the Earth at a faster rate[1].The Carbon-di-oxide emissions globally is shown in Figure

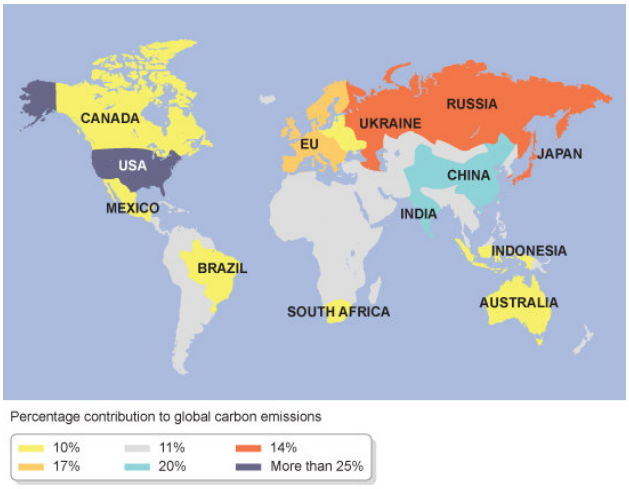

Fig. 8: ***Global carbon emissions (*****Source:*****worldenergy.org)***

The combined power generation of fuel-based and climate-friendly energy sources like the Renewable Energy resources can

- reduce the fuel consumption
- reduce CO2 emissions
- increases energy independence

F Political

International grid interconnections may bring the political benefits to the interconnected countries includes increased experience and political comfort with international cooperation, can have friendly relationship and avoid conflict with neighbors, increased democratization ,and an increase in internal political stability. Sharing of power resources, moving forward with the interconnection project, how interconnection project contractors will be paid, and by whom , and how the benefits and costs of the project will be shared between and within nations is done through political agreements. Agreements also are needed as to how the interconnection infrastructure will be operated and secured, including agreement on the governance of the interconnection operator, and how information necessary to plan, operate and protect the interconnection will be shared. Political agreement and cooperation between the trading countries, as well as between different constituencies inside each of the trading countries has to have an effective international legal framework governing the construction and operation of any international grid interconnection. Designing, constructing, and operating power line interconnections require political cooperation both between and within countries on a number of fronts, including:

(a) Agreements in principle as to sharing power resources;
(b)Agreements on moving forward with the interconnection project, including agreements on contractor selection, power line routing, and other major decisions;
(c)Agreements as to how interconnection project contractors will be paid, and by whom;
(d)Agreements as to how the benefits and costs of the project will be shared between and within nations;
(e) Agreements as to how the interconnection infrastructure will be operated and secured, including agreement on the governance of the interconnection operator;
(f) Agreements as to the sharing of information necessary to plan, operate and protect the interconnection.

Countries which are sharing the political will has to cooperate and function smoothly and in a timely manner. Political barriers to interconnection between Countries, can include longstanding national rivalries or territorial disputes, religious or tribal rivalries between nations, internal political disunity, substantially different political systems and traditions, an emphasis on national energy self-sufficiency to the exclusion of other options,

and an internal energy sector organization that may be politically at odds with an interconnection project [1].

DISCUSSIONS AND CONCLUSIONS

"The Way Forward", strategies for cooperation on energy interconnections [19]

- Increasing bilateral trade ("bottom up")
  - Pursue simpler deals first
  - Get the private sector involved (in partnership with the public sector)
- Strengthening physical infrastructure (in conjunction with specific trading deals and investment projects): gradually constructing regional electricity (and gas) transmission network, starting from bilateral interconnections
- Getting the broad framework right to open up longer term trading and investment potential ("top down"):
  - Analysis of regional energy trade economics
  - Addressing institutional, regulatory and policy issues
  - Addressing technical issues: parallel operation of electrical grids
  - Developing commercial framework for trading: framework trading agreements, model power purchase agreements
  - Addressing investment issues: investment protection, regional investment planning, riparian rights, right of way for electricity transmission lines and gas pipelines, environmental and social concerns, etc.
- Using the existing (or complementing) regional forums for multi-country discussions and coordination (SAARC, ECO).

We need to be prosumers and be a part in developing our Country to reach 100 percent power access to everyone by 2030. We have to analyze the impacts (Technical, Legal, Economical and Financial, Social, Political, and Environmental) while underlying the Grid Interconnection. So, we as Engineers have to be innovate and be a part in integrating the power Grids so as to ensure reliable, stable, sustainable , and eco-friendly energy generation and transmission . International Grid Interconnection will upgrade the society, establish a friendly rapport between the neighboring Countries and reduce the energy pricing. .We have to adapt to a changing world.

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