THE BOTTOM UP DISTRIBUTED GENERATION FOR UTTAR PRADESH, INDIA

By

Mr. Lov Kumar Mishra

Under the Guidance of

Guide

Dr. Avanish K Tiwari

Senior Principal Scientist

Center for Alternate Energy Research

Co-Guide

Dr. Krishan K Pandey

Sr. Associate Professor & Head of Department

College of Management & Economic Studies

Submitted

In the partial fulfillment of the requirement of the

Degree of Doctor of Philosophy

To

University 0f Petroleum & Energy Studies

Dehradun, India

Acknowledgements

Apart from personal effort and steadfastness to work, constant inspiration and encouragement given by number of individuals served as the driving force that enabled me to submit my thesis in the present form.

First of all, I take this opportunity to express my deep sense of gratitude and sincere thanks to my guide Dr. Avanish K Tiwari, Senior Principal Scientist, Center for Alternate Energy Research,University of Petroleum & Energy Studies for his mature, able and enlightenening guidance and persistent encouragement. I am extremely indebted to his for the scientific attitude he has installed in me which will definitely stand in all futures endeavor.

Special thanks to my Co- guide Dr. Krishan K Pandey, College of Management & Economics Studies, University of Petroleum & Energy Studies for his mature, able and enlightening guidance and persistent encouragement.

The authors also thank the Managing Director, Dr. Nilesh Chand Aggarwal, M/S Earth Protection Group Environmental Consultant pvt ltd, Lucknow for the support.

Declaration

I, **Lov Kumar Mishra** declare that the thesis entitled **The Bottom Up Distributed Generation for Uttar Pradesh, India** and the work presented in it are my own and has been generated by me as the result of my own original research.

The work was done under the guidance of Professor [Dr. Avanish K Tiwari and Dr. Krishan K Pandey], at the University of Petroleum & Energy Studies, Dehradun.

Lov Kumar Mishra

SAP Id: P500011014

Date:

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Executive Summary

Worldwide many developing economies have started top-down power sector reform approach due to both internal resource constraints and external macro and micro economic need. An overarching pressure to reduce input costs for reliable power generation and distribution, that can provide local employment to the population made developing economics to think on these lines. Current prevailing practice of top-down reform in a developing world context has encountered several serious challenges, primarily due to the fact that the top the top-down model relies on:

1. A stable grid with adequate capacity and regular maintenance regime;

2. High regulatory capacity;

3. A strong judiciary with enforcement of contract law;

4. A robust distribution companies (physical and financial) to make markets work

5. Predictable cash flows and low levels of corruption/theft to make contracts solvent; and slow and controlled demand growth to ease implementation.

Rapid power sector reform growth and the lack of supporting institutions, including judicial, financial and other political economical factors, make the top-down model a in-efficiently fit for developing economies.

This work indicates is that no single model will fit all countries; there is no "textbook" restructuring. A set of politically, social and economical complex and complementary reforms are desired with careful pacing. Judicial capacity, improved corporate governance, efficient financial instruments, open trade environment and tariffs all act to support the goals of power sector restructuring. Importantly, the concentration in the literature on the financial and efficiency should positively impact public benefits objectives.

To establish an alternative approach, the role of Hybrid model comprising of small scale and captive generation supplies is examined as a baseline for an alternative, bottom-up power supply reform route. An examination reforms impact in China, Indonesia, Philip-

pines and Thailand highlights the observations with top-down reforms and demonstrates how each has partially pursued Distributed Generation and captive generation option as an alternative. These four examples indicate that a bottom up approach can be successful and thrive., only under positive and adequate regulatory environment.

The serious fiscal and electricity supply shortage in Uttar Pradesh has helped to push power sector reform liberalization and restructuring to the forefront. However there is a strong possibility that interest group may debase the process or attenuate its effectiveness. The reform process in Uttar Pradesh has been part of critics for being too slow and thus preserving a financial and performance dilemma in the electricity sector. The reforms are expected to deliver and shown an energetic IPP presence with trend for practical future. A danger is also anticipated in existing Electricity Act of 2003 as it may result in the implementation of patchy reform that may only change ownership while not attacking the core fundamental problems of high industrial tariffs, disorganized agriculture subsidies and the finally resulting to lack of revenue from the sale of electricity. The regulatory unpredictability of the Uttar Pradesh bearings, as well as the underprivileged financial position of the Power supply system has left urban, rural and industrial power consumers poorly served. The high industrial tariffs that have been unwaveringly increasing over the past few decades, have led many larger industrial setups to produce their own electricity. The progressive dominance of the Electricity Boards, which has proven poor performing due to inadequate supplying to rural areas, encourage industrial and small scale generators to participate with local communities to strengthen service deliveries.

The political economy of power in Uttar Pradesh also incorporates the availability of fuel resources and supplies, the most significant being imported coal and the sustained development on renewable energy sources in Uttar Pradesh. Each will have a remarkable impact on electricity markets and attraction of new investments in power, fertilizer and other core sectors. Despite, rising international oil and gas prices and the prevalence of gas contracts, crude prices have increased the cost of imported gas supplies resulting to reduced demand growth. A run up in imported coal costs and domestic coal shortages have made newly proposed large central station projects much more expensive than anticipated.

The cost of energy in fossil fuel based centralized power stations consists of generation, transmission and distribution costs, whereas in the decentralized power generating system the energy cost is primarily the generation cost. Conventional centrally-managed approaches to electricity distribution have been expensive and unsustainable and the financial analysis presented in this thesis makes the case for a distributed approach in remote, rural areas using hybrid power systems.

This thesis demonstrates that hybrids distributed generation model can be a cost-effective solution for providing energy services in rural Uttar Pradesh. Distributed Generation can help to reduce both technical and non-technical losses by decreasing the grid issues, needed to deliver adequate and quality electricity. The susceptibility of the system to non-technical loss may also be reduced by pushing the center of control closer to the user, thus improving the incentives and control on theft through social, managerial, and technical means. Distributed Generation has a number of other technical advantages over centralized electricity production. Since electricity cannot be stored, power generation must match in time and scale of demand which means that there must always be sufficient capacity available to meet peak demand, even though that capacity may only be needed for a few hours per year. Distributed Generation can be used to meet these demand peaks, thereby allowing electricity companies to delay investment in centralized generation, transmission, and distribution. Where rapid growth is anticipated, as in Uttar Pradesh, incremental DG investment may also be used to meet timing differences between large-scale investment and local load growth. The main lesson of the work area in Kanpur district of Uttar Pradesh is that Distributed Generation has an important role to play, but regulatory and significant initial capital investments are needed to overcome the financial and institutional barriers for Distributed Generation. The high costs of delivering power to remote areas has not been adequately accounted for in past by energy planning in Uttar Pradesh and should be taken into account when choosing energy supply options in remote areas.

The conclusion from this work suggests that small scale distributed hybrid energy supply systems may have better economic and market efficiency enhancing properties.

By initiating the generation sector from the bottom-up, the market power of incumbent utilities may be reduced, which would encourage a range of innovations in the Uttar Pradesh electricity sector. Without question, there is significant work to be done at the local level to develop appropriate business models to support better power supply through hybrid Distributed generation systems. However, strong models from the experience of micro-credit institutions in the sub-continent can be instructive. By harnessing local accountability networks transaction costs can be reduced and quality service could be maintained at an affordable level. A recent study of rural energy programs in India shows promise for this approach. Going further, the regulatory environment is now ripe for more bottom-up solutions, with the 2003 Electricity Act explicitly allowing supply via distribution licensees, though local Panchayat councils, user associations, cooperative societies and generator-distributors in rural areas. The use of micro-finance is also a promising area for rural DG, and recent proposals argue for a two part solution using an energy supply company in tandem with a focused financial services firm.

Captive power achieves many of the same benefits as DG, but from the other side of the spectrum of customer categories. The policy of encouraging captive power will be beneficial in the long run for the economy, but easing the transition will require significant adjustment of the current SEB-led reforms and some continued cross-subsidy payment by industry. For industrial and commercial consumers, that will mean continued taxes on power, but with the policy compact that taxes would be reduced over time on a set schedule and that subsidies would become more targeted to reduce their growth. This policy approach would hopefully lead to higher investments in captive generation. CPP entry into the generation market would begin to create a competitive wholesale power market without the political upheaval or blanket privatization. The bottom-up approach recognizes the political economy of the Uttar Pradesh situation and the limitations of the approach used in the 1990s, which encouraged IPP entry and a single buyer model.

Conclusively, this pattern of power generation using Hybrid distributed model will requires tariff rationalization so that the cost of delivering power is reflected in the power tariffs. Higher tariffs would attract more resources for the state owned power companies to invest in new infrastructure and encourage the efficient use of electricity. It is anticipated that the findings of the study will be helpful to market players in India and beyond as reform attempts are shaped by more private players and partnerships.

List of Symbols

1	DG	Distributed generation
2	ESI	ElectricalăSystem Integration
3	RE	Renewable Energy
4	SERC	State Electricity Regulatory Commissions
5	CERC	Central Electricity Regulatory Commission
6	NEP	National Energy Policy
7	NTP	National Tariff Policy
8	RGGVY	Rajiv Gandhi Grameen Vidyutikaran Yojana
9	JNNSM	Jawaharlal Nehru National Solar Mission
10	IEA	International Energy Agency
11	OECD	Organisation for Economic Co-operation and Development's
12	EIA	Energy Information Administration
13	UPPCL	Uttar Pradesh Power Corporation Ltd
14	UPRVUNL	Uttar Pradesh Rajya Vidyut Utpadan Nigam Ltd
15	UPJVNL	Uttar Pradesh Jal Vidyut Nigamă
16	KESCO	Kanpur Electricity Supply Company
17	UPSEB	Uttar Pradesh State Electricity Board
18	NTPC	National Thermal Power Corporation
19	CPSU	Central Power Supply Unit
20	NHPC	National Hydel Power Corporation
21	KESA	KanpurăElectricity Supply Company
22	NREL	National Renewable Energy Laboratory
23	GBI	Generation based Incentives
24	RPO	Renewable purchase obligation

25	REC	Renewable energy certificates
26	COE	Cost of energy
27	NPC	Net present cost
28	SPP	Small power producers

CHAPTER 1

Introduction

1.1 Back Ground

Energy presence can be described as the uninterrupted physical availability, while respecting environment concerns. It may also be defined as the availability of usable energy supplies, at the point of final consumption, in sufficient quantity and timeliness so that, given due regard for encouraging energy efficiency, the economic and social development of the country is not materially constrained.

Access to reliable energy has become essential to the functioning of modern economies. However, the uneven distribution of energy supplies among countries has led to significant vulnerabilities. Threats to energy security include the political instability of several energy producing countries, the manipulation of energy supplies, the competition over energy sources, attacks on supply infrastructure, as well as accidents and natural disasters. The limited supplies, uneven distribution, and rising costs of fossil fuels, such as oil and gas, create a need to change to more sustainable energy models in the foreseeable future. Energy Security has many aspects: long-term energy security is mainly linked to timely investments to supply energy in line with economic developments and environmental needs. On the other hand, short-term energy security is the ability of the energy system to react promptly to sudden changes in supply and demand.

Energy is a key building block for sustaining any nation socio-economic development. As the global economy continues to grow, global energy needs as well as global emissions will increase by approx 60% between 2004 and 2030 as per the World Energy Outlook 2004 published by the International Energy Agency. Policy makers in developed as well as developing countries have realized that economic security of a nation has direct linkage with its energy security; hence for the sustainable growth of an economy it is essential to ensure the availability of dependable and affordable energy sources. Nations are now encouraging pragmatic energy policies and implementing state-of-the-art technology to mitigate the harsh economic impact of volatile energy prices, global climate change and to manage their energy security requirements. We believe that technology innovations can significantly contribute towards the development of clean, efficient, affordable energy sources over the longer term, while continuing to contribute towards improving the efficiency across various segments of the energy value chain.

Increasingly Information Technology (IT) is playing a role of a facilitator in realizing complete benefits from such innovations. Such technological breakthroughs will help countries manage the energy needs of its population, grow their economies and reduce poverty.

Any step which contributes towards either creating new sources of energy or helps in reducing energy consumption enhances energy security. Encouraging the use of renewable energy sources like bio-fuels, solar power and wind power through tax credits and other incentives for such technology innovations will help in reducing our dependence on fossil fuels whereby enhance energy independence. Conservation and energy efficiency initiatives also contribute to enhancing energy security as it results in using less energy for undertaking the same tasks.

In the World Energy Council report on Long-term energy Scenarios, one of the ecologically driven scenarios described, appears to be the ideal solution for achieving energy independence. This is a scenario based on new renewable energy resources allowing a gradual phasing out of most fossil fuel use and also creation of a new generation of inherently safe small-scale nuclear reactors, which achieve public and political support. The indicated possibilities over the next century are huge; For instance, global fossil fuel dependency may decline from its present 76% to scarcely 20%. There will also be huge shifts lying behind these global figures. The present developing countries that accounted for 34% of world primary energy consumption in 1990 are expected to account for about

50% by 2020, at least 60% by 2050, and over 70% by 2100.

Financing adequate electricity generation capacity has been a persistent problem in developing countries. India is a rapidly growing economy and is currently growing at the rate of 5% to 7% annually, and is further predicted to continue growing at this high rate. According the many estimates, Indian economy is poised to become the world third largest economy by 2030, only after China and United States. With such high rate of growth in the economy of India, its energy needs are expected to proliferate at a very high pace. Managing its rapidly growing energy needs is turning out to be one of the biggest problems for the country. Change in any system typically comes from one of two directions, from the top-down or from the bottom-up. The conventional response to low levels of investment has been from the top-down: create competitive electricity markets by encouraging new entry into the generation sector and by breaking up vertically integrated monopolies power companies.

A bottom-up method of power reform enables capacity from independent and industrial sources, which will best harness the financial and engineering resources of the Indian electricity supply industry (ESI), and differs from top-down methods in that it encourages non-incumbent actors to enter the ESI instead of relying on existing players or assets to begin competing against each other. The solution proposed is not put forward as an optimized policy prescription, but instead represents the best of the feasible options available within current political and economic constraints.

To meet this huge expected demand of energy requirement, it is needless to say the need to shift towards renewable sources of energy. In 2010, renewable energy contributed a mere 17GW, i.e. 9% of the total installed capacity of the country. Countries dependence on conventional sources is still much more than its dependence on RE. But, Indian government has lately started to reform the energy sector of the country that favours RE. With the establishment of SERC and CERC, introduction of Electricity Act 2003, NEP 2005 and NTP 2006, government of India is trying to augment the scope of RE in Indian energy industry. Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) is also an initiative of the government in order to penetrate the rural areas of the country. Jawaharlal Nehru National Solar Mission (JNNSM) has also been started in order to increase the contribution of solar power in India which can be a big changing factor considering India geographical position and the concentration of rural population in areas receiving high sunshine. All these steps are taken keeping in mind the two fundamental points:

- Increase rural electrification in order to further escalate the growth of Indian economy.

- Change from conventional sources of power to non-conventional sources so as to reduce dependence on fossils.

A bottom-up method of power reform enables capacity from independent and industrial sources, which will best harness the financial and engineering resources of the Indian electricity supply industry (ESI), and differs from top-down methods in that it encourages non-incumbent actors to enter the ESI instead of relying on existing players or assets to begin competing against each other. The solution proposed is not put forward as an optimized policy prescription, but instead represents the best of the feasible options available within current political and economic constraints.

1.2 Energy needs

Meeting the world growing need for energy will require more than $48 trillion in investment in energy supply over the period to 2035, according to a special report released by the International Energy Agency (IEA).

According to the IEA, today's annual investment in energy supply of $1.6 trillion needs to rise steadily over the coming decades towards $2 trillion. Annual spending on energy efficiency, measured against a 2012 baseline, needs to rise from $130 billion today to more than $550 billion by 2035. Investment decisions are increasingly being shaped by government policy measures and incentives. While many governments have retained

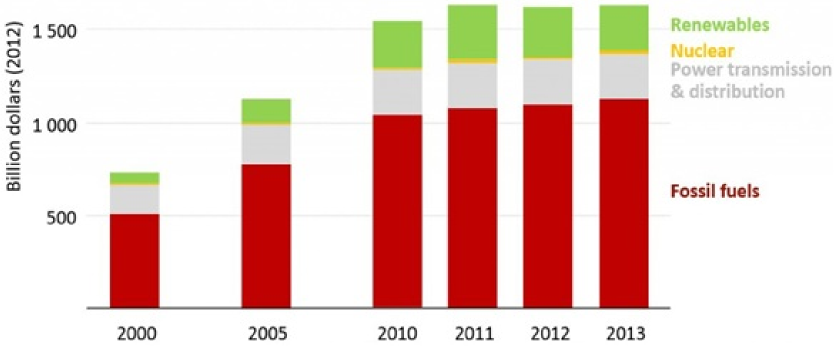

Figure 1.1: Annual energy supply investment. (Credit: OECD / IEA, 2014)

direct influence over investment in energy supply, some stepped away from this role when opening energy markets to competition: many of these have now stepped back in, typically to promote the deployment of low-carbon sources of electricity. In the electricity sector, administrative signals or regulated rates of return have become, by far, the most important drivers for investment: the share of investment in competitive parts of electricity markets has fallen from about one-third of the global total ten years ago to around 10% today.

Policy makers face increasingly complex choices as they try to achieve progress towards energy security, competitiveness and environmental goals. These goals would not be achieved without mobilizing private investors and capital, but if governments change the rules of the game in unpredictable ways, it becomes very difficult for investors to play.

Of the cumulative global investment bill to 2035 of $48 trillion in the report's main scenario, around $40 trillion is in energy supply and the remainder in energy efficiency. Of the investment in energy supply, $23 trillion is in fossil fuel extraction, transport and oil refining; almost $10 trillion is in power generation, of which low-carbon technologies - renewable ($6 trillion) and nuclear ($1 trillion)- make up the lion's share; and a further $7 trillion in transmission and distribution. More than half of the energy-supply investment is needed just to keep production at today's levels, that is, to compensate for declining oil and gas fields and to replace power plants and other equipment that reach the end of their productive life. The $8 trillion of investment in energy efficiency is concentrated in the main consuming markets, the European Union, North America and China: 90% is spent in the transport and buildings sectors. Energy demand is expected to increase considerably

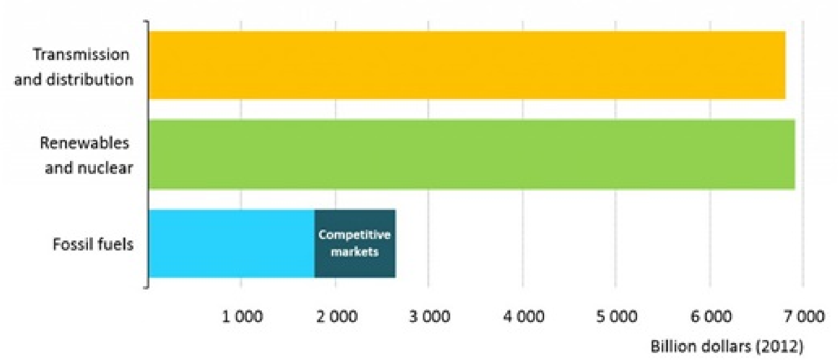

Figure 1.2: Power sector investment, 2014-2035. (Credit: OECD / IEA, 2014)

in the coming years as the result of population growth and economic development (EIA, 2007). Many people in the world are currently experiencing dramatic shifts in lifestyle as their economies make the transition from subsistence to an industrial or service base. The largest increases in energy demand will take place in developing countries where the proportion of global energy consumption is expected to increase from 46 to 58 percent between 2004 and 2030 (EIA, 2007). Figure 1.3 shows the Annual Per Capita Electricity Consumption, Source: IEA World Energy Outlook 2009 Figure 1.4 shows the Electricity

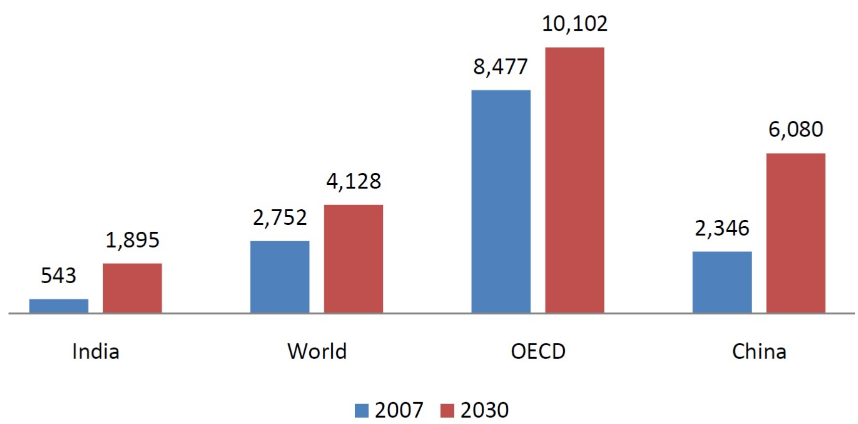

Figure 1.3: Annual Per Capita Electricity Consumption

Production vs. Consumption by Country (2012) Figure 1.6 shows the Demand/Supply Forecasts for India. The electricity sector in India had an installed capacity of 245.394 GW as of end April 2014, the world's fourth largest. Captive power plants generate an additional 39.375 GW. Non Renewable Power Plants constitute 87.55% of the installed capacity, and Renewable Power Plants constitute the remaining 12.45% of total installed

Production vs Consumption by Country.jpg

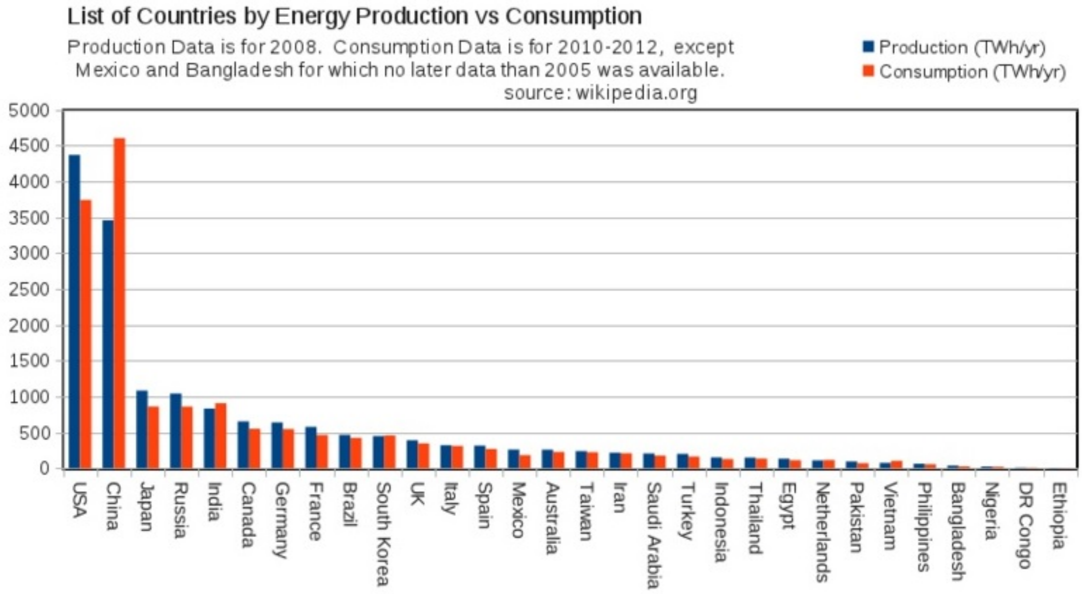

Figure 1.4: Electricity Production vs. Consumption by Country (2012)

Capacity. India generated around 911 BU (911,652 MU i.e. 911 TWh) of electricity (excluding electricity generated from renewable and captive power plants) during the 2012-13 fiscal. The total annual generation of electricity from all types of sources was 1053.9 TeraWatt-hours (TWh) in 2012.

In terms of fuel, coal-fired plants account for 59% of India's installed electricity capacity, compared to South Africa's 92%; China's 77%; and Australia's 76%. After coal, renewable hydropower accounts for 17%, renewable energy for 12% and natural gas for about 9%.

In December 2011, over 300 million Indian citizens had no access to frequent electricity. Over one third of India's rural population lacked electricity, as did 6% of the urban population. Of those who did have access to electricity in India, the supply was intermittent and unreliable. In 2010, blackouts and power shedding interrupted irrigation and manufacturing across the country. States such as Gujarat, Madhya Pradesh and others provide continuous power supply. The per capita average annual domestic electricity consumption in India in 2009 was 96 kWh in rural areas and 288 kWh in urban areas for those with access to electricity, in contrast to the worldwide per capita annual average of 2600 kWh and 6200 kWh in the European Union. India's total domestic, agricultural and

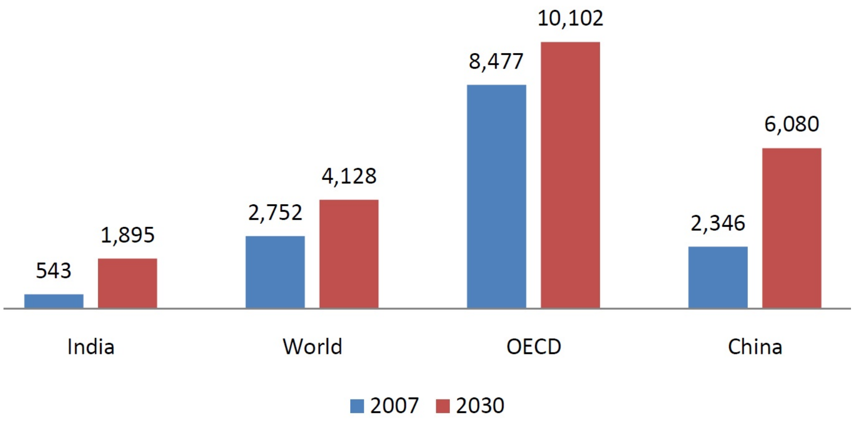

Figure 1.5: Demand/Supply Forecasts for Developing Countries, Source IEA world Energy Outlook 2009

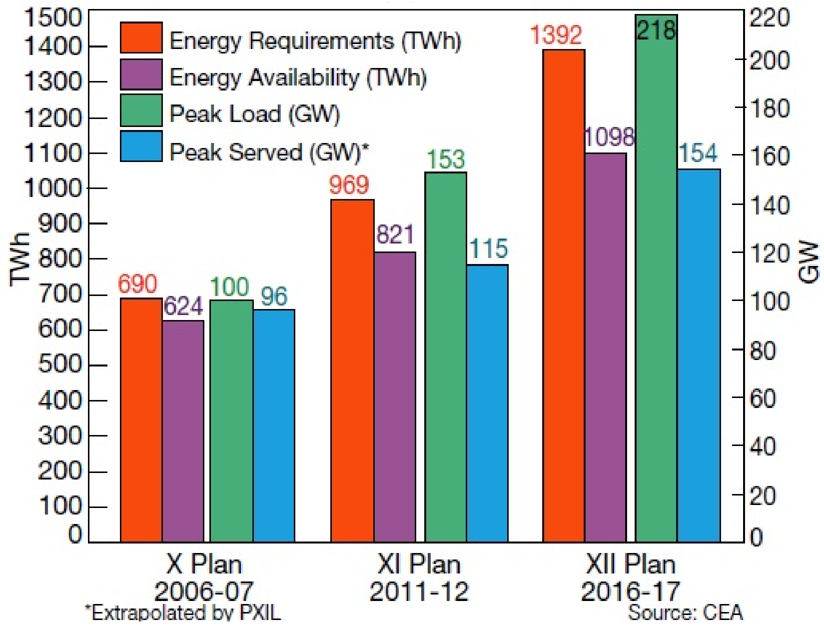

Figure 1.6: Demand/Supply Forecasts for India

industrial per capita energy consumption estimate varies depending on the source. India currently suffers from a major shortage of electricity generation capacity, even though it is the world's fourth largest energy consumer after United States, China and Russia.

The International Energy Agency estimates India will add between 600 GW to 1200 GW of additional new power generation capacity before 2050. This added new capacity is equivalent to the 740 GW of total power generation capacity of European Union (EU-27) in 2005. The technologies and fuel sources India adopts, as it adds this electricity generation capacity, may make significant impact to global resource usage and environmental issues.

Energy needed @ 8% & 9 % GDP growth

Year/GDP	Billion kWh		Installed Capacity (GW)	
	8%	9%	8%	9%
2006-07	700	700	140	140
2011-12	1029	1077	206	215
2016-17	1511	1657	303	331
2021-22	2221	2550	445	510
2026-27	3263	3923	655	785
2031-32	4793	6036	962	1207

Figure 1.7: Energy Needed w.r.t GDP for India

India electricity sector is amongst the world's most active players in renewable energy utilization, especially wind energy. As of December 2013, India had an installed capacity of about 29.5 GW of renewal technologies-based electricity, exceeding the total installed electricity capacity in Austria by all technologies. India's network technical losses are 23.65% in 2013, compared to world average of less than 15%. The Government has pegged the national T&D losses at around 24% for the year 2011 & has set a target of reducing them to 17.1% by 2017 & to 14.1% by 2022. A high proportion of non-technical losses are caused by illegal tapping of lines, and faulty electric meters that underestimate actual consumption also contribute to reduced payment collection. Key implementation challenges for India's electricity sector include new project management and execution, ensuring availability of fuel quantities and qualities, lack of initiative to develop large coal and natural gas resources present in India, land acquisition, environmental clearances at state and central government level, and training of skilled manpower to prevent talent shortages for operating latest technology plants.

Electricity has become the lifeblood of the modern world, without which the world will come to a virtual standstill. Any sluggishness in the growth of the power sector can throw the region far behind other regions in industrial, economic and social growth.

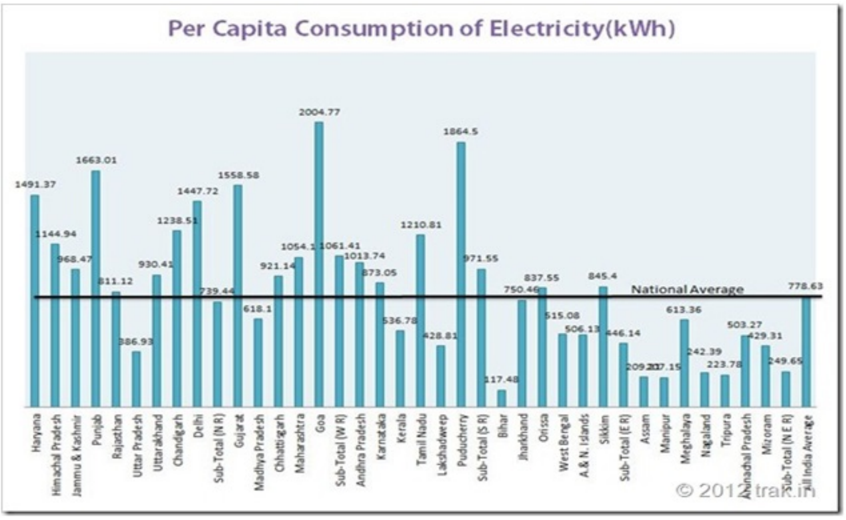

Figure 1.8: Per capita Energy consumption, Source: IEA World Energy Outlook 2009

Thus, power has been recognized as one of the key factors of infrastructure for a sustained growth of the state economy. Electricity is a primary input factor for the progress of the economy of the state. Full utilization of other input factors, such as manpower, land including irrigation and capital-related resources heavily depend upon the uninterrupted availability of electricity. Electricity has therefore, become the most essential factor in improving the social conditions and welfare of people.

Over a period of time, Industrial growth has been so fast that the increase in energy supply could not maintain an equal pace. The major problems faced worldwide are fast depletion of non-renewable energy sources, increasing costs for energy, and inability to create sufficient returns for investment for growth. These problems have created a shortage of power in both quantity and quality. Power sector was mainly treated as a Government business worldwide, considering its importance as a vital infrastructure for the growth of the state. But growth in this sector, however impressive it was, looked insufficient to cope with the impulsive growth in industrial and other sectors. In UP's perspective, there had been no substantial augmentation in the state power generation capacity till the 1990s. Power has been the bane of UP's industry, with the current demand-supply gap widening to almost 3,000 MW. The current demand in the state is estimated at 10,000 MW.

Taking it as a cue, the Government of UP has formulated UP Power Energy Policy 2009 for in-creasing the role of public private partnership in generation, transmission and distribution, in addition to the work already being carried out under State sector. The Government is slowly but surely inching ahead towards the development of Power sector with the help of private sector through Public Private Partnerships (PPPs), joint ventures, memoranda of understanding and co-generation by sugar mills.

In this backdrop, during the fiscal 2011-12, the Government has proposed budgetary provisions of Rs. 8,227 crore towards various projects in the power sector. Out of this amount, Rs. 1,267 crore has been earmarked for augmenting the generation capacity in the state. An amount of Rs. 200 crores has been proposed to be set aside for thermal power project being set up at Ghatam-pur, Kanpur in a joint collaboration with Neyveli Lignite Corporation Limited.

The Government has envisioned to meet out the power demand fully across the state by the year 2014, and to increase the annual per capita consumption power up to 1000 units, the Government has taken many pro-active measures in Generation, Transmission and Distribution sectors.

1.3 About Uttar Pradesh

Uttar Pradesh, the land of opportunities is widely acknowledged for its multi hued culture, religion, natural resources and variety of geographical land. Uttar Pradesh is a steadily growing state at around 6% during the last decade.

With large span of agrarian fertile planes and diverse agro climatic conditions, agriculture is one of the most important and thrust areas of the economy of Uttar Pradesh. Uttar Pradesh is the largest producer of food grains and sugarcane in India. The major crops grown in the state are paddy, wheat, sugarcane, potato, mustard, groundnut, gram, pea and lentil. The state carries immense potential for food processing industries, which has been profitably undertaken in the state.

The scenario of industrial investments in the state is quite encouraging. With availability of large skilled and semi skilled workforce coupled with good infrastructure, friendly policy framework and a conducive environment for private investments, Uttar Pradesh is one of the most attractive destinations for investors and entrepreneurs. The state has set up several industrial estates. The key industries are IT, textile, cement, vegetable oils, sugar, cotton yarn, jute, carpet, brassware, glassware and bangles.

Uttar Pradesh has a great potential in handicraft sector and it accounts for 60% of the total exports from the state. The state has emerged as a hub for IT and ITES industries including software, BPOs and electronics. The major export items from the state are marble products, textiles, handicrafts, art pieces, gems and jewellery, textiles, electronics, software, computer, hardware & software, apparel, brass work, silk, leather and leather goods, glass items, art metal, chemicals and many others.

The economic agenda of the Uttar Pradesh focuses mainly on food industry, biotech, IT and tourism. The state has been able to attract both domestic and foreign investments in different sectors of the economy and have promoted Public Private Partnerships in big way in various sectors such as power, roads, expressways, education etc.

Uttar Pradesh has immense potential to emerge as one of the most economically developed state in India. The state offers a wide range of subsidies, fiscal and policy incentives, industry friendly policy framework to provide conducive milieu to foster investments and industrial growth coupled with availability of skilled and semiskilled workforce, attractive incentives and a responsive and prompt public delivery system.

The state is keen to improve the industrial infrastructure and has emerged as a hub for IT and ITES industries including software, captive business process outsourcing, and electronics. six strategic Thrust Areas for the state of Uttar Pradesh have been defined. It is shown in Table 1.1.

Uttar Pradesh has developed itself as an industrial hub of North India and it has potential to grow at an even better pace. The economy of Uttar Pradesh has undergone several changes which have come about with collaborative efforts of the government and other stake holders. It is all set to scale new heights to emerge as a strong economy with sustainable and inclusive growth, going forward.

Agro & food processing industry	• Largest producer of food grains and sugarcane • Leading producer of farm commodities such as vegetables, wheat, potato and milk. • Diverse agro climatic conditions. • Conducive policy for Food Processing Industry. • Exemption from tax/cess/duty on inputs used in production of export goods. • Exemption of electricity duty for food processing units. • Operational food parks at Varanasi, Gorakhpur, Saharanpur and Barabanki. • Lucknow is known as the biotechnology city of India and has established.
Biotechnology	• Biotechnology Research Park at Lucknow. • Single window facility and relaxation of taxes on biotechnology based products. • 100% relaxation on registration fee and stamp duty for biotech units. • Uninterrupted power supply for biotech units with a capital investment of more than Rs. 10 crore.
Khadi and village industries	• Marketing Development Assistance Programme aids in facilitating the marketing of products. • Mukhya Mantri Gramodyog Rojgar Yojna and Skill Upgradation Training • Programmes have been sanctioned to facilitate the sector.

Handicrafts	• Significant share in exports from the state • Immense potential to be an exporting hub • Moradabad SEZ for handicrafts • Handicrafts Training Programme for artisans • Pension schemes for distinguished artisans • Software Technology park at Kanpur.
Information technology	• Noida SEZ for facilitating the exports of electronics software • Proximity to national capital, Delhi • Functional SEZ- Wipro Technologies Ltd at Greater Noida, HCL Technologies Ltd and Seaview Developers Ltd. at Noida • 100% exemption from payment of stamp duty and registration fees for IT units and call centres • Preferential allotment of land • Large pool of trained human resources in rural areas.

Table 1.1: The Key strategic thrust areas

Uttar Pradesh is poised for a high growth in coming years. The state has been able to pull huge investments in the recent years due to favorable government policies. The state aims to promote Public Private Partnership to boost infrastructure, industrial and social development.

- Heartland of India, Uttar Pradesh is the country most populous state.
- One-sixth of the National population, or 200 million people, as per the 2011 Census.
- The state has a population comparable to Brazil.

Figure 1.9: Map of Uttar Pradesh

- Only four countries namely China, USA, Indonesia and Brazil have a population higher than that of Uttar Pradesh.

- Population density of 828 people per square kilometer.

- UP is also one of the densest states in India.

- Out of the 200 million population of the state Nearly 78 percent lives in rural areas across nearly 100,000 villages.

- According to the 2011 Census, UP also has the largest rural population in India.

1.3.1 Power Sector in Uttar Pradesh

Uttar Pradesh regularly experiences power crises because demand for electricity frequently exceeds supply significantly. Over the last 20 years power shortage has remained within the range of 10-15%, while shortages in periods of peak demand reaches at even higher levels. In 2013, even a gap of up to 43% opens up between the state's demand and supply of electricity. As per figures presented in the Power Ministry's review meeting in March, the state's projected demand for summer 2013-14 is 15,839 MW showing a gap of 6,832 MW. This results in poor and unreliable power supply with rampant power cuts and prolonged periods of low voltage. As a consequence industrial investment in Uttar Pradesh has been constrained, with industries preferring to locate themselves elsewhere.

This situation also repeatedly forces the UP government to purchase power for high prices from other states in India. In 2011 for example the UP government bought power at rates as high as Rs 17 per unit from the central pool to ensure adequate supply in the state. This practice regularly incurs significant financial losses to the State Electricity Board, which (in part) have to be borne by the UP state government, constraining the state's expenditures in areas social development such as education and public health. In 1999 the UP government tried to address the problems of growing power shortage and poor financial condition of the State Electricity Board (SEB) by reforming UP's power sector. The power sector was restructured in order to unbundle and privatize it. Accordingly the SEB has been divided into three independent cooperation's: UP Power Corporation Limited (UPPCL), UP Rajya Vidyut Utapadan Nigam (UPRVUNL) and UP Jal Vidyut Nigam (UPJVNL) - responsible for transmission and distribution, thermal generation, and hydro generation, respectively. Another distribution company, Kanpur Electricity Supply Company (KESCO) was formed as a 100% subsidiary of UPPCL.

However, the UP Electricity Reform Act, formulated in 1999, had several shortcomings, which is a major reason for the problems of the UP power sector to persist until today. Besides not curtailing the enormous powers of the Uttar Pradesh Energy Regulatory Commission by making it accountable, and besides omitting the promotion of efficiency and energy conservation, the act did not address the main reasons for the financial problems of the SEB: High cost of power purchase in relation to the lower tariffs for consumers, which are determined by the UP government (no tariff adjustment), and arbitrary depreciation methods. Additionally, the unbundling of the power sector was limited and did not lead to competition.

Energy Capacity

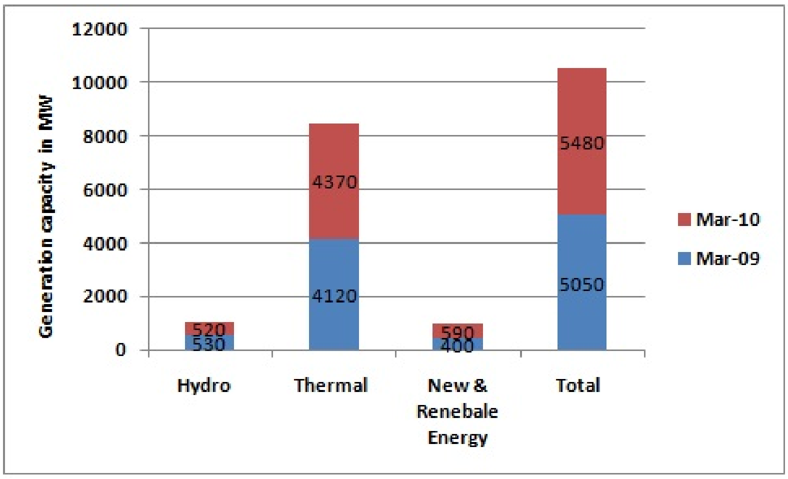

Figure 1.10: Installed generation capacity in March 2009 and 2010 in MW

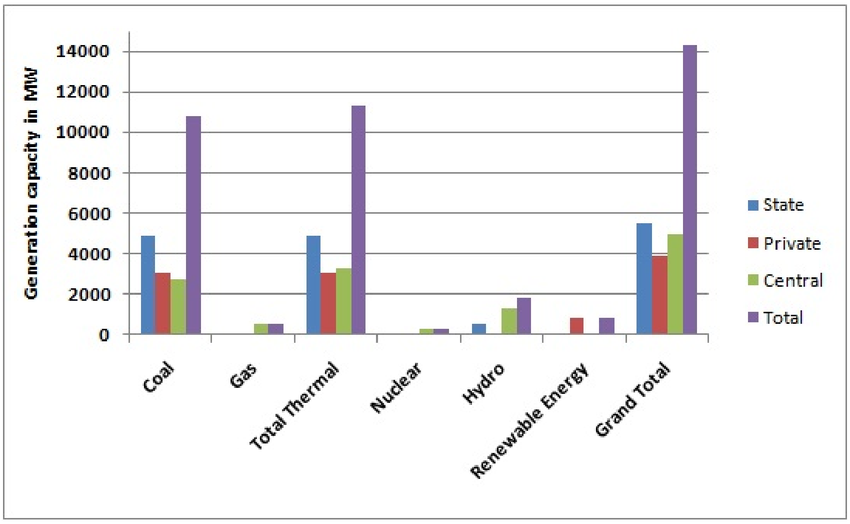

Figure 1.11: Installed generation capacity by sector in March 2013 in MW

Energy Consumption

In 2009-10 the average per capita energy consumption in UP amounted to 387 KW/h, while the country's per capita energy consumption stands at 734 KWh in 2008.

Energy Supply

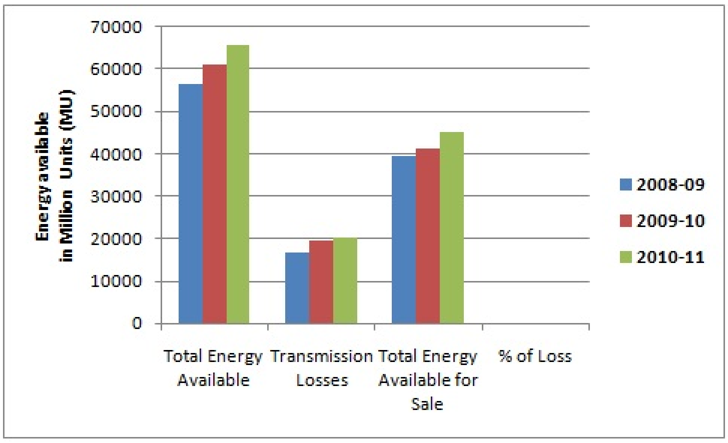

Figure 1.12: Total Energy available for sale in Million Units (MU)

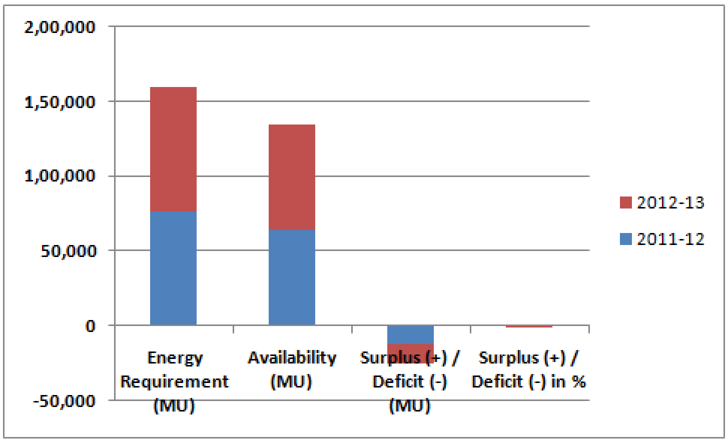

Figure 1.13: Electricity Consumption by Sector

High transaction and distribution losses (T&D) are boosting the yearly deficits. In 2009 UP reported distribution losses of about 38%, which are higher than the national average TD loss of 25.4%.

Rural Electrification

In 2007 about 89% of households have been un-electrified, while the number indicated

Year	Energy Requirement (MU)	Availability (MU)	Surplus (+) / Deficit (-) (MU)	Surplus (+) / Deficit (-) in %
2011-12[13]	76,292	64,846	-11,446	-15
2012-13[14]	83,938	70,058	-13,880	-16.5

Table 1.2: Demand and Supply in Million Units (MU), and gap between those figures in %

Year	Peak Demand in MW	Peak Supply in MW	Surplus (+) / Deficit (-) in MW	Surplus (+) / Deficit (-) in %
2012-2013	13,940	12,048	-1,892	-13.6

Table 1.3: Peak Demand and Peak Supply

Year	Total Number of Villages	Number of Villages Electrified	In%
2009-10	97942	86450	88.3

Table 1.4: Number of Villages Electrified

that only about 40% of the villages in UP have not been electrified.This indicates that also today the number of un-electrified households is likely to be much higher than the number of un-electrified villages.

1.3.2 Generation

During 11th Five year plan, many initiatives have been taken, which includes:

• Power plants of 600 MW in Rosa and 600 MW in Anpara (Unit-I) have already been commissioned.

• Several other Power plants of the aggregate of 3030 MW are scheduled to be commissioned by March 2012 which include:

- 2 × 250 MW Harduaganj Extension

- 2 × 250 MW Parichha Extension

- First 500 MW unit of Anpara D under state sector

- 1 × 600 MW Anapara C Thermal Extension (Unit-II)

- 4 × 82.5 MW Shri Nagar Hydro

• Power plant of 450 MW co-generation in sugar mills is being commissioned under private sector.

- The work for 3×660 MW Bara Thermal Power Project and 2×660MW Karchhana Thermal Power Project have been entrusted to private developers and work has already commenced.

- The work for 2×660 MW Mega Thermal Power Project (Allahabad) is also underway in Joint Sector with NTPC and UP Rajiya Vidyut Utpadan Nigam Ltd.

By the end of 11th Five Year Plan, it is hoped that the state would get 2000 MW from the state-run projects, 2130 MW from the private sector, 450 MW from MOU route projects and 1571 MW from various projects being implemented by the central agencies.

Under 12th Five year plan (April 2012 - March 2017), the Government of U.P. has planned for 25000 MW capacity additions. This envisage capacity addition of 5000 MW under State/Joint sector, 15000 MW under Private sector and 5000 MW to be procured through competitive bidding, by which power can be supplied from any power project located in any State of the country.

As on date, bid process for 2×660 MW Jawaharpur Thermal Power Project has already been initiated. Consultant has been identified and the bidding process for selection of developer is underway for 3x660 MW Sonebhadra Thermal Power Project. The selection of consultant for 2000 MW Yamuna Expressway Thermal Power is also under process. Department will provide land, coal linkage, water linkage and environmental clearance to the developer and power will be purchased on levelised tariff through competitive bidding. Further, Government of U.P. has signed MOU(s) with the developers for 3×660 MW Lalitpur Power Project and 2x660 MW Bhognipur Power Project (District Ramabai Nagar).

1.3.3 Transmission

At present UP has a transmission network to cater about 8000-10000 MW of power. To cater the enhanced generation by the end of 11th plan, UP transmission system is being augmented to evacuate 15000 MW of power. Accordingly, transmission development programme has been worked out and numbers of 765 KV/ 400 KV/ 220 KV/ 132 KV sub-stations and associated transmission lines are under construction.

These includes sub-stations of 765 KV (3 in numbers), 400 KV (9 in numbers) along with associated transmission lines under public private partnership model for evacuation of power from 3×660 MW Bara, 2×660 MW Karchhana and 3×660 MW Mega Thermal Power Projects.

Apart from above, sub-stations of 765 KV (2 in numbers), 400 KV (3 in numbers), 220 KV (24 in numbers) and 132 KV (54 in numbers) are to be constructed under State sector.

Figure 1.14: Line Loss % in Uttar Pradesh, Sources: UP Power Corp,2009

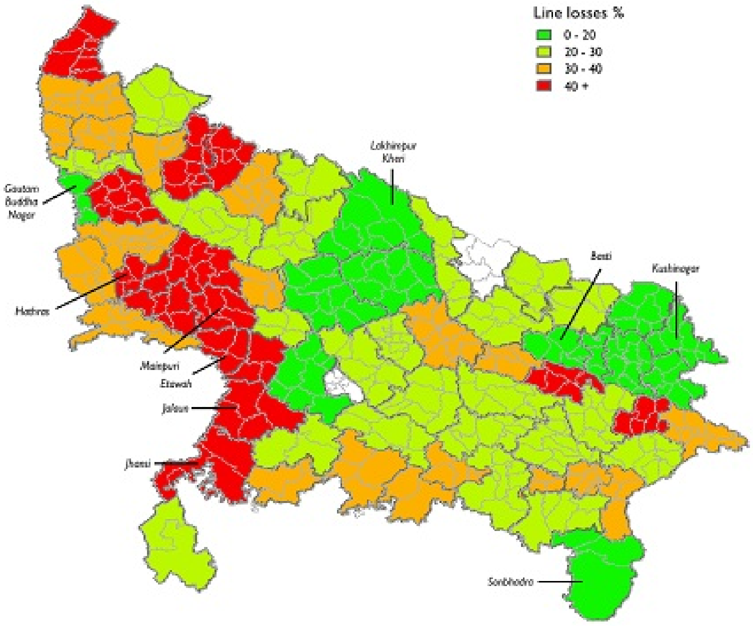

Figure 1.14: Line Loss % in Uttar Pradesh

1.3.4 Distribution

In order to improve the performance of the power sector, and for bringing financial and operational independence, besides creating conditions for competitive and self sustainable developments of the power sector, Government of India has enacted Electricity Act 2003 with effect from June 2003. Govt. of UP has had undertaken an input-based franchisee distribution model in cities like Agra and Kanpur for economizing on power. While the distribution system in Agra has already been handed over to a private partner M/s Torrent Power Ltd. with effect from 01.04.2010, things are moving in a similar direction for Kanpur. The process would soon be rolled out in nine other towns.

With an aim to attract more and more companies to participate in open bid for the selection of input based franchisee, UPPCL will provide the following facilities to the prospective distribution franchisee :

- Distribution franchisee can use utilities distribution assets

- Distribution franchisee can utilize other services of utilities such as testing facility of HT/LT between switching / sub-stations and distribution transformer and/or other technical assets.

- Utility shall provide inventory of first three months.

- Utility shall ensure the supply of power to the distribution franchisee.

- Utility shall allow distribution franchise to purchase power through open access.

To augment distribution system, 202 numbers of new 33/11 KV sub-station are under construction and 174 numbers are under planning stage.

It is certainly not the end here, the Government is mulling all available options and relentlessly striving hard in making U.P. a power surplus state, to create an industry friendly ambiance so as to compete in true sense with all the peer states across the country and also enshrine U.P. among the most developed states within the country and globally as well. The mission may seem difficult but is surely not impossible once the people of the state from all walk of life shall also be determined and join their hands to bolster every initiatives taken by the Government for the better future prospects of the state so that the benefits of development may reach the doorsteps of every citizen of U.P.

1.4 Rationale and Motivation

The Indian government is struggling to supply its industrial, residential and commercial sectors with power. The government has conceded that it can no longer fund infrastructure investments in electricity, nor can it afford to continue subsidizing residential, agriculture and commercial customers. The power sector is virtually bankrupt as a result of protracted mismanagement and political interference.

The impact of the power sector reform model is even more acute in developing countries where implementation of the top-down liberalization approach is frequently pursued without adequately taking account of the socio-political and economic environment. Typically, the electricity grid coverage in most developing countries is both too small and too weak to supply the hundreds of millions of people who live without access to electricity supplies; even if it could, the availability and reliability of generating capacity is often far below that necessary to meet potential demand.

Both DG and CPP capacity in Uttar Pradesh (and India more broadly), is an under-utilized potential source of electricity for the many power-starved regions of the country. High industrial tariffs create an arbitrage opportunity for low cost power to enter the market, but regulators are under heavy pressure to protect the state electricity boards (SEBs) and to fund the give away of low cost or free power to rural areas. DG will only prosper in rural areas if SEBs stop providing free or heavily subsidized power to rural consumers.

1.5 Business Problem

Performance of UPSEB has been poor compared to many other Boards in India. At nearly 50% Plant Load Factor (PLF) of the state sector thermal plants has been one of the lowest. The national average figure for PLF is about 67% and NTPC figure 83%.

Position of UPSEB in transmission and distribution areas has also poor, T&D losses are high at about 40%.

With above situation, it is challenging to have efficient electricity supply system in terms of quality and availability to support the economic development of the state of Uttar Pradesh.

1.6 Contribution of the study

This thesis argues, using a study from Kanpur, Uttar Pradesh, India, for an alternative approach to leverage the captive power capacity (self-generation) of industry to reshape the generation and distribution sectors from the bottom-up. The evidence demonstrates that captive power plants (CPP) and distributed generation (DG) are well positioned to both add capacity to systems struggling to meet demand and increase competition in the power market.

The bottom-up reform approach proposed in this thesis has been developed through a critical analysis of the Indian ESI, with a particular focus on the state of Uttar Pradesh. The case example is used to demonstrate that the bottom up appropriate model can be adopted as an alternative against current to provide a better path going forward. The primary objective of this thesis has been to establish the feasibility of a bottom up approach to liberalization of electricity markets for Uttar pradesh. This has been achieved by studying the options for and impact of small-scale distributed generation and captive power plants. Moreover, the weakness of the physical grid, the lack of generation capacity, lack of autonomy for any new regulator, heavy subsidization of prices, tacit agreement condoning theft of power, weak legal systems, and poorly defined land rights are major barriers to reform. If not addressed, they are very likely to inhibit ESI growth and ultimately lead to the failure of the ESI reform process itself.

This demonstrates the advantages of using DG and CPP in a bottom-up model to change the demand and supply functions and introduce an element of real competition to the Uttar Pradesh state electricity board (SEB).

1.7 Thesis Structure

The thesis begins in Chapter 2 with a literature and theory review of power sector reform around the globe. Electricity reform programs have been started in many developing countries as a result of internal and external forces. This chapter reviews the various approaches to reform programs and examines the challenges to the top-down or standard prescription for electricity supply industry (ESI) reform. To add further context to a bottom-up approach, Chapter 2 details the policies used in other developing countries to enable large and small private power systems. In many cases, industrial and remote users then must take the situation into their own hands. This chapter looks at several developing economies power sectors and examines the structure of the ESI and how DG and CPP have fit within their development plans.

In Chapter 3 the study's methodology is detailed. Chapter 4 talks about the data collection and data analysis respectively. A combination of qualitative interviews conducted during fieldwork as well as quantitative methods are used to examine the research questions. In undertaking any study, one of the most difficult issues faced by all social science researchers concerns their claims to knowledge and understanding. If it is possible to attain such knowledge, what methods of gathering data about the world ensure an accurate representation of reality? Once the data have been gathered, we are then faced with the twin problems of analysis and interpretation, followed by the challenge of presenting these data in our findings. It quickly becomes clear that every stage of the research process, from the initial design to data collection, analysis and interpretation is fraught with challenging considerations.

Chapter 5 details about the feasibility of Distributed generation for the state of Uttar Pradesh. Feasibility approach is taken with consideration of factors like Market and Demand, Financial , Technical, Social Cost and Ecological. It also unwraps about political economy expectation for distributed generation. This details the reasons why Distributed Generation is encouraged Worldwide. The importance of Electricity cost is discussed in detail with global experience. It also shares expectation as a part of Government responsibilities. This also identifies the points which can be applied to Uttar Pradesh. This chapter talks comprehensively on the policy expectation, sustainability and economic impact of Distribution. Energy loss reduction is a key to success for the Uttar Pradesh ESI and this is elaborated too here. With details of Impact distributed generation impact on Environment, Social and Technical aspects chapter end with conclusive remarks.

This chapter examines the modeling of distributed generation in a rural and urban area of Kanpur, U.P as an alternative to the top-down development model led by state or federal power companies. Numerous renewable and small-scale DG technologies have now progressed to the stage where their technical feasibility has been proven and full-scale projects have been successfully implemented worldwide. This chapter surveys the available DG technologies and models their economic performance in areas of Kanpur with particular emphasis on comparing the costs of hybrid DG systems with conventional grid connections for remote rural village-level applications. Modeling inputs are based on demand, fuel availability, costs and local operating conditions found in the Kanpur District of U.P, India. Results demonstrate that hybrid power systems can provide electricity in rural areas in an economically feasible manner if local energy resources are adequate (e.g., wind, solar, biomass). Additional environmental and economic benefits of hybrid DG are also quantified for the Uttar Pradesh State. This Chapter gives detailed insight for the operational adoption and sustainability of Hybrid model by way of Franchisee and other recommendations.

The thesis concludes with Chapter 6 where the survey for bottom-up ESI reform is summarized and areas for further research are detailed. With this combination of large and small options, the top-down reform method and the current monopoly structure of the states power supply is challenged from both sides. The chapter explains the advantages of the bottom-up model using captive power and how the approach is well positioned to add capacity to a system struggling to meet demand. The chapter concludes that more power from independent and industrial sources will best harness the financial and engineer resources of the Indian electricity supply industry (ESI) and ultimately benefit the economy.

1.8 Concluding Remarks

The conventional response to low levels of electricity sector investment has been from the top-down with an aim to create competitive electricity markets by encouraging new entry into the generation sector and by breaking up vertically integrated power companies.

This research argues for an alternative approach-utilizes distributed generation (DG) and captive power capacity (self-generation) of industry to reshape the generation and distribution sectors from the bottom-up. This research will examine the technical and political feasibility of distributed generation and captive power for industrial use in Uttar Pradesh, India, taking into account the economic, technical and political factors that shape investment decisions.

This thesis has direct implications for reframing the theoretical debate of power restructuring by providing a robust example of how an alternative reform path, the bottom-up approach, can deliver electricity services more effectively than more orthodox top-down reform programs.

Second, there has been no published work on the use of hybrid energy systems in northern India, and no study of the energy situation in Kanpur district of Uttar Pradesh. As a remote rural district, Kanpur has not been part of any published rural energy studies that evaluate hybrid energy system options. This provides a useful addition to both the understanding of Kanpur energy challenges, and also adds to the work done on system selection and design using a mix of fossil and renewable energy technologies.

In the present study optimization and modeling of a hybrid energy system to meet the electrical requirements of a remote area with industrial development has been done. It emphasizes the renewable hybrid power system to obtain a reliable autonomous system with the optimization of the components size and the improvement of the capital cost. This hybrid energy system consists of Photo voltaic array, wind turbine and biomass plant accompanied with battery and diesel generator for emergency backup considering uncertain availability of these weather dependent sources. As a first step, an operational scheme has been organized for measuring the electrical load profile, renewable sources availability, their condition and specifications like solar irradiation, wind rate. Then, the whole system is simulated in Hybrid Optimization model for Electric Renewable (HOMER) environment. Finally, simulation results are presented for the proposed hybrid energy system and economical, environment aspects for the same have been discussed.

CHAPTER 2

Review of Literature

2.1 Overview

The evolution of power systems in developing countries, like developed countries has been extremely varied. Within developing countries, however, the power structure is generally government owned and operated either as a parastatal agency or within a ministry. In contrast, in the U.S. and a few market economies, the major portion of the power sector is organized along the lines of private ownership with public oversight. In between these two structural forms of public power and private power may be found several other organizational and market-environments within which the power sector functions in these and other countries.

2.2 Drivers of Market Reforms

Deloitte and World Bank/USAID Policy (2004) Paper suggested that Power sector reform in developing market has four major drivers. These drivers have spurred the donor community to launch policies guiding the major initiatives, grants, loans, and conditionally that have become the basic architecture of development assistance not only for infrastructure but for many other sectors. The drivers of reform are outlined below

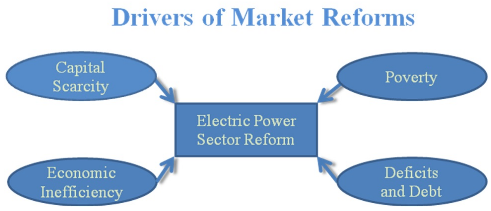

Figure 2.1: Drivers of Market Reforms

Singh et al. (2004) indicated the demand for investment in the electricity sector in the world between 2000 and 2030 is estimated to be USD 9.8 trillion. Developing countries would require more than half of this investment. Given the limited fiscal space for public investment, a number of developing countries have undertaken policy initiatives to improve the investment climate for the private sector. The pace, scope, sequencing and outcome of reform process varies across countries. Vaccaro et al. (2009) rightly pointed that Effective and sustainable energy-planning policies are needed in developing countries to stimulate investment in power-plant modernization and in rationale energy usage. In this connection, the main critical points to address are:

• The electric power industries are among the most capital-intensive in an economy and drain scarce financial resources;

• For countries lacking energy resources, importing fuels is a major drain on foreign exchange reserves;

• Environmental issues, such as the fact that higher levels of carbon emissions go along with economic development, further increase the complexity of energy decision making;

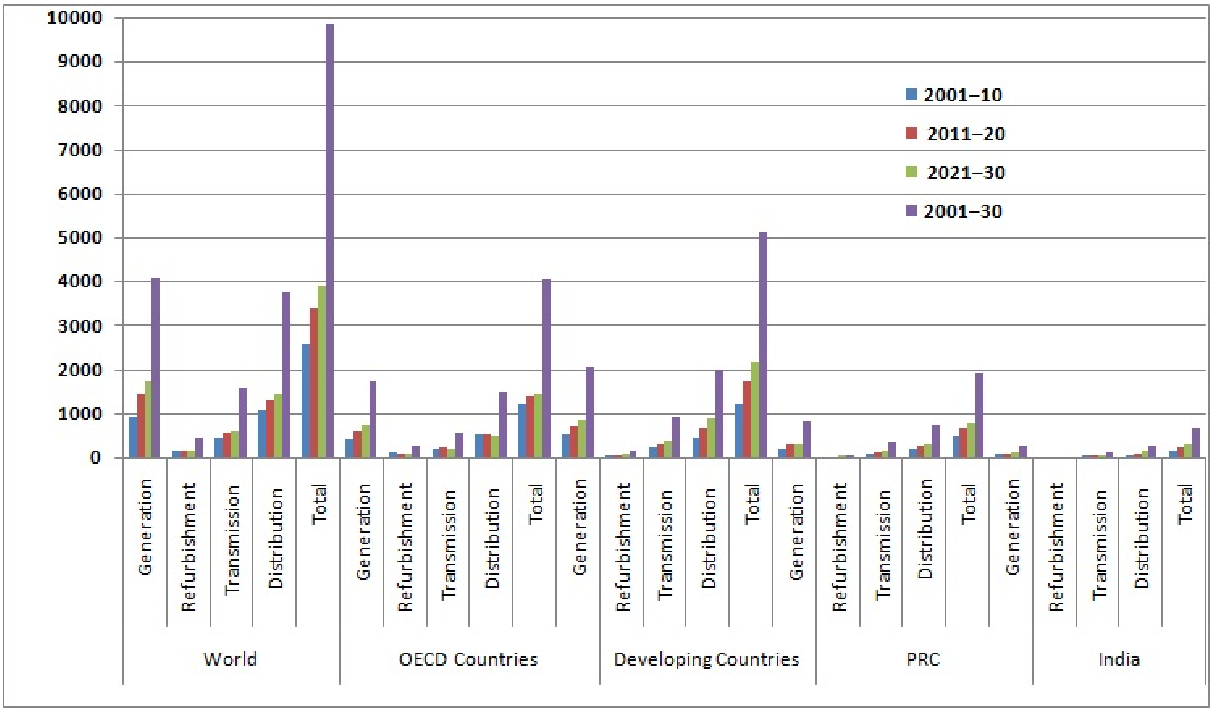

Figure 2.2: Investment Outlook for Electricity Sector (USD billion) Source: IEA (2003a)

Yin - Fang Zhang et al (2008) identifies that over the last two decades electricity sectors in both developed and developing countries have been subject to restructuring to introduce private capital and increase competition. This has been accompanied by the introduction of new regulatory regimes. The effects of such reforms in a number of the developed economies are now well documented. This is important because privatization, competition and the reform of state regulation are key themes of donor aid programes, notably those of the World Bank.

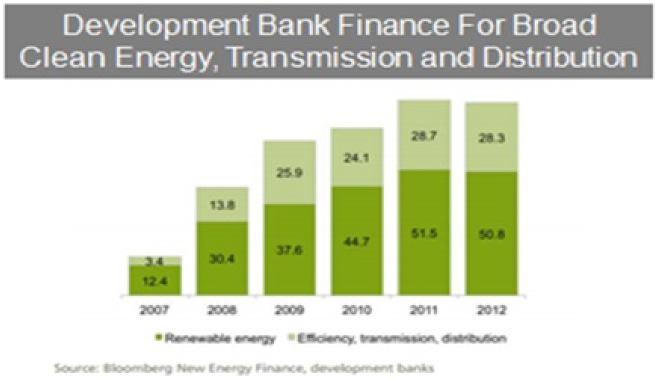

Figure 2.3: Development Bank Finance

John E. Besant-Jones (2004) shared the lessons from experience that power markets in developing countries should be organized to deliver modern energy services to promote poverty alleviation and economic growth, since these are the overriding priorities for these countries. Meeting these objectives requires the provision of reliable electric power services in sufficient quantity to meet affordable demand at the lowest cost, reflecting the resources and impacts involved in their production and transportation. As per World Energy Council, January 2012, the energy availability in India has increased by 5.6% in 2010-11, while the peak demand met has increased by 6% in the same period. Despite the increase in availability, India faced an energy deficit of 8.5% and a peak deficit of 9.8% in 2010-11. It is expected that the energy deficit and peak deficit will rise to 10% and 13% respectively in 2011-121.

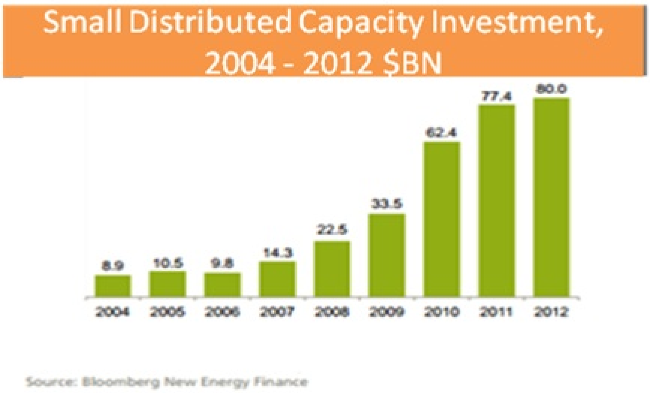

Figure 2.4: Small Distributed Capacity Investment

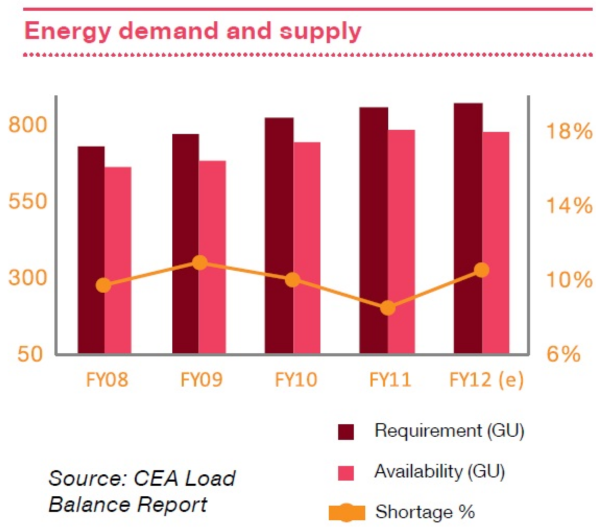

Figure 2.5: Energy Demand and supply

2.3 Global Power Sector Reform

The rationale for the different modes of organization are usually based on a diverse set of considerations ranging from economic, social, legal, and financial to political and ideological. Considerable differences in performance also exist, where the degree of success achieved by the power sector in meeting national goals and objectives, also varies substantially.

Changes in the power sector have moved relatively quickly since the first wave of reforms in Chile and the United Kingdom in the 1980s. The reform mantle was picked up by many other OECD countries in the 1990s and soon became part of the World Bank and

IMF orthodoxy, which pushed privatization and reform of the electricity supply industry (ESI) as part of the Washington Consensus. Many lessons of experience can be drawn from

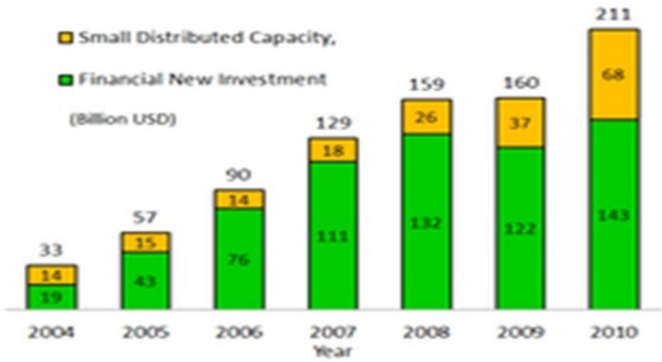

Figure 2.6: Global New Investment in renewable Energy

empirical analysis of the outcomes of reform. Confidence in the findings of the empirical analysis to date about power sector reform, however, is constrained by concerns about the rigour of the methodology used and/or inadequacy of the data (both cross-country and longitudinally over time) available for analysis Jamasb et al. (2004). Furthermore, even the theoretical literature shows differing views about fundamental issues such as the effectiveness of privatization and competition in network industries such as electric power, at least in OECD countries.

Many developing countries-from the very large, such as China, to the very small, such as Bolivia-are adapting reform models to their own needs and circumstances (APEC 2000, Bacon and Besant-Jones (2001), EBRD (2001), World Energy Council 2001b). In fact, during the 1980s Chile became the first country in the world to break up power monopolies, progressively withdraw the state from management - but not regulation - of the electricity supply industry, and divest state ownership in most of them to private investors.

The extensive range of economic and institutional endowments found across developing countries rules out cookbook solutions for reforming power sectors. This lesson applies regardless of the choices made for roles of public and private sectors for power supply (World Bank 2004b). Reform strategies should be adapted to country conditions. But these choices must address a generic set of interrelated challenges: changing the manner in which new investments are financed, increasing the efficiency and development effectiveness of those investments, and increasing operational efficiency, while addressing equity concerns as the power market expands.

The drivers for reform have tended to reflect specific country circumstances, including the various forces that have driven changes in public policy towards power markets within a broader drive for economic reform. In the United States, the passage of the Energy Policy Act of 1992 aimed at fostering competition to enhance efficiency, encourage technological innovation, and lower prices. Criticisms of the inefficiency of rate of return regulation for encouraging gold-plating and cost inefficiency (Averch and Johnson 1962) became decisive in the liberalization movement in the United States.

• In Europe, the desire to bring about a single market in electricity as well as other industries has been a key driver of change. The countries of Eastern Europe have been motivated by the requirements of the European Union's Electricity Directive of 1996 for accession to European Union.

• In much of the developing world, the driving forces have been fiscal pressure, disenchantment with the performance of publicly owned utilities, and the need for new investments and modernization.

• In Britain, privatization was primarily driven by more political motives, to roll back the frontiers of the State and because the business of government is not the government of business. Economists argued that competitive pressures were more likely to deliver cost improvements and hence politically attractive price reductions.

2.4 Indian Power Sector Reform

Following the liberalization and reform of the economy in 1991-92, the electricity sector too witnessed major policy and regulatory initiatives. The sector while it was growing rapidly in the eighties, faced issues of a debilitating and serious nature. Losses especially in distribution were large, efficiencies low, and tariff reform was long overdue. Tariff and subsidy policies, and the leakages that resulted inter from the tariff and subsidy policies severely affected the viability of the sector. India power sector Reform efforts goes through following:

2.4.1 The IPP Policy

The Independent Power Project (IPP) policy was one of the earliest initiatives predating the formation of independent regulators that came about following the stabilization and structural reform of the Indian economy in 1992-93. The idea of using the private sector to add to investments in the electricity sector was meaningful since the state owned enterprises as a whole (and therefore in the electricity sector too) were put on tight leash in terms of the funds they could hope from the central government

2.4.2 Unbundling and Privatization Initiatives by States

Even as the IPP policy was being operationalized, the idea that the inefficiencies of the SEBs could be overcome by unbundling and privatization was pursued. The initiative in this direction came largely from the multilateral agencies including the World Bank and the Asian Development Bank. These agencies besides providing for the services associated with unbundling - consultancy services for laying out the frame work, process consultancy for privatisation, studies to develop financial plans for restructuring etc. also laid out significant amounts by way of low cost loans to the SEBs.

2.4.3 Distribution Losses and CM's Conference in 1996

From post Orissa privatization experience, and studies undertaken by World Bank and others, it became evident that the T&D losses reported by the SEBs were low because assessed consumption for agriculture and elsewhere was estimated at much higher level than what was the reality. The studies indicated that the AT&C losses (losses including commercial theft or non-payment) were higher than 40% in most states. The problem was becoming serious. To address some of these issues and to get the states on board, the first Chief Ministers conference was organized in December of 1996. Later similar conferences were organized in 1998 and 2001.

2.4.4 Independent Regulations: ERC Act of 1998

As the entities got unbundled and the role of the private sector in electricity was set in motion through the IPPs and in one state - Orissa - in distribution as well, the need for independent regulators was obvious since now there was private sector when the state itself had a significant market role. Since electricity was a concurrent subject under the constitutional framework and the authority to set prices was with the state government, the need for regulators at the state level was obvious. The regions rather than the states would have been the more appropriate level for price regulation since the connectivity within the region was thick and some of the states were too small. Under the ERC Act 1998, the centre was to cover tariffs related to interstate movement of power and regulate all entities that operated under one identity across many states (These were the PSUs- NHPC, NTPC, PGCIL and some others).

2.4.5 MS Ahluwalia Committee: Reducing Payment Risks

The core problem of the SEBs not generating sufficient revenue to pay the suppliers of electricity had became serious by the year 2000. The receivables from the SEBs to the NTPC and the CPSUs more generally reached astronomical levels threatening the viability of upstream players including their ability to expand capacities and the network. Being owned by the central government, any threat on the part of CPSUs to supply power to defaulting SEBs, was incredible. The SEBs on their own assets could realize just sufficient to be sustainable on a cash basis but on power purchases from NTPC and NHPC, they could not play the game of cash viability. Their payables to CPSUs had crossed over

Rs. 41,000 crore including more than Rs. 15,000 crore of interest/surcharge. In such a context, an expert group under the chairmanship of Sh. M S Ahluwalia, Member, Planning Commission, appointed by the Government of India submitted its report in May, 2001. The group noted that the dues are not due to problems of the past but because of continuing non-viability of the current operations of SEBs.

2.4.6 Strengthening Distribution Network and Reduction in Distribution Losses APDRP

The Accelerated Power Development Reforms Programme (earlier known as Accelerated Power Development Programme or APDP) was launched in 2002 with the objective of upgradation of sub-transmission and distribution in densely electrified zones in the urban and industrial areas and improvement in commercial viability of State Electricity Boards.

It has two components (i) investment component for strengthening the distribution system, and (ii) incentive component to motivate utilities to reduce cash losses.

2.4.7 Comprehensive Legal Framework for Reforms: The Electricity Act of 2003

The latest legislative salvo in the reform of the ESI is the 2003 Electricity Act (EAct), and allowed each state to set up state electricity regulatory commissions, known as SERCs (the EAct was predated by the more limited in scope 1998 Act that established an independent regulatory commission at the federal level). The process of creating state level regulators moved quickly after passage, and by March 2003, 22 states had formed SERCs and 13 of them had passed tariff orders (ICRAb 2003; MoF 2003). The EAct requires each state to have a SERC that is responsible for determining the tariffs to be charged to different classes of customers and the tariffs for and functioning of intrastate transmission. This duty is further encouraged and spelled out in the EAct with open access and competition in the generation and distribution sector being the two primary goals of the legislation.

By 2009, the Act remained only partially implemented. Litigation continues in individual states against incumbents resisting tariff, surcharge and open access provisions in the Act, e.g. (CERC 2008; CERC 2009).

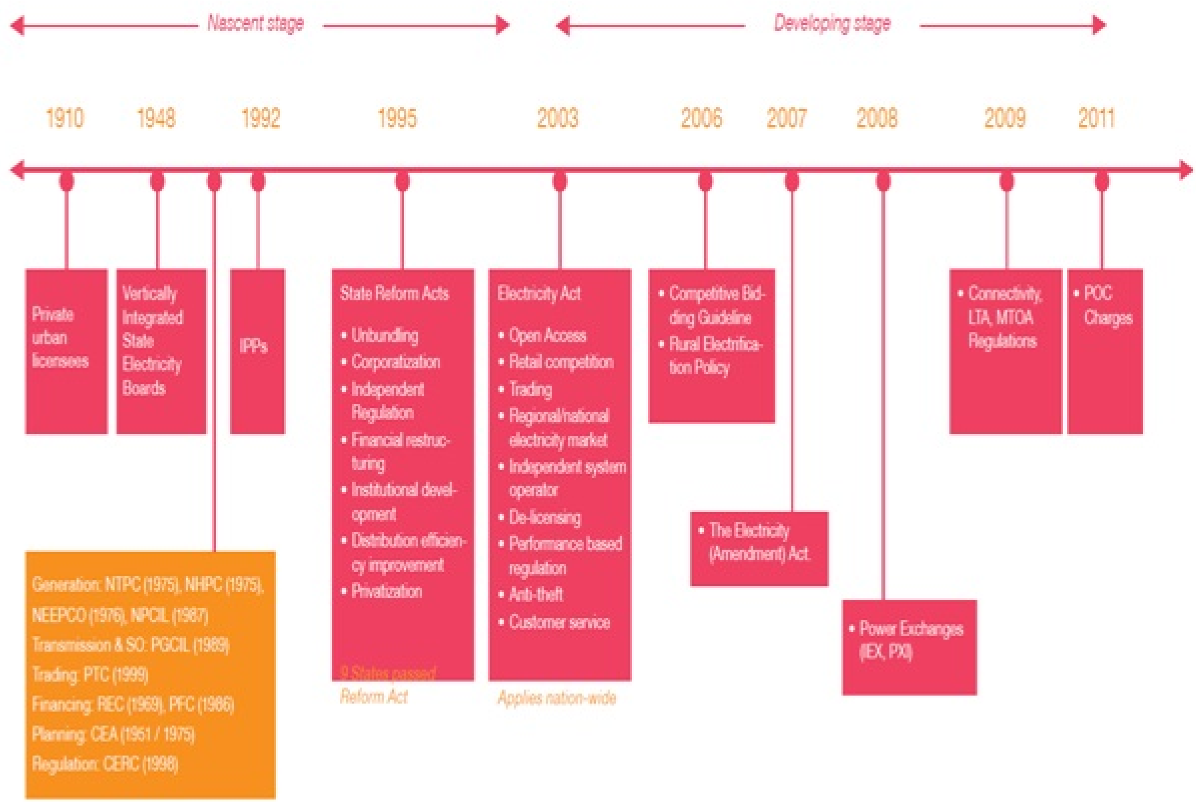

Figure 2.7: Summary of power sector reform in India

2.5 Uttar Pradesh Power Sector Reform

Uttar Pradesh State Electricity Board (UPSEB) was constituted in April 1956 under section 5(i) of the Electricity (Supply) Act 1948. The UPSEB has managing the activities of generation, transmission and distribution of power in the state. As installed capacity of 5,886 MW only 3300MW energy was generated. The State Government was very much concerned about the continuing power shortage and in the year 1999.

Performance of UPSEB has been poor compared to many other Boards in India. At nearly 50% Plant Load Factor (PLF) of the state sector thermal plants has been one of the lowest. The national average figure for PLF is about 67% and NTPC figure 83%. Forced outgoes of thermal stations in 2000 was 25.6% against a national average of 13%.

Position of UPSEB in transmission and distribution areas has also poor, T&D losses are high at about 40% bill collection efficiency is about 78% and uncollected revenue arrears as a percentage of annual sales revenue was 80% against a national figure of 34%. As per the policy document, accumulated commercial losses of the UPSEB as on March 1997 stood at Rs. 7,000 crore (excluding state subsidies) and cash liabilities were to the turn of Rs. 4,200 crore. The net worth of the UPSE is ranged from between Rs. 1,526.25 crore and Rs. 2,685.95 crore during April 1997 to Jan.2000.

UP Reforms Act was prepared in mid 1999 and passed in the assembly in September 99. After the required formalities, the act became effective on 14 Jan. 2000.

2.5.1 Objectives of UP Power Sector Reforms

1. The electricity will be supplied under the most efficient conditions in terms of cost and quality to support the economic development of the state of Uttar Pradesh.

2. Power sector ceases to be a burden to the state's budget and eventually becomes a net generator of financial resources.

3. Protection of Interest of Consumers.

2.5.2 Steps taken in Reform

(i) UPERC established, Power Sector in UP started functioning under regulate regime since June 1999.

(ii) UPSEB unbundled in January 2000 in to three corporations i.e. UPPCL, UP-RVUNL and UPJVNL. Different corporations started functioning commercially.

(iii) First Tariff Revision, step towards rationalization of tariff after reform made effective from 09/08/2000.

(iv) Trust to protect employees terminal benefits established, the first of its kind in reformed structure starts functioning Oct. 2000.

(v) Formation of special electricity courts in all districts and state level court also done. First sitting of all courts on Oct. 22, 2000.

(vi) Transparency in working visible.

(vii) Electronic meter installed at all sub stations and big consumers. Metering of all consumers to be completed by the end of 2001.

(viii) Energy Auditing down-up to consumers level.

(ix) On the spot billing functioning extended to more new areas.

(x) On billing in 20 major towns to start soon.

(xi) Process of strengthing the transmission and distribution system with the help of World Bank Loan started.

2.5.3 Phases of Reforms

A. Phase I : Restructuring and Unbundling of Power Sector

In the first phase, following the effectiveness of the Reform Act and the notification of the first transfer scheme on 14 January 2000 the generation, transmission and distribution functions of UPSEB have been transferred to the following three legal entities (Corporation registered under Indian Companies Act 1956) based on functional specialization, namely : Uttar Pradesh Power Corporation Limited (UPPCL), which is responsible for transmission and distribution of electricity in Uttar Pradesh. Uttar Pradesh Rajya Vidyut Utpadan Nigam Limited (UPRVUNL) which owns and operates the existing thermal power stations of UPSEB. Uttar Pradesh Jal Vidyut Nigam Limited (UPJVNL) which is addition to their own small hydro power houses owns and operates the existing and under construction hydro power stations of UPSEB.

Another Transfer Scheme for unbundling of distribution undertaking of Kanpur Electricity Supply Authority (KESA) of UPPCL and transfer of its assets, liabilities and personnel to Kanpur Electricity Supply Company (KESCO), a company registered under the Indian Companies Act 1956 was made effective on 15th Jan. 2000.

Corporate and Commercialization

Under the reforms, companies to enter into Corporation Agreement with State Govt. and not any interferences of the Govt. in the day today management of new corporations, corporation to be given full autonomy, selection of Directions by a selection committees (nominees from Govt. and recognized institution as member of committee). The new companies plan to implement comprehensive institutional development plans like modification to present accounting system, corporate, financial planning and budgeting, improvement in metering, billing and collection procedures and professionalization of the organization.

Independent Regulatory Body

Under the reforms Act, set up UP Electricity Regulatory Commission Act, 1998 of Govt. of India UPERC are to create a regulatory environment to promote transparency, efficiency and economy in the operation and management of the power utilities, encourage competition and help up to attract private capital for the power sector. The main functions of commission are as below:

(i) Determine the tariff for electricity, wholesale, bulk, grid or retail.

(ii) Determine the tariff payable for the use of the transmission facilities.

(iii) Regulate power purchase and procurement process of the transmission utilities and distribution utilities.

(iv) Aid and advise the state government in matters concerning electricity generation, transmission, distribution and supply in the state.

(v) Issue license for transmission, distribution or supply of electricity and determine the conditions of the license.

(vi) Require licensees to formula plans and schemes for the promotion of generation, transmission, distribution supply or utilization electricity and quality of service and to device proper power purchase procurement process.

(vii) Collect and record information relating to generation, transmission, distribution or utilization of electricity.

B. Phase II : Private Sector Participation :

In this phase the different Generation and Distribution companies will be horizontally divided into number of companies. These companies will ultimately be privatized. After the establishment of the distribution companies may also enter into a PPA directly with the generators and other bulk suppliers.

Privatization of different segment of power sector was one of the reforms objective. In Dec. 2003, the State Government has come out with its Power

Policy which, inter alia, states private participation in all the segment, generation, distribution trading and repair and maintenance as one of its main objective.

Rationalization of Tariff

A step towards rationalization of tariff after reform, made effective from 09/08/2000. Main features of tariff -

(i) Cross subsidy reduced

(ii) For industries number of tariff categories reduced and structure simplified.

(iii) Public lighting tariff rationalized on the basis of supply hours and population of the area.

(iv) Concession given to seasonal industries / load during off season.

(v) Assessment for defective / burnt meters allowed for maximum of three months, thereby putting pressure on entity to replace such meters at the earliest.

2.6 The Top-Down Approach

Since the early 1990s, a large number of developed, transition and developing countries around the world have embarked on electricity sector reform. The pace and the extent of the trend has been remarkable and, by the end of 1990s, the majority of OECD countries and over 70 developing and transition countries had taken some steps toward reforming their electricity sector (Bacon, 1999; Steiner, 2001). This has occurred under a broad paradigm shift from state ownership and centralized organization of infrastructure industries to private ownership, public regulation and market-oriented structures (OECD, 2000). The technological progress and reform pioneered in some countries has encouraged others to follow suit.

2.6.1 The Standard Model

The model adopted for the electricity supply industry (ESI) since the Second World War resulted in the use of costly generation technologies, neglect of customer services and economic inefficiency. The common feature of many of the programs, pushed by the World Bank, regional development banks, and many bilateral aid agencies relied upon what is known as the standard prescription. The standard prescription as described by Hunt (2002) calls for:

- Privately-owned, competing generation companies that bid into a bulk/wholesale power pool
- Stand-alone transmission company
- Supply competition for all or part of the retail market
- Third-party access to transmission and distribution on non-discriminatory, transparent terms
- Independent and transparent regulator

To achieve these goals, a staged transition from a vertically integrated, typically state-owned.

Monopoly to a market with full customer choice and with the price of power controlled by Competition was proposed (Bacon and Besant-Jones 2001). Figure 2.8 represents the typical configuration of the standard model of liberalisation and its four phases.

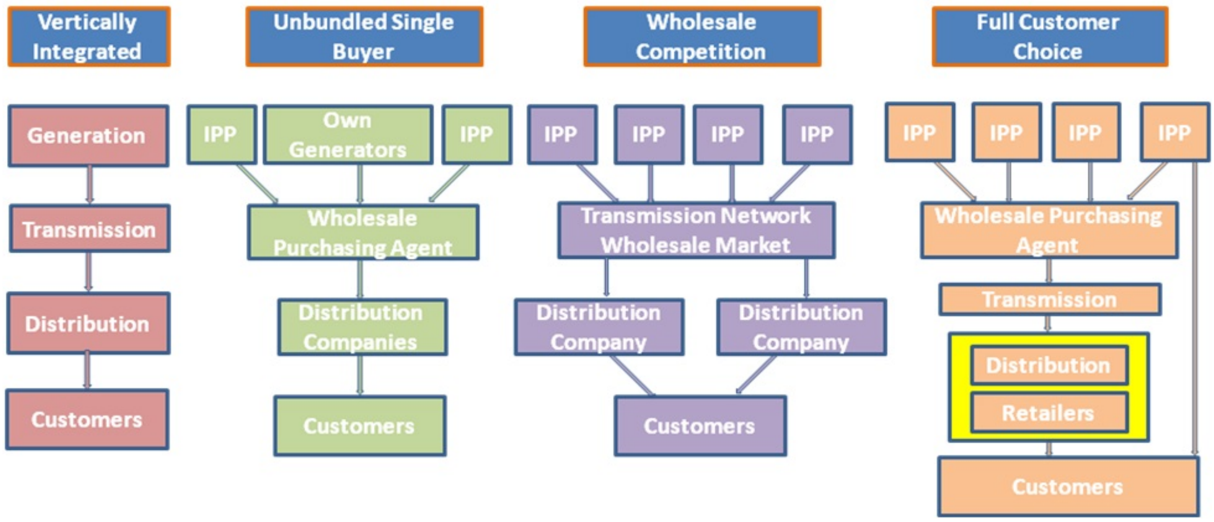

Figure 2.8: Standard Prescription Model Stages (Hunt 2002)

2.7 Top-down assumptions

The top-down reform design in a developing world was with following assumptions:

- Assumption 1: The model relies on a stable grid with adequate capacity and regular maintenance regime;

- Assumption 2: Need for high regulatory capacity, strong judiciary and contract law enforcement;

- Assumption 3: Robust distribution companies (physical and financial) are needed to make markets work;

- Assumption 4: Predictable cash flows and low levels of corruption/theft to make contracts solvent;

(transmission and distribution losses as percent of power output)

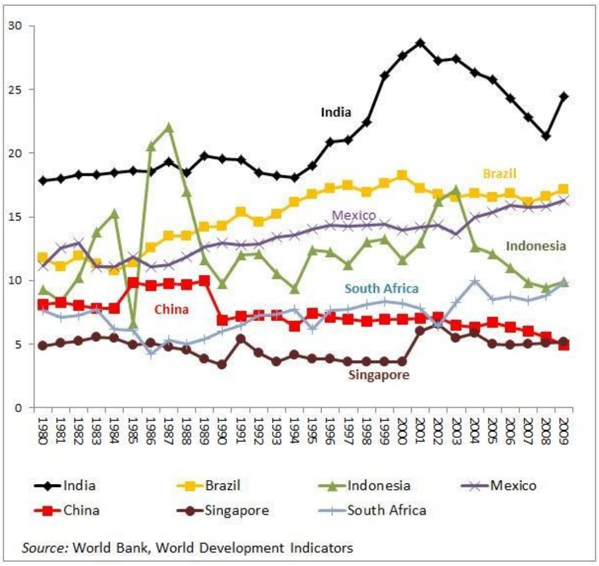

Figure 2.9: Power sector Inefficiency: International Comparison, 1980-2009

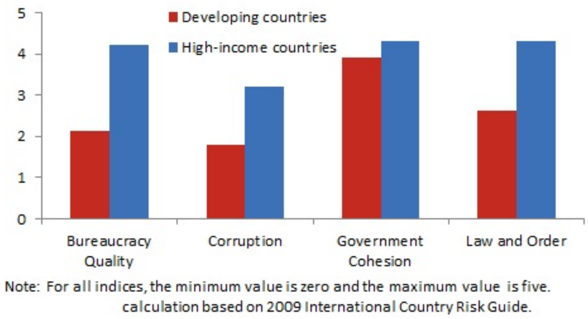

Figure 2.10: Indices of Administrative Capacity

- Assumption5: Model assumed slow and controlled demand growth.

Source: Oxford Economics: Between 2000 and 2015,the number of people whose power consumption is growing faster than per-capita GDP will double, from 2.5 billion to over 5 billion

2.7.1 The Top-Down Approach (The Standard Model) vs Distributed generation

Edward M. Petrie and H. Lee Willis (2003) empirical analysis constitutes Developing countries are expected to account for over half of the increase in global energy consump-

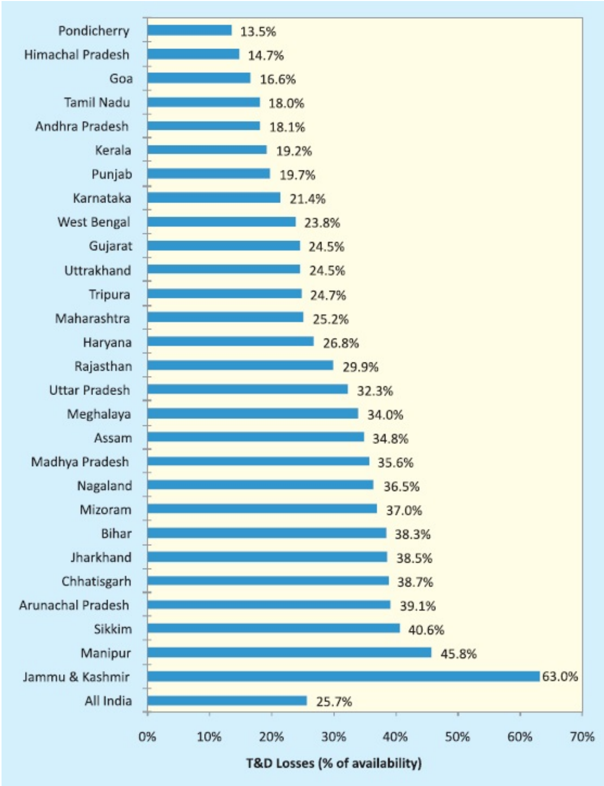

Figure 2.11: Transmission and distribution in 2009-10 (in percentage)

tion during the next 30 years. The demands of industry and a growing population put tremendous pressure on leaders to raise the standard of living in villages. New distributed generation technologies, using small scale generators near to the end-user of electricity, may offer a lower cost, environmentally kind alternative to traditional central power plants and associated transmission and distribution infrastructure. Distributed generation could be a reasonable alternative for electric power needs in remote or sparsely populated situations such as villages in developing countries. In rural areas where electric service points are far apart, even a power distribution system of modest capacity will cost a great deal. By contrast, DG placed at just a few sites, as needed, can be less than half the total cost of more traditional power systems. Fuel delivery may be a problem in developing countries, but where it is truly burdensome, power generation from renewable resources may be justifiable.

K. Purchala et al. (2006) concluded that in the liberalized market environment, the distributed generation offers a number of benefits to the market participants. As a rule,

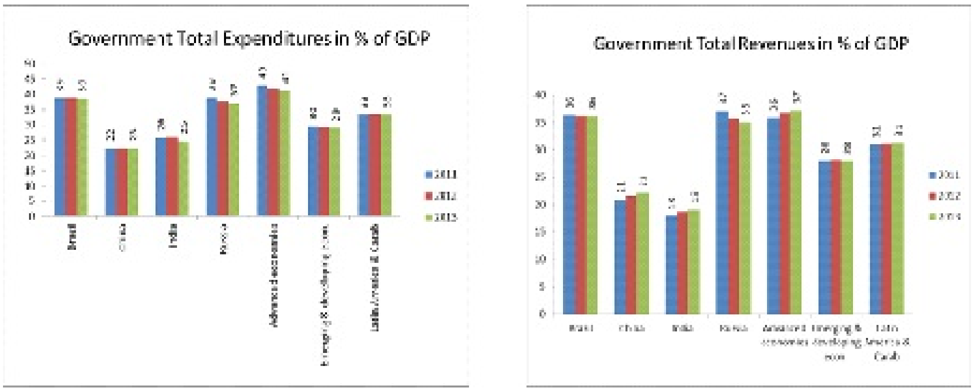

Figure 2.12: Govt capacity to invest (Expenditure vs. Revenue)

World Bank Group Energy Portfolio by Region, FY2007-FY2011 (US$ Millions)

Region	**FY2007**	**FY2008**	**FY2009**	**FY2010**	**FY2011**
Sub-Saharan Africa	1,224	1,261	1,754	5,281	1,156
East Asia and the Pacific	251	1,505	1,229	990	2,116
Europe and Central Asia	518	1,194	2,295	1,182	2,384
Latin America and the Caribbean	489	1,157	801	1,948	1,331
Middle East and North Africa	368	360	806	1,050	67
South Asia	947	2,158	1,446	2,495	1,062
Multi-Region Projects	65	35	-	-	64
Total Energy Financing	**3,862**	**7,670**	**8,332**	**12,947**	**8,181**

customers look for the electricity services best suited for them. Different customers attach different weights to features of electrical energy supply, and distributed generation technologies can help electricity suppliers to supply the type of electricity service they prefer. One of the most interesting features is the flexibility of DG that could allow market participants to respond to changing market conditions, i.e. due to their small sizes and the short construction lead times compared to most types of larger central power plants.

As per India Energy portal Distributed power generation systems are needed to address the following issues:

- High peak load shortages? With a deficit of 12.3% in peak demand, distributed generation sys-tems that can reduce the peak demand is seen as the most effective solution

Is corruption widespread within businesses located in this country, or not?

Region	Yes, corruption is widespread	GDP per capita (median)
U.S. and Canada	60%	$44,463.89
Developed Asia	60%	$37,719.62
European Union	63%	$29,074.13
Other Europe	69%	$10,504.38
Latin America and the Caribbean	66%	$9,286.72
Middle East and North Africa	69%	$7,333.23
Commonwealth of Independent States	70%	$5,491.09
Developing Asia	63%	$3,693.53
Sub-Saharan Africa	76%	$1,481.06

GDP (ppp) per capita estimates are from the International Monetary Fund's World Economic Database for 2011.
Gallup data collected in 2011.

GALLUP

Figure 2.13: Corruption Survey

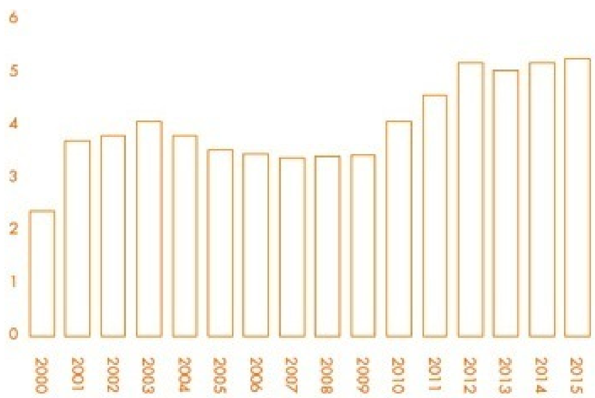

Figure 2.14: Population with electricity consumption growing faster than GDP (billion)

to the problem.

• High transmission and distribution losses? Current losses amount to about 35.03% of the total available energy. Distributed power generation systems can greatly reduce these losses and im-prove the reliability of the grid network.

• Remote and inaccessible areas? In many parts of the country extension of the grid may not be economically feasible. In such cases distributed generation can play a major role.

• Rural electrification? Rural electrification has been identified as a priority for rural development by the Government of India. Wherever grid extension is not feasible, the government has directed that decentralized distribution generation facilities with local distribution network be provided.

• Faster response to new power demands? The modular nature of distributed generation system coupled with low gestation period enables the easy capacity additions when required.

• Improved supply reliability and power quality? Disruptions such as grid failure, etc., can be prevented as electricity is produced close to the consumer. The quality of power? voltage and frequency?can also be maintained easily.

• Possibility of better energy and load management? Distributed generation systems offer the possibility of combining energy storage and management systems.

• Optimal use of the existing grid assets? Inadequacies in distribution network has been one of the major reasons for poor supply of power. Distributed generation facilitates an optimal use of the grid that improves the reliability of the grid network and reduces the congestion.

An extensive technical evaluation was undertaken by CAE (2003) of DG opportunities in New Zealand. The commentary based on the study tests the hypoResearch that distributed generation now permits a paradigm shift in thinking about solutions for meeting consumer energy capacity and reliability requirements. The key to DG's future will be migrating from current strategies into a new energy market focused on customer solutions rather than utility responses. This commentary defines how DG might emerge in the future and identifies the strategies required to make this happen.

Integrated Teaching and Learning Program, College of Engineering, University of Colorado at Boulder 2001 indicated that Distributed generation is often contrasted to central generation. In the case of central generation, power is generated in a large plant (GW in size) and electricity is transmitted over transmission and distribution lines (collectively referred to as the power grid) to buildings where the power is consumed. In the case of distributed generation, the potential exists to provide generation at the building where the power is consumed AND feed excess power back into the power grid as well as take power from.

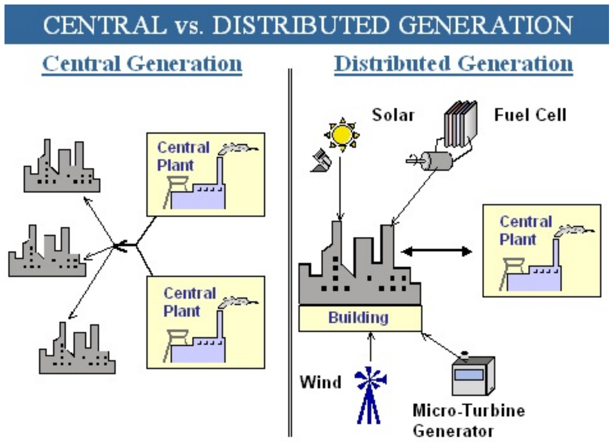

Figure 2.15: Pictorial comparison of Central vs Distributed Generation

Daniel Vieira, (2011) research demonstrates that, in a holistic approach, Distributed Gena-ration choices are the best to address social, economic, environmental and technical aspects: they are more cost-effective, promote substantial industry development and equity, improve grid capacity, help reduce energy losses and increase systems reliability. However, the methodology used depends on the trade-offs and that the choices to encourage one or another technology might have impacts that are significantly different from each other.

The Brazilian Federal Energy Regulatory Agency (ANEEL) on April 17, 2012 enacted new rules aimed at reducing barriers for the incorporation of distributed power generation (DG Regulation) into utility procurement and into Brazil's distribution planning processes. According to the regulation, qualifying small distributed generators include:

• Distributed Micro generators: Any energy generating facility with installed capacity of 100 kW or less that utilizes an incentivized energy source (solar, wind, biomass, hydro and co generation) and is interconnected at the concessionaire's distribution network through consumer-installed systems.

• Distributed Mini generators: Any energy-generating facility with installed capacity be-tween 100 kW and 1 MW that utilizes an incentivized energy source and is interconnected at the concessionaire's distribution network through consumer-installed systems.

School of Power Source and Environmental Protection, Shanghai University of Electric Power,Shanghai, P.R. China and Faculty of Environment Engineering, the University of Kitakyushu, Kitakyushu, Japan concluded that because of its characteristics, the distributed power (DP) plays good function in power-peaking adjustment, providing electric power for far-reaching consumers, commercial and resident regions, saving cost of electric power delivering and distribution, and improving the reliability of the electric power supplies, and it develops very quickly in China. With the improvement of the DG technologies, devices, and efficiency, it is believed that distributed generation holds huge potential in the coming decades. It will not only act as an important supplement of the traditional electric power supply mode, but also hold important position in the field of comprehensive energy applications, and it will become an important developing direction.

A Parashar et al (2011) emphasized that in order to meet the energy needs in India alternative ways and strategies need to be developed. Decentralized electricity production offers a very innovative solution to this problem. India has a plan to double the generation capacity in next ten years. It needs to review the policy followed hitherto of encouraging large sized Central Power generation and rather think about encouraging distributed generation with utilization of waste heat by em-ploying CHP/CCHP technologies. Decentralized electricity is not as capital intensive as centralized. For a cash strapped economy like India this is an important factor. Due to higher efficiency, this can lead to a substantial savings on fuel costs and better environment compliance. It can create ecosystem for small entrepreneurs in rural areas.

N.T. Mutshidza and O.D. Dintchev, Tshwane University of Technology (2010) recommended that given the benefits identified from distributed generation and the expected need for new capacity, Distributed Generation offers a logical, ideal and timely means of bringing new capacity online.

J H Muller, Germiston (2005) South Africa summation that over the last two decades the requirements of the Interconnected Power System has changed significantly. From a grid with a large margin of spare capacity supplying customers with the most basic of electrical needs, to a highly interconnected power system, supplying customers with the highest power quality requirements. Currently the Interconnected Power System with generation located far from its large load centers, have lost a large part of its ability to deliver quality electrical supply to the point the customer take their supply. This is where the benefits of Distributed Generation can be realised.

Unique geography, demography, a huge population living in rural areas and inadequate grid gives India a unique opportunity to exploit decentralized electricity production. Increasing manufacturing capacity, R&D and IP creation done for region specific problems and a huge scope for various innovative business models may lead Indian policy makers to focus on decentralized energy production.

H. Zareipour et al (2004) summarized that the wide range of potential applications for distribution generation (DG), decentralization of power system and the trend to use renewable energies in most developed countries suggest that DG may have a large share in power generation in the future. Nevertheless, more research and development is required to overcome the barriers that DG systems are currently confronting. Higher efficiency, lower emissions and lower capital costs are the main goals these DG systems need to accomplish. On the other hand, electricity market regulatory authorities and government policy makers should consider the worth of DG systems and modify the structure, operation and pricing mechanisms of the open markets to help their viability and development.

Lilley and William E (2012) argued based on modeling that potential impact of that DG may have in terms of economic and greenhouse gas savings in the Australian energy sector. The modeling indicates that a future energy system which incorporates wide spread DG has the potential to provide significant economic and environmental benefits to society. The modeling shows the primary savings occur through long term reduction in expenditure on large scale centralized plant and associated transmission infrastructure. Detailed modeling of the energy market also suggests that DG can lead to significantly lower and less volatile wholesale prices through better management of demand supply imbalance.

U.S. Agency (2004) for International Development, Bureau for Economic Growth claims that although distributed generation is not a panacea for solving developing country energy problems, when combined with energy efficiency measures it has considerable potential to help meet increased electricity needs. Distributed generation can lesson demand and reduce peak loads, postpone the need for expensive line upgrades, add much needed power to the grid through greater use of combined heat and power and other DG technologies, extend power to remote areas and create income through the sale of excess power back to the grid. It also offers important environmental benefits. DG technologies have the potential to reduce air emissions and improve public health. They also emit less greenhouse gases than the traditional energy mix.

Prof. John Forrer (2012) has presented an overview of Brazilian Electric System emphasizing the benefits of distributed generation and describing the main characteristics of each source, pointing out their growth potential and their average building costs. He also presented the legal and regulatory incentives that were created to stimulate the expansion of distributed generation in Brazil. Besides, it was illustrated the renewable energy policy of the California State, which was developed after the energy crisis of 2001, showing their effort to increase the participation of renewable energy and achieve the goal of 33% state's electricity matrix by 2020.

James A. Momoh (2012) compared the merits and costs of co-optimizing DG and CG in a future electric grid. The various assessments of technology, cost, and maintenance have been identified to determine the extent to which DG or CG should be used to meet different uncertainties in demand growth. It is also recommended that , it becomes important to evaluate the economies of scale for DG and CG technology. The factors (such as cost of maintenance, economies of scale, resiliency, sustainability, and ability to withstand growing demand) are important. A matrix of performance is proposed to include resiliency, stability, and reliability are defined to measure the grid-connected solely as CG or DG or in combination.

December 11, 2011, edition of The Hindu carried an article The coming Dark Age of India, which inter alia said: We need to cut down on transmission and distribution losses and untangle the environmental problems that coal mining has run into. Policymakers have to balance the needs of development with environmental considerations. But for some urgent steps from the government, the country may well return to the Dark Ages, literally. Even in the case of electric power, any increase in generation capacity is more than offset by inefficiencies and wastage at every stage - production, transmission, distribution and delivery. Without fixing these inefficiencies and wastage, increasing generation capacity and production is like filling a bucket full of holes! The first and foremost task should be to fill these holes, which is very much doable. For this, the basic philosophy of power utility management should undergo a sea-change and move away from generation-led augmentation mindset to distribution/delivery-led optimization alternative.

Rural electricity access in India is currently inadequate for needs of the rural population, and there is observed and revealed willingness to pay for better electricity supply. The Indian government is pursuing large scale initiatives towards greater access mainly through grid expansion. James Cust et al (2001) recommended that the prospects for rural electricity needs to be met by conventional approaches may be limited. Indeed from an economic perspective, non-conventional forms of rural electrification may least-cost, particularly where villages are some distance from the existing grid. It argues that renewable energy Distributed generation projects, if widely replicated, can ease the burden on both electricity supply shortfalls (by serving rural areas and subsequently feeding back into the grid), and reduce the urgency of costly grid extension. In addition, by securing high bill payment rates, locally operated projects can ensure better cost recovery than equivalent grid distribution.

Kevin Bullis (2012) edited on experience of some 600 million people in India have been left with-out power after parts of the country's massive electricity grid collapsed 31 July 2012. While the cause is not yet clear, the outage is not surprising. India's grid has long been strained, with demand often exceeding supply by hundreds of megawatts, forcing regular rolling blackouts in some areas. And as a big part of the solution is obvious: more power plants, more power lines, and an increased supply of coal and other fossil fuels-in India, many power plants don't operate at full capacity because they can't get enough fuel. But another part could be technology that's already starting to catch on in many parts of the developing world: micro grids. Instead of relying only on large, centralized power plants, micro grids supply a small area with electricity from distributed sources.

Andrew C Revkin (2012) New York times, Here's a round of analysis related to India's long for-seen electricity gap and the resulting grid failure and blackouts affecting half the country's 1.2 billion people. It'd be great to think that renewable energy sources and distributed electricity generation could solve such problems, and they're great where they work.

Arpana Udupa (2011) Greenpeace India argued based on the audit of RGGVY for Uttar pradesh and Bihar, while the RGGVY scheme has raised expectations of people with no access to electricity, lack of quality and unreliable electricity supply has underlined that the scheme has failed to deliver so far and has also failed to match the expectations created. The principle behind the planning of this scheme, which is to build a centralized electricity network to ensure access to power, is flawed. On the other hand, various DRE (decentralized renewable energy) projects in the surveyed state are working very effectively and the same was recommended by people during the survey and public hearings.

M. Neubert, G. Balzer (2007) indicated that economy of distributed generation units in the power sup-ply is basically new. Comparability and power scheduling is no longer restricted to great thermal power plants and distributed generation will play an important role in this case. To receive more information about the economic structure, the research of the total cost Ktotal will be presented. A general formulation of the total cost can be generally written in form of Equation 1:

$$K_{total} = K_{fixed} + K_{variable(x)} \tag{2.1}$$

Kristopher A. Pruitt, et al (2012) shared that Distributed generation (DG) has gained interest as an alternative source of power for new and existing buildings in the residential, commercial, and industrial sectors. Rather than solely purchasing electricity from a centralized utility, a building owner can invest in an on-site system to supply power using non-renewable technologies such as reciprocating engines, micro turbines, and fuel cells, and renewable technologies such as photo-voltaic (PV) cells and wind turbines.

2.7.2 Advantage of Distribution Generation

Distributed generation offers a number of different benefits for power consumers, generators, distribution companies, independent power producers and society as a whole. For one, it offers consumers more efficient, reliable and flexible power at a reasonable cost. In addition, it can provide utilities and distribution companies with a number of ancillary services, such as reduced congestion and lower transmission and distribution losses.

Several studies were conducted to emphasize the main shortfalls of the centralized generation paradigm and to explicit the motivation of the agents in keeping distributed generation as a primary source of electricity or as a back up generator El-Khattam et Salama, (2004); Perpermans et al., (2005). The main drivers listed in the literature are summarized below:

Transmission and distribution costs: transmission and distribution costs amount for up to 30% of the cost of delivered electricity on average. The lowest cost is achieved by industrial customers taking electricity at high to medium voltage and highest for small customers taking electricity from the distribution network at low voltage (IEA, 2002).

The high price for transmission and distribution results mainly from losses made up of:

• line losses: electricity is lost when flowing into the transmission and distribution lines;

• Unaccounted for electricity; and

• Conversion losses when the characteristics of the power flow is changed to specifications of the network (e.g. changing the voltage while flowing from the transmission network to the distribution network) (EIA, 2009).

Rural electrification: Under integrated power system, rural electrification is challenging for two reasons. As large capital expenditures are required to connect remote areas due to the distance to be covered through overhead lines, connecting remote areas with small consumption might prove uneconomical. This effect is amplified when taking into account transmission and distribution losses because both tend to increase with the distance covered. Rural electrification is thus costly. It often proves more economical to rely on distributed generation in such cases (Carley, 2009).

Investment in transmission and distribution networks: The International Energy Agency (2003) estimated the total amount to be invested in generation, transmission and distribution up to 2030 for the OECD countries to stands between 3,000 and 3,500 billion dollars (base case predictions). In order to cut these costs, distributed generation can be used as a way to bypass the transmission and distribution networks.

Security and reliability: The persistence of distributed generation contributed to energy security through two effects:

• Fuel diversity: as distributed generation technologies can accommodate a larger range of fuel that centralized generation, distributed generation has been used to diversify away from coal, fuel, natural gas and nuclear fuel (IEA,2002). For instance, distributed generation has been used at landfills to collect biogas and generate energy;

• Back up generation: the main use of distributed generation is for back up capacities to prevent operational failures in case of network problems. Backup generators have been installed at critical location such as hospitals, precincts etc.

Electricity deregulation and cost control device: in a deregulated electricity market, the diminution of reserve margins or the failure of generators to supply the network (due for example to unplanned outages etc) can lead to capacity shortfalls resulting in high electricity prices to the consumers. In order to hedge against negative price impacts, large electricity consumers have developed acquired distributed generation capacities.

Environmental Impact: the environmental impact of the centralized energy system is significant due to the heavy reliance on fuel, coal and to a lesser extent natural gas. The electricity sector is responsible for 1/4 of the NOx emissions, 1/3 of the CO_2 emissions and 2/3 of the SO_2 emissions in the United States (EPA, 2003). Distributed generation has been used to mitigate the impact both in terms of emissions associated with transmission and distribution losses, to increase efficiency through Co Generation.

SHEILA BOWERS excerpted The Energy Reader: Overdevelopment and the Delusion of Endless Growth, Tom Butler, Daniel Lerch, and George Wuerthner, (Healdsburg, CA: Watershed Media, 2012) , that a growing body of research and analysis favorably demonstrates the economic, environmental, and community benefits of local distributed energy compared to remote utility-scale energy of all types. With policies that favor distributed clean energy generation and efficiency, the United States could avoid the elevated economic and ecological costs of remote utility-scale power development, preserve critical wildlife habitat,reduce greenhouse gas emissions, create jobs, and gain significant economic benefits for local residents, businesses, and communities.

Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO) recently completed a major study investigating the value of distributed energy (DE; collectively demand management, energy efficiency and distributed generation) technologies for reducing greenhouse gas emissions from Australia's energy sector (CSIRO, 2009). This comprehensive report covered potential economic, environmental, technical, social, policy and regulatory impacts that could result from the wide scale adoption of these technologies.

2.8 Conclusion

Although distributed generation is not a panacea for solving developing country energy problems, when combined with energy efficiency measures it has considerable potential to help meet increased electricity needs. Distributed generation can lesson demand and reduce peak loads, postpone the need for expensive line upgrades, add much needed power to the grid through greater use of combined heat and power and other DG technologies, extend power to remote areas and create income through the sale of excess power back to the grid. It also offers important environmental benefits. DG technologies have the potential to reduce air emissions and improve public health. They also emit less greenhouse gasses than the traditional energy mix.

Still, challenges to DG technologies abound. Most developing country electricity markets suffer from a lack of competition and weak regulatory bodies. Continued use of subsidies undermines the financial stability of many utilities and discourages the use of distributed generation by hiding the true cost of providing electric power to the consumer. Promoting DG technologies requires new investment, sufficient equipment and skilled technicians. It also involves a high degree of regulatory complexity and government involvement, which seems difficult at a time when several studies point to the need for developing countries to simplify their energy regulations to better reflect local market conditions.

With most power sector reforms in developing countries still a work-in-progress, governments have an opportunity to modify the traditional central power station model and adopt a more flexible regulatory framework that levels the playing field for DG technologies. Recognizing that there are both benefits and costs associated with DG, the first step for governments is to carefully examine the impact and viability of DG under local market conditions and the potential contribution that DG can make to a country's energy mix. Working in close consultation with utilities, transmission companies, energy service companies, regulators, trade associations and NGOs, governments will need to assess:

- Existing distributed generation power sources from local industry;

- The potential for greater use of combined heat and power applications;

- The availability of manufacturers, suppliers and distributors of DG technologies;

- The true costs and infrastructure needs of transmission and distribution networks;

- Options for DG technologies to meet rural and urban electrification needs without compromising system integrity, reliability or safety;

- The impact of DG on the financial viability of the central electric utility system; and Specific technical, regulatory, administrative and financial barriers to distributed generation.

From this process should emerge a development plan that clearly identifies ways to accelerate the use of DG technologies in targeted areas to help meet power sector objectives. Key elements of such a plan should include or address the following issues:

Essential Market Reforms and Conditions: Even if a vertically integrated electric utility remains intact, private entities should be allowed to generate power, interconnect with the grid and compete in wholesale markets on non-discriminatory terms. Transmission and distribution costs need to be evaluated to help determine the benefits and impacts of DG to the grid and promote least-cost system upgrades and expansion. An independent regulator should be established with the authority and resources necessary to police the market.

Uniform Standard and Procedures: Uniform technical standards for grid interconnection and testing and certification procedures for DG equipment should be made easily accessible. Similarly, grid interconnection and parallel operation applications and power purchase agreements should be streamlined and standardized to lower transaction costs. Dispute resolution procedures should be adopted to ensure fair and speedy resolution by a qualified entity or government body. Equipment installers should be certified to ensure quality system performance and adequate maintenance. Local authorities should be directed to simplify application procedures to comply with fire, health and safety, zoning, environmental impact, water discharge and waste management requirements.

Elimination of Cross subsidies: Cross subsidies should be gradually discontinued.

Pricing: The ancillary and environmental benefits of distributed generation should be recognized in any pricing system. Long-term and stable tariffs and power purchase contracts should be provided for DG power producers connected to the grid.

Transmission Charges and Fees: Connection and back-up charges should be limited to a generator's impacts and benefits to the distribution system. Transmission rate structures should not be biased against low-capacity renewable DG technologies.

Market-Based Mechanisms: There should be a thorough exploration of market-based mechanisms, such as emissions or renewable energy credits, and taxes that incorporate environmental costs and more adequately represent energy conversion efficiencies.

Economic Incentives: An economic incentive package to stimulate DG market development should ensure that production actually occurs and incentives do not distort the market. An aggressive marketing and out-reach campaign should be undertaken simultaneously in collaboration with utilities, trade associations, NGOs and local government entities.

Rural Electrification: DG technologies should be allowed to fairly compete with grid extension based on a least cost analysis and an assessment of local electricity needs. Whenever possible, rural electrification should be integrated with other infrastructure development projects.

Technical and Institutional Support: Governments will need to provide a wide range of technical and institutional support to industry and business, utilities, local entrepreneurs and government agencies to facilitate the deployment of DG technologies and services. Wider awareness of both the pros and cons of distributed generation will be needed. Government leadership and commitment is essential.

In the long run, power sector reforms in developing countries that continue to unduly favor conventional centralized power generation technologies will have an increasingly detrimental environmental impact and are likely to fail in meeting the performance, quality and power needs of end users, especially those located outside large cities. With the proper regulatory structures and incentives, DG can complement central power while increasing access to energy in an incremental, clean and reliable manner.

CHAPTER 3

Research Methodology

3.1 Introduction

While undertaking any research work, one of the most important factor observed by social science researchers is to deal their claims of knowing and understanding of the issue. Analyzing and interpretation is most critical exercise once the data have been gathered. At every level of the research process i.e. from the definition of initial design to data collection and analysis to interpretation has to pass through important considerations.

The aim of this chapter is to elaborate the rationale behind my research design, outline the methodological approach and to provide research process followed. It explains how the data were gathered during different stages of work. It also explains the ways in which the data were analyzed and refined.

This chapter discusses the methodology that is used in this study. The section describes here are the Research Gap leading, Research Questions and follows by Research Objectives. It also describes the Research Strategy and Research variables that are required in this work.

3.2 Research Gap

Uttar Pradesh is a very important and vital geography with acute shortage of power and have below average availability of power for both the residential and industrial sectors. Solving this issue is one of the compelling economic, environmental and social alleviation questions for now.

Based on Review literature and historical research support followings gaps are identified w.r.t to Uttart Pradesh Geography.

1. No study on alternate power supply model like bottom up distributed generation is done for Uttar Pradesh.

2. Alternate Suitable Power system model is to be studied on existing technical and political economic conditions of Uttar Pradesh.

3.3 Research Questions

Central Research Question: What are the options to address power requirement of Uttar Pradesh under current Scenario.

To address the the central research question following research question need to be addressed:

- Is bottom up Distributed Generation approach is correct for Uttar Pradesh similar to other developing countries?

- Are there a set of Market motivations in select Developing countries and can be adopted by Uttar Pradesh, leading to substantial growth of the Distributed Generation sector.

- Are there a set of Distributed power generation models, identified for Uttar Pradesh

3.4 Research design

To answer the research questions required developing an approach to collecting and analyzing data of different types.

Following areas of investigation were undertaken:

• A concise analysis of the socioeconomic and political environment of Uttar Pradesh, India,

• Relevant information on power policy as it relates to rural DG

• The linkages between different stakeholders

• An economic analysis of DG hybrid technologies and captive units

• The implications for generalizing the DG and captive power approach across Uttar Pradesh.

The situation in Kanpur, Uttar Pradesh is used as a case study to provide insight into both the specific and more general sable results.

3.5 Interdisciplinary Approach

The study of energy systems in rural areas requires knowledge and techniques from several disciplines, including: development studies, economics, finance, politics, and engineering. The literature is replete with examples that emphasise each aspect to different degrees. For power systems in developing economies, Munasinghe (1987) relied on both a cost benefit approach that incorporated economic development benefits and a least cost financial analysis to determine the best system choice within engineering constraints. Gregory, et al. (1997) concentrated on the different financing options for renewable energy projects that satisfied the ability to pay constraints of poor rural households. The technique is based on life cycle cost calculations taken from the management literature. Barnes (1988) used a detailed study of the capital and energy costs of rural electrification and compared them with the development benefits. For hybrid systems the best example can be found in Morris (1998), where she applies a combination financial optimization based on lowest life span discounted cash flows that is constrained by engineering factors and allowing for incorporation of local conditions.

In each case, an attempt to use financial measures to estimate the feasibility or value of a rural energy project was applied. However, the need to reflect or document real decision making criteria means that political and engineering constraints had to be reflected in the financial models. To this end, it is expanded upon Morris's approach by adding an analysis of the political economy of the power sector in Uttar Pradesh and how it will affect the viability of a hybrid projects.

3.6 Qualitative and Quantitative Approaches as Complements

This thesis uses both qualitative and quantitative methods to examine the feasibility of different energy options for rural areas and captive power for industrial applications. The two approaches complement each other because each helps to cross-check the other for consistency and accuracy. Balance and integration between qualitative and quantitative data is also needed to provide a more cogent picture of reality and to better inform decision makers who use the research. Numbers by themselves can calcify into unrealistic conclusions; and while qualitative information is needed to tell the story but research is not just story telling. (Devereux and Hoddinott 1992). Table 3.1 shows the breakdown between the differing roles of qualitative and quantitative date for different aspects of the research process.

One of the dangers of economic modelling, including the technique applied in this thesis is to approach the results as nomothetic, meaning that they hold for all times and places. Qualitative fieldwork helps to temper the results with ideographic reality, meaning that the findings are for a specific time and place. Integrated methods help to increase understanding of the causes of a problem and both are needed to describe and understand one reality.

	Quantitative	Qualitative
Role of Research	Preparatory	Means to explore actors interpretations
Relationship between researcher and subject	Distant	Close
ResearcherŠs stance in relation to subject	Outsider	Insider
Relationship between theory and research	Confirmation	Emergent
Research strategy	Structured	Unstructured
Scope of Findings	Nomothetic	Ideographic
Image of social reality	Static and external to actor	Socially constructed by actor
Nature of data	Hard, reliable	Rich, deep

Table 3.1: Qualitative and Quantitative Research Methods Summary. Source: (Bryman 1988)

3.7 Research Objectives

To address the above Research Questions following Research Objectives are identified:

1. Feasibility analysis for Distributed Generation as an option in Uttar Pradesh context (Kanpur).

2. To formulate Market presumption for growth of Distributed Generation in Uttar Pradesh.

3. To develop a theoretical Bottom up model of Distributed Generation for Uttar Pradesh.

3.8 Research Strategy

The research process began with an extensive review of the available literature concerning DG technologies. Common power system indicators are used to compare four developing Asian countries categorized as:

- Country Investment Environment

- Capacity and Ownership
- System Weaknesses
- Regulatory Framework and Reform Path
- Government Policy for Distributed and Captive Generation

Particular focus is given to how each ESI incorporated distributed and captive generators into the system and which policies have encouraged or discouraged bottom up approaches to reform.

To enable gathering data on the forces at work in the Uttar Pradesh electricity sector, a case study research strategy was used. The case study seeks to accomplish following main aims: illuminate a decision or set of decisions; explain why they were taken; and discusses how they were implemented and with what result (Yin 1994). With the literature review as background, I used a case study approach to perform a series of directed interviews in Uttar Pradesh with key managers in the local electricity industry, academic and governmental personnel during fieldwork. In addition, primary data were collected during a site visit to the Kanpur District of Uttar Pradesh, which was used to model the cost and performance of a hybrid power system. A well tested and documented program from the National Renewable Energy Laboratory, HOMER, was used for the subsequent economic modelling (NREL 2003). This modelling forms the analytical heart of the thesis.

HOMER Model Description HOMER stands for the Hybrid Optimisation Model for Electric Renewables and was developed by the National Renewable Energy Laboratory in Golden, Colorado, USA. HOMER was developed as a hybrid system design tool accurate enough to reliably predict system performance, but simple and efficient enough to conveniently evaluate a large number of design options and then rank the results to find the optimum configuration (NREL, 2003). HOMER identifies the least cost system for supplying electricity to remote loads by performing hourly simulations of thousands of potential power systems and rank ordering them by life cycle costs. It also performs sensitivity analyses to evaluate the impact of a change in any of the input parameters and provides both annual and hourly outputs in tabular and graphic form. Hybrid system design is made difficult by the intermittency of renewable resources, the need to match electrical supply and demand, and the large number of potential component size combinations. HOMER provided an excellent platform on which to test hybrid viability in kanpur and eliminated the need to spend time building an optimisation model from scratch. The HOMER model is also well tested and validated (Lilienthal, Flowers et al. 1995). The formulate details for the three most important output variables of the model are below.

Net Present Cost

The net present cost is the discounted value of all the cash flows needed to operate and purchase the hybrid system over its lifetime of 20 years. The following formula was used:

$$C_{NPC} = \frac{C_{ann,tot}}{CRF(i, R_{proj})} \tag{3.1}$$

Where $C_{ann,tot}$ = total annualized cost (dollars per year)

CRF = capital recovery factor

i = interest rate (percent)

R_{proj} = project lifetime (year)

The first variable is the total annualized cost of the system, which is equal to the sum of each component's annual operating cost plus its annualized capital cost over its useful lifetime plus the annual fuel cost, if applicable (NREL, 2003). By adding the results for all components, the total annualized cost can be calculated, C_ann, tot. The capital recovery factor is a function of the real interest rate and the project lifetime and is used to discount the cash flows to time zero.

Cost of Energy

The cost of energy (COE), in dollars per kWh, is the level of tariff needed to recoup the net present cost (NPC) of the hybrid project. However, differential tariff structures can be used to aid poor clients, so the COE figure is only indicative of the median level of charges that must be supported by the host community:

$$COE = \frac{C_{ann,tot}}{E_{prim} + E_{def}} \tag{3.2}$$

Where $C_{ann,tot}$ = total annualized cost (dollars per year)

E_{prim} = primary load served (kWh per year)

E_{def} = deferrable load served (kWh per year)

The two loads, Eprim and Edef, are based on village per capita estimates

3.9 Research Variables

Variables can be defined as any aspect of a theory that can vary or change as part of the interaction within the theory. In other words, variables are anything can effect or change the results of a study. Every study has variables as these are needed in order to understand differences. List of Variables identified for this research work are as follows:

- Feed in Tariffs (FiT)
- Tax holiday
- Generation based Incentives (GBI)
- Legally enforceable RPO/REC for Distributed generation
- Faster approvals/Single Window Clearance
- Market motivations
- COE

- NPC
- Tariff determination on Off grid and On Grid basis and not on conventional method
- Financial incentives like zero import duty, excise duty waiver
- Renewable fuel based incentive
- Regulatory support

3.10 Conclusions

After covering the details of the research methods used for this thesis, the following chapters present the background, data, analysis and results from the research process. The first step is to collect data to understand the political economy of the Uttar Pradesh power sector, which is addressed in Chapter 4. To achieve this we need to go through the process of selecting the area and follow the sampling process. Chapters 5 deals with the data analysis based on the survey.

CHAPTER 4

Analysis

Understanding the key drivers that influence the adoption of DG solution are essential in determining strategies for decreasing the barriers for adopting and implementing further DG solutions in Uttar Pradesh. It is important that key learning's gained from experiencing a DG implementation process is utilised to benefit other potential proponents that may be interested in implementing a DG project. By analysing the survey results from all 181 respondents, a number of correlations and trends have helped to recommend DG for Uttar Pradesh. This analysis has been organized into a number of themes as follows:

- Quantitative Analysis
- Technical Analysis
- Operative Analysis

4.1 Overview

Data collection is the process of gathering and measuring information on variables of interest, in an established systematic fashion that enables one to answer stated research questions, test hypotheses, and evaluate outcomes. The data collection component of research is common to all fields of study including physical and social sciences, humanities, business, etc. While methods vary by discipline, the emphasis on ensuring accurate and honest collection remains the same.

The importance of ensuring accurate and appropriate data collection Regardless of the field of study or preference for defining data (quantitative, qualitative), accurate data collection is essential to maintaining the integrity of research. Both the selection of appropriate data collection instruments (existing, modified, or newly developed) and clearly delineated instructions for their correct use reduce the likelihood of errors occurring.

It is important to Consequences from to have proper collected data to achieve following:

- Ability to answer research questions accurately
- Ability to repeat and validate the study
- Accurate findings with Optimal resources
- Avoid misleading and fruitless avenues of investigation
- Desired decisions for public policy

While the degree of impact from faulty data collection may vary by discipline and the nature of investigation, there is the potential to cause disproportionate harm when these research results are used to support public policy recommendations.

Issues related to maintaining integrity of data collection:

The primary rationale for preserving data integrity is to support the detection of errors in the data collection process, whether they are made intentionally (deliberate falsifications) or not (systematic or random errors).

Most, Craddick, Crawford, Redican, Rhodes, Rukenbrod, and Laws (2003) describe quality assurance and quality control as two approaches that can preserve data integrity and ensure the scientific validity of study results. Each approach is implemented at different points in the research timeline Whitney, Lind, Wahl, (1998)

4.2 Selection of Area for Primary Data collection

Yin (1994) claims that one of the primary issues to be considered in the beginning phases of research design is the development of research questions. My research questions, focused as they were on understanding the ways in which DG and captive generators enable effective growth in power systems, pointed to the efficacy of using a case study methodology. In order to answer the research questions set out earlier, it was clear that at least one primary case study of a state power system attempting to grapple with DG and captive power was needed. Because the implementation of DG/captive practices constitutes a departure from more traditional methods of centralized power system planning, it was important to select a case study that would highlight the key issues involved. Kanpur provided this natural laboratory because of the existence of three salient factors. First Kanpur has undeserved rural areas that are remote from **robust** grid connections and have renewable resources available.Second, the Kanpur is highly industrialized with a high proportion of captive power in operation; and third, there is a current power shortage and rapid demand growth highlights the need for additional generation capacity.

Conducting research on a District level ultimately involved sacrifices in terms of the nature and broad applicability of claims that could be made. However, the depth of the case study approach had the advantage of demonstrating the actual challenges of implementing ideas on a practical level, and would helped capture nuances that would have been unavailable merely from large surveys and basic observations (Yin 1994).

Kanpur is the second most populous city and the largest urban agglomeration in the Indian state of Uttar Pradesh. It is one of the largest industrial cities in India. It is the administrative headquarters of Kanpur Nagar district and Kanpur division and is known as Leather City as it contains some of the largest and finest tanneries in the world. Kanpur is one of North India's main commercial and industrial centers.

Kanpur is situated on the bank of the Ganges River and has been an important place in the history of modern India. Kanpur was one of the main centers of industrial revolution in India. It was known as Manchester of the East. Towards the end of 19th century, Sir John Burney Allens established a group of companies such as Kanpur Textiles, Cawnpore Woollen Mills (Lal Imli), Flex Shoes Company, Elgin Mills and North Tannery under the banner of British India Corporation having headquarters at Kanpur.

Politically Kanpur is divided in two district i.e Kanpur Nagar and Kanpur Nagar

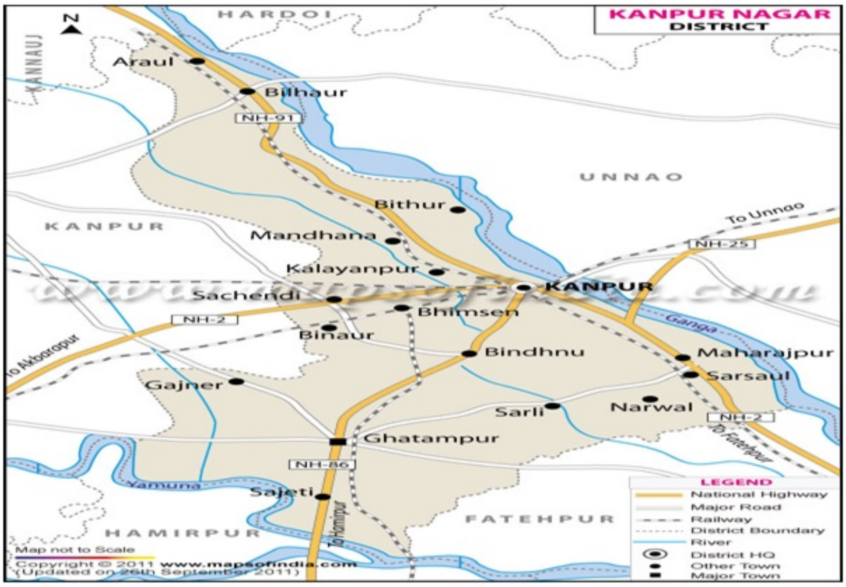

Figure 4.1: MAP of Kanpur Dehat District

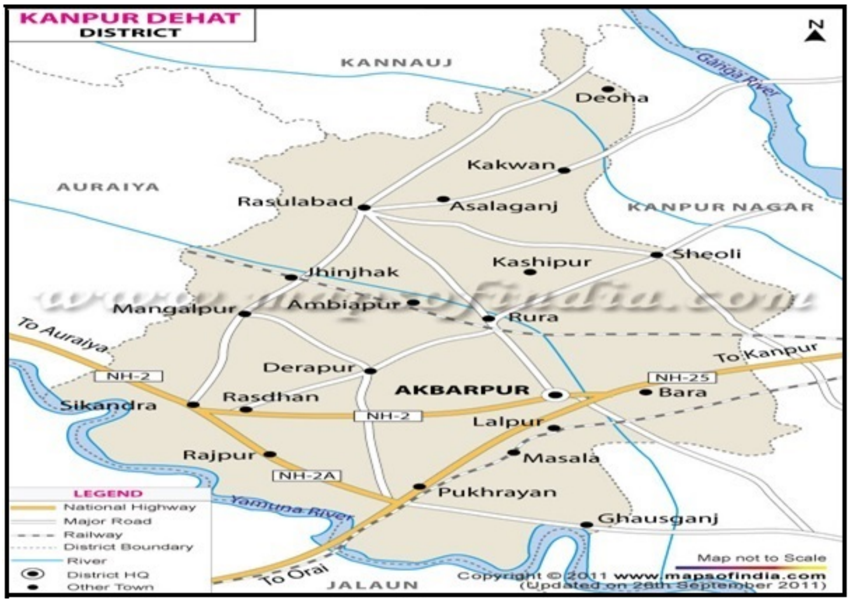

Figure 4.2: MAP of Kanpur Nagar

4.3 Source of data

Secondary data

Secondary data on reforms, policies, institutions etc. are collected from existing literature, websites, offices, reports of various committees set up from time to time, books, magazines and journals etc. Details of such secondary sources are given in the references.

Primary Data

To demonstrate the case for this bottom-up reform path, it is necessary to evaluate both technological and Political Economical options. In order to answer the mooted research questions, primary data of various technological and Political Economical influencing factors need to be collected.

Source of Primary data identified are as follows:

1. Filed visits during feasibility study
2. Personal Interview
3. Schedule/Questionnaire Method

Formation of Questioners: Democratic societies make decisions and policy based on many inputs, including fiscal considerations, societal values, prevailing public views, and the ideals and vision of the government of the day. But democratic governments want to make good decisions and at the base of such decision making should be the use of high quality information and evidence, both in developing new policies and in evaluating current policies. Decisions made in the absence of such informed background material are, by definition, less likely to be effective or efficient and can entrench policies which may be of little value. Thus governments can become constrained by earlier policy decisions that are not easily reversible because there may be a popular or political perception that they are effective when in fact they are not.

While information and evidence do not themselves make policy, good information and evidence provide an important base for a rational assessment of options weighed up against those other criteria that politician and their supporting policy advisors should consider.

Thus the questions in this thesis are designed based on the evidence of few other developing countries which is shown in Table 4.1, 4.2, 4.3, 4.4.

S.NO	**Factors**	**Evidence**
1	Country Investment Environment	China has been and continues to be a magnet of foreign direct investment, particularly in the manufacturing sector. However, this boom has not spilled over into the power sector
2	Capacity and Ownership	Generation ownership remains almost exclusively with government owned companies, with a small sliver in private hands. Transmission and distribution are 100 percent state-owned.
3	System Weaknesses	The Chinese system suffers from a number of weaknesses including poor interconnections between the country's regional grids. The Chinese government's emphasis on generation development has resulted in the delay of construction of more transmission and distribution networks, which has caused severe bottlenecks in some region's grids
4	Regulatory Framework and Reform Path	The regulatory framework in China remains a state-owned system, with a total grid monopoly that serves as single buyer for any power sellers

5	Government Policy for Distributed and Captive Generation	The centrally planned renewable energy target aims to push the share of renewable to rise from 9 to 16 percent of total primary energy consumption by 2020. According to the Renewable Energy Law, power grid companies are mandated to provide wire access and purchase 100 percent of renewable power. Renewable power also will enjoy a high feed-in tariff and they will not participate in wholesale market competition.

Table 4.1: Evidence from China

S.NO	**Factors**	**Evidence**
1	Country Investment Environment	Indonesia investment environment has been improving steadily since the 1997
2	Capacity and Ownership	The grid-connected generation owned by PLN is only 58 %. 60 % of these residual captive units are diesel generators and 25 %are cogeneration units
3	System Weaknesses	Suffers from inadequate investment in new capacity, as the planned additions from IPPs have not come to fruition. PLN is a perennially cash starved, state-owned electric utility and has been unable to build large capacity additions using its own resources.

4	Regulatory Framework and Reform Path	The power sector reform effort has mostly stalled after the introduction of IPPs in the 1990s
5	Government Policy for Distributed and Captive Generation	In 2002, Ministerial Decree on Distributed Small and Medium Power Generation came into effect. It provides an opportunity for small power producers to generate up to 10 MW

Table 4.2: Evidence from Indonesia

S.NO	**Factors**	**Evidence**
1	Country Investment Environment	The Philippines has had a tumultuous recent political history, with several changes in government, often labelled as extra-constitutional. However, for the power sector the laws and regulations have remained steady and have been applied reasonably impartially.
2	Capacity and Ownership	Total central power station capacity in the Philippines is approximately 16 GW with a total load of 57 TWh split over three main networks centered on each of the three largest islands, Luzon, Mindinao, Visayas. There are many dispersed power systems on the smaller islands.

3	System Weaknesses	There is no formal mechanism for small power producers in the Philippines. The Act seeks to set up a framework for fiscal and non-fiscal incentives for all renewable energy activities and to create the National Renewable Energy Board (NREB).
4	Regulatory Framework and Reform Path	The outlook for additional reform in the main power market on the island of Luzon remains positive, with plans for further unbundling through privatization of assets (generation and transmission).
5	Government Policy for Distributed and Captive Generation	There is no formal mechanism for small power producers in the Philippines and the Renewable Energy Act has languished in the congress for years.

Table 4.3: Evidence from Philippines

S.NO	Factors	Evidence
1	Country Investment Environment	In the wake of the 2006 coup, the political situation in Thailand has remained unsettled, but no economic dislocations have resulted. S&P has sovereign debt at a BBB+ and Thailand is currently enjoying robust economic growth.
2	Capacity and Ownership	Fuel choice in Thailand is dominated by natural gas and coal and this is expected to continue as the system double capacity to 2020

3	System Weaknesses	The transmission grid require major investment and EGAT will have to develop the transmission system expansion plan to ensure that power supply would adequately meet the increasing demand in the future.
4	Regulatory Framework and Reform Path	Primary control of the electricity supply industry (ESI) in Thailand is currently held by EGAT, the Electricity Generating Authority of Thailand while electricity rates are determined by the National Energy Policy Office, (NEPO). The Thai power reform process has been underway for more than a decade.
5	Government Policy for Distributed and Captive Generation	Thailand has been meeting electricity demand by steadily increasing the generation capacity, through new state-owned plants, imports of electricity, and new independent power producers and small power producers (SPPSs).

Table 4.4: Evidence from Thailand

187 Structured Interview, Questionnaire and mailers are done with following matrix:

Technological Option	**Govt Source**	**Private Sector**	**Targeted question I**	**Targeted question II**	**Targeted question III**
Generation	UPRVUNL UPRVNL	Industrial Captive plants	Technology choice	Grid Integration	Fuel Availability
Transmission	PGCIL, SEB		Grid Quality	Grid performances	Limitations
Distribution	SEB,	Torrent Power	Power Loss	ROI	Limitations

Table 4.5: Data collection Methodology - Technology Feasibility

Political economics	**Sample Count**	**Targeted question I**	**Targeted question II**	**Targeted question III**
Industrial Users	100	Subsidy	Pricing	Availability
Domestic users	150	Pricing	Availability	Theft
Media	5	Corruption	Theft	Public Grievances
Power Distribution Agency	2	Theft	Pricing	Collection

Table 4.6: Data collection Methodology - Political Economy Feasibility

Validity and Reliability Check of Questions: Validity and Reliability Check of Questions checked using Chronbach's alpha test that discussed in discussion chapter.

4.4 Sampling

• Apart from offering above referred advantages, Uttar Pradesh fulfills the authors a natural Convenience sampling.

• For primary data, research will be conducted on Kanpur city based on purposive sampling.

Statistical tool: Creation of charts, tables, and frequencies will be done using Excel packages.

4.5 Data Reliability Test

Reliability is defined as the extent to which a questionnaire, test, observation or any measurement procedure produces the same results on repeated trials. In short, it is the stability or consistency of scores over time or across raters, that means reliability pertains to scores not people. Here reliability check of Questions is checked using Chronbach's alpha test. Cronbach's alpha allows us to estimate the reliability of a composite when we know the composite score variance and the covariances among all its components Crocker and Algina (1986).

Cronbach's alpha is a measure of internal consistency, that is, how closely related a set of items are as a group. It is a coefficient of reliability The major use of reliability coefficients is to communicate the repeatability of results Nunnally and Bernstein (1994)

A high value of alpha (Greater than 0.7) is often used as evidence that the items measure an underlying (or latent) construct as obtained in the result.

S.175	1	0	0	0	0	0	1	1	1	0	4
S.176	1	0	0	1	1	1	1	1	1	1	8
S.177	1	0	1	0	0	1	1	1	0	1	6
S.178	1	1	1	1	1	1	1	1	1	1	10
S.179	1	0	0	1	1	1	1	1	1	1	8
S.180	1	0	1	0	0	1	1	1	0	1	6
S.181	1	1	1	1	1	1	0	1	1	1	9
											= (e.g.) VAR(L6:L10)
Item variances	0.13	0.24	0.25	0.24	0.24	0.13	0.14	0.13	0.18	0.21	

Sum of item variances = 1.888=SUM(C12:L12)

Number of items = 10=COUNT(C12:L12)

Cronbach's alpha = 0.749490 =G14/(G14-1)*(1-(G13/(O8^2))) = k/(k-1)* (1- (Sum of Item Variances/((SD persons)^2)))

4.6 Survey Analysis: Existing condition

4.6.1 Citizen's Charter of Uttar Pradesh Power Corporation Ltd

As per website Uttar Pradesh Power Corporation Ltd. is bound by this Charter as detailed below.

1. Efforts to provide better supply of power to all types of consumers according to its availability.

2. Efforts to provide power connection to all categories of its consumers connections

such as domestic/on domestic, Light and Fan, Irrigation (PTW /STW), Industrial, Temporary and Permanent Connections.

3. To simplify the procedures for providing connections and making it time bound to all type of consumers, such as domestic / Non domestic, light and Fan, Private Tube wells, Industrial units etc.

4 Efforts for the early disposal of complaints of consumers.

5. Efforts to provide better, friendly and co-ordinated consumer service.

6. To transmit the information of its programs and plans to Public through the peoples representatives, and Public Relation media.

7. Efforts of the corporation to apprise prospective Consumers about all relevant rules and regulations regarding release of power Connections.

8. Wide publicity of all the notices regarding power cuts.

9. Prorogation of mass education programs to stop misuse of electricity and importance to make it more useful.

10. Displaying all the important notices pertaining to consumers at the Notice board of all the Divisions ans Sub-division offices.

11. All the services provided by the department to consumers are the rights of the Consumers without giving any bribe.

Website of U.P. Power Corporation Ltd.

(a). All the information regarding electricity connection, Billing, Commercial and power supply are available on the website http://www.uppcl.org.

(b) Any other informations including theft of Electricty can be given by the consumer at the website http://www.powerup.org.

Charter for release of Domestic / Non Domestic L&F connections.

Information to consumers regarding new connections:

1. Consumers desirous to obtain L/F connection upto 7.5 kw and having the distance from the LT pole upto 40 mts can obtain the prescribed application form free of cost from the sub-divisional office and shall deposit it after filling the desired informations along with duly filled B & L form alongwith the prescribed processing charges in SDO's office.

After the reciept of application, the consumer shall be provided with the relevent terms and condions charges with in a weekand accordingly the security charges and service line charges shall have to be deposited by the applicant alongwith the Declaration duly signed by two witnesses with their full residential addresses. After completion of the above formalities if no shortcoming is found at the premises of the consumer, his power connection shall be released within 15 days.

2. Formalities required to be completed for new electricity connections.

(a) Certificate of being the land Lord / Tenant of the premises.

(b) Decleration on a plain paper (Stamp paper not required)

(c) B & L form.

(d) Security charges @ Rs 300 per kilowatt or part thereof,.

(e) Service connection charges

i) Single Phase - Rs.203

ii) Three Phase - Rs. 218

Redressal of Consumer Problem / Complaints

To educate the consumers and redressal of their problem / complaints about electricity the sub-ordinate offices of the corporation viz distribution Divisions and sub-division organize various Camps at different places after wide publicity. The concerned officer / officials shall be present to redress the problems on the spot.

In the zonal, circle, divisional offices various complaints of consumers / public which are lodged by VVIP/VIP and are of important nature are disposed off and monitoring of decision on them are also ensured. In power corporation to attend the various complaints of the consumers such as wrong/excess billing,non receipt of bills, non replacement/delay in replacement of defective meters, disconnection, reconnection,payment of arrears, a Bijilee adalat has been constituted at each district level to settle the revenue matters at a fast pace. State level, also a Bijli Adalat has also been constituted.

4.6.2 Feeder data analysis

Data retrieved from KESCO revealed that both the power outage on account of Rostering and Break down is very high. This impact both residential as well as industrial sector.

This clearly paves a way for small distributed generation option with or without grid connectivity. The Small distribution Generation set up can fulfill the power crisis based on existing Feeder connected consumers. Any surplus power can be shared with other demanding Feeders.

A community based Distribution generation can be an alternate option too.

Id	**Date**	**Division**	**Time**	**Type**	**Feeder Name**	**Interruption**	**Duration**
1	09-09-2013	Aloo Mandi	10:38:57	220/132 KV	220 KV S/S RPH	Roastering	3 hrs
2	09-09-2013	Dada Nagar	10:38:38	220/132 KV	220 KV S/S Panki	Roastering	3 hrs
3	09-09-2013	Govind Nagar	10:36:18	220/132 KV	220 KV Panki	Roastering	3 hrs
4	09-09-2013	Govind Nagar	10:35:31	220/132 KV	220 KV Naubasta	Roastering	3 hrs

5	09-09-2013	Dada Nagar	10:35:01	220/132 KV	132 KV S/S Dadanagar	Roastering	3 hrs
6	09-09-2013	Zareeb Chauki	10:34:26	220/132 KV	132 KV S/S Azad Nagar	Roastering	3 hrs
7	09-09-2013	Harrish Ganj	10:33:41	220/132 KV	132 KV Krishna Nagar	Roastering	3 hrs
8	09-09-2013	WB Barra	10:32:41	220/132 KV	132 KV Dadanagar	Roastering	3 hrs
9	09-09-2013	Electricity House	10:31:08	220/132 KV	132 KV Azad Nagar	Roastering	3 hrs
10	09-06-2013	Electricity House	21:18:30	220/132 KV	132 KV Azad Nagar	Roastering	2 hrs
11	09-06-2013	Electricity House	21:17:56	220/132 KV	132 KV Azad Nagar	Roastering	2 hrs
12	07-09-2013	Electricity House	12:01:06	33/11 KV	33/6.6 KV Muir Mill	Shutdown	4 hrs

13	07-09-2013	Electricity House	12:00:59	33/11 KV	33/6.6 KV Muir Mill	Shutdown	4 hrs
14	07-08-2013	Harrish Ganj	15:02:29	33 KV	Wajidpur	Breakdown	4 hrs
15	07-08-2013	Harrish Ganj	15:01:46	33 KV	Jajmau	Breakdown	4 hrs
16	07-08-2013	Harrish Ganj	15:01:38	33 KV	Jajmau	Breakdown	4 hrs
17	07-08-2013	Harrish Ganj	15:01:34	33 KV	Jajmau	Breakdown	4 hrs
18	07-08-2013	Govind Nagar	11:15:14	33 KV	G - 7	Breakdown	4 hrs
19	07-08-2013	Harrish Ganj	15:01:38	33 KV	Jajmau	Breakdown	4 hrs
20	07-08-2013	Harrish Ganj	15:01:34	33 KV	Jajmau	Breakdown	4 hrs
21	07-08-2013	Govind Nagar	11:15:14	33 KV	G - 7	Breakdown	4 hrs

Table 4.7: Feeder interruption, Data Source: http://www.kesco.co.in

Distribution Challenges:

Based on the surveyed and publish data it shows issues related to maintenance and theft (by way of unauthorized connection or tempered meter) contributes to the distribution loss as high at 30%. This losses leads to heavy financial loses to KESCO and forcing to shut downs due to no payment to power generation companies. Based on survey done on few areas like Chamanganj, Bakargank, Burra 1/2/3, major challenge for distribution

Figure 4.3: Electricity Steeling or in local Katiya in Karpur city

system is found to in appropriate maintenance and theft which is shown in Figure 4.3 and 4.4. Maximum numbers of thefts found are in the form of fraud (meter tampering), stealing (illegal connections), billing irregularities, and unpaid bills. Also, these thefts ae alos known as known as the Katiya in the local language

Figure 4.4: one more type of Katiya in Kanpur city

The illegal lines are easy to detect as they are often above ground and highly visible. However, one finds reports of staff being assaulted and needing police security to carry out the removal of the lines. Corrupt staff from the electricity organization may take bribes to allow the practice to continue. On a larger scale, businesses may bribe power organization staff to rig direct lines to their buildings or offices and the power does not go through a meter. The bribes can be much less than the cost of the power. Money also can be given to inspectors to keep them from finding and/or reporting the theft.

The major portion of losses are due to theft and pilferage that is estimated at about 20,000 crore annually, for entire India. The problem is compounded by the fact that no standard real time procedure exists for end to end tracking of anti-theft raids. Apart from rampant theft, the distribution sector is beset with poor billing (only 55 percent) and collection (only 41 percent) efficiency in almost in all States.

Reduction of ATC losses The reduction of ATC losses is generally done through a system of anti-theft raids and their scientific end to end tracking. There has to be flawless electronic metering at consumer premises. There has to be improvement in collection efficiency through a system of effective disconnection of non-paying consumers. Option has to be developed for real time tracking system that ensures end to end tracking of in-field revenue oriented activities of:

- Raids conducted against electricity theft,
- Replacement of defective meters at consumer premises,
- Disconnection of power supply of nonpaying consumers
- And subsequently FIRs under section 138 (lodged in case above consumers reconnect supply without paying dues.

The level of demand in Kanpur is larger than the amount that can be accommodated by small PV systems but smaller than the amount needed to capture significant economies of scale to be served by the grid, meaning the load factor does not support the grid investment. The small manufacturing facility and demand from the village require reliable and high quality three-phase power.

Most of the power systems in different states of India devote inadequate resources and effort to generation, transmission and distribution systems and do not use the latest

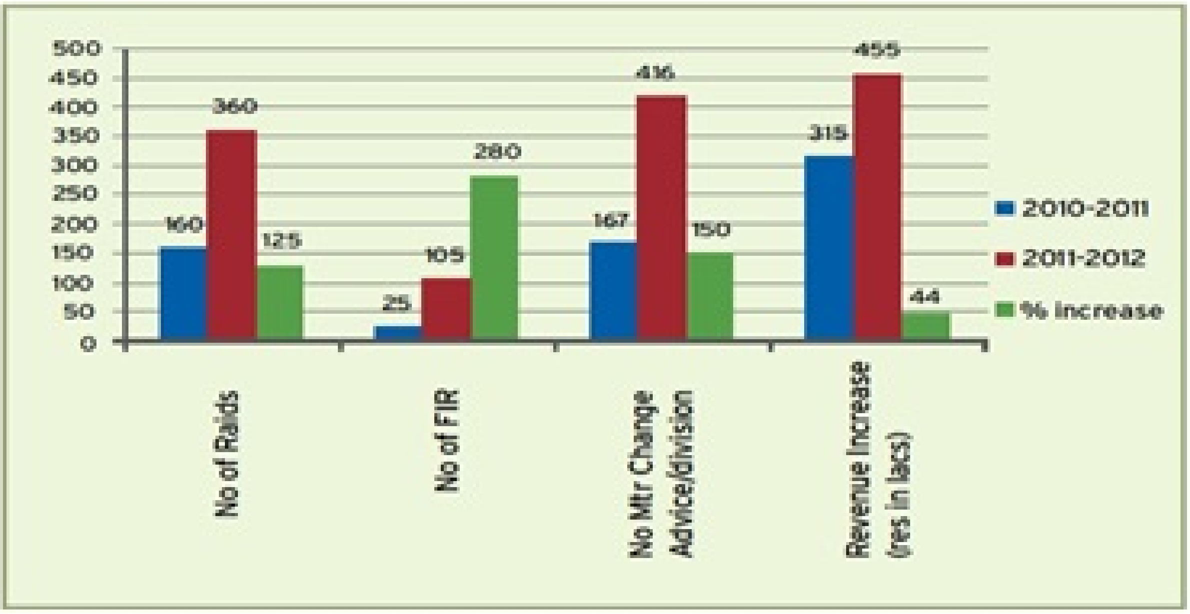

Figure 4.5: Raids and FIR to control Power theft

technologies. The investment necessary to reduce losses includes upgrading power lines, transformers, information technology monitoring systems, and installing and maintenance of modern metering systems that are at the interface of the organization and the consumers of the electricity.

In this situation three energy options are available to Kanpur/ Uttar Pradesh.

- First, it can continue with low quality, but highly subsidized grid power;

- Second, install a diesel genset for all uninterruptible demands and thus pay a high marginal cost for the power; or

- Thirdly, install a hybrid system that allows for reliability while reducing the amount of diesel fuel that needs to be transported to the area.

This research examines the economic and operational results from the optimization modeling of a hybrid system for Kanpur.

4.7 Hybrid power systems

Hybrid power systems are combinations of two or more energy conversion devices (e.g., electricity generators or storage devices), or two or more fuels for the same device, that when integrated, overcome limitations that may be inherent in either.

Hybrid systems can produce synergistic benefits in which the whole is greater than the sum of its parts. System efficiencies are typically higher than that of the individual technologies used separately, and higher reliability can be accomplished with redundant technologies and/or energy storage. Some hybrid systems include both, which can simultaneously improve the quality and availability of power.

In general, well-designed hybrid systems will substantially reduce diesel fuel consumption while increasing system reliability. In addition to the diesel generator and the renewable energy generator, hybrid systems consist of a battery bank for energy storage, a control system and particular system architecture that allows optimal use of all components.

Hybrid systems are potentially very cost-effective solutions to rural AC electricity needs. For low load applications ($<$ 10 kWh/day), Wind/PV Hybrid Systems are very attractive. For Larger Applications, Wind/Diesel Hybrids are very attractive as long as a reasonable wind resource is available. Bilateral and multilateral finance and market stimulation programs should be based on best service at least cost.

Hybrid Power Systems Offer Advantages. Hybrid Power Systems Hybrid power generation systems can combine solar, wind, battery and generator power. The Possible options for Hybrid Models are as follows:

Grid connected renewable based power system

Grid-interactive renewable power projects based on wind power, biomass, small hydro and solar are mainly private investment driven, with favorable tariff policy regimes established by State Electricity Regulatory Commissions (SERC), and almost all-renewable power capacity addition during the year has to come through this route.

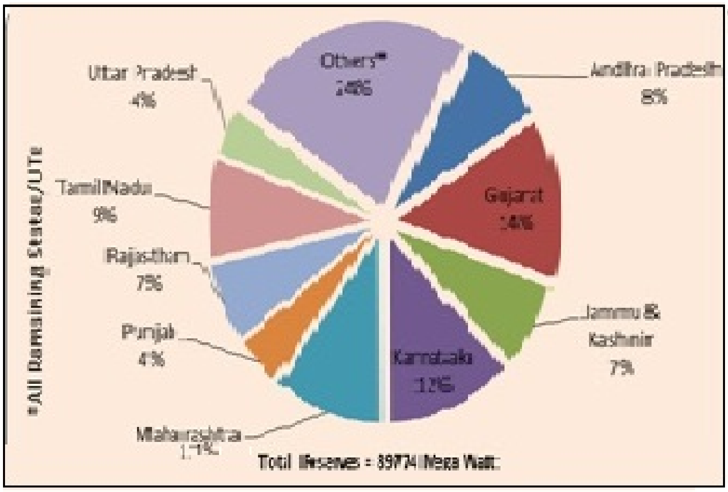

Figure 4.6: State wise Estimated Potential of Renewable Power

Wind Power

Wind power installable potential of the country has been estimated with reference to Indian Wind Atlas and insitu measurements. On a conservative consideration, a fraction of 2% land availability for all states except Himalayan states, Northeastern states and Andaman Nicobar Islands has been assumed for energy estimation. In Himalayan states, Northeastern states and Andaman & Nicobar Islands, it is assumed as 0.5%. However the potential would change as per the real land availability in each state.

Installable wind Potential:

States / UTs	Installable Potential (MW) at 50 m Level
Andaman & Nicobar	2
Andhra Pradesh	5394
Arunachal Pradesh*	201
Assam*	53
Chhattisgarh*	23
Gujarat	10609
Himachal Pradesh *	20

Jammu & Kashmir *	5311
Karnataka	8591
Kerala	790
Lakshadweep	16
Madhya Pradesh	920
Maharashtra	5439
Manipur*	7
Meghalaya *	44
Nagaland *	3
Orissa	910
Rajasthan	5005
Sikkim *	98
Tamil Nadu	5374
Uttarakhand *	161
Uttar Pradesh *	137
West Bengal*	22
Total	**49130**

Table 4.8: Installable wind Potential, Data Source:Centre for Wind Energy Technology

Data Source:Centre for Wind Energy Technology http://www.cwet.tn.nic.in

Solar Power: Among the various renewable energy resources, solar energy potential is the highest in the country. In most parts of India, clear sunny weather is experienced 250 to 300 days a year. The annual radiation varies from 1600 to 2200 kWh/m2, which is comparable with radiation received in the tropical and sub-tropical regions. The equivalent energy potential is about 6,000 million GWh of energy per year. The National Action Plan on Climate Change also points out: "India is a tropical country, where sunshine is available for longer hours per day and in great intensity. Solar energy, therefore, has great potential as future energy source. It also has the advantage of permitting the decentralized distribution of energy, thereby empowering people at the grassroots level".

With the objective to establish India as a global leader in solar energy, by creating the policy conditions for its diffusion across the country as quickly as possible Government of India launched National Solar Mission. The National Tariff Policy was amended in January 2011 to prescribe solar-specific RPO be increased from a minimum of 0.25 per cent in 2012 to 3 per cent by 2022. CERC and SERCs have issued various regulations including solar RPOs, REC framework, tariff, grid connectivity, forecasting etc. for promoting solar energy. Many States have come up with up their own Solar Policy.

In view of the ongoing efforts of Central and State Governments and various agencies for promoting solar energy, Ministry of New and Renewable Energy has undertaken an exercise to track and analyze the issues in fulfillment of Solar Power Purchase Obligation and implementation of Solar REC framework in India. This would help various stakeholders to understand the challenges and opportunities in the development of solar power. It would also include monitoring of Solar RPO Compliance; analyzing key issues related to the regulatory framework for solar in various states of India.

Sr. No.	**States**	**Installed Capacity (MW)**
1	Andhra Pradesh	23.15
2	Arunachal Pradesh	0.025
3	Chhattisgarh	4
4	Delhi	2.525
5	Goa & UT	1.685
6	Gujarat	824.09
7	Haryana	7.8
8	Jharkhand	16
9	Karnataka	14
10	Kerela	0.025
11	Madhya Pradesh	11.75

12	Maharashtra	34.5
13	Odisha	13
14	Punjab	9.325
15	Rajasthan	442.25
16	Tamil Nadu	17.055
17	Uttarakhand	5.05
18	Uttar Pradesh	12.375
19	West Bengal	2
	Total	1440.605

Data Source; MNRE as of 09 March 2013

Table 4.9: Solar Power installed Capacity

Biomass

Biomass has always been an important energy source for the country considering the benefits it offers. Potential of Biomass as taken example of Bagassed based power plant in India is shown in Figure 4.7. It is renewable, widely available, carbon-neutral and has the potential to provide significant employment in the rural areas. Biomass is also capable of providing firm energy. About 32% of the total primary energy use in the country is still derived from biomass and more than 70% of the country's population depends upon it for its energy needs. Ministry of New and Renewable Energy has realised the potential and role of biomass energy in the Indian context and hence has initiated a number of programmes for promotion of efficient technologies for its use in various sectors of the economy to ensure derivation of maximum benefits. Biomass power generation in India is an industry that attracts investments of over Rs.600 crores every year, generating more than 5000 million units of electricity and yearly employment of more than 10 million man-days in the rural areas. State Wise / Year-Wise List of Commissioned Biomass Power / Co generation Projects (as on 31.03.2011) (In MW) is shown in Table 4.10. For efficient utilization of biomass, bagasse based cogeneration in sugar mills and biomass

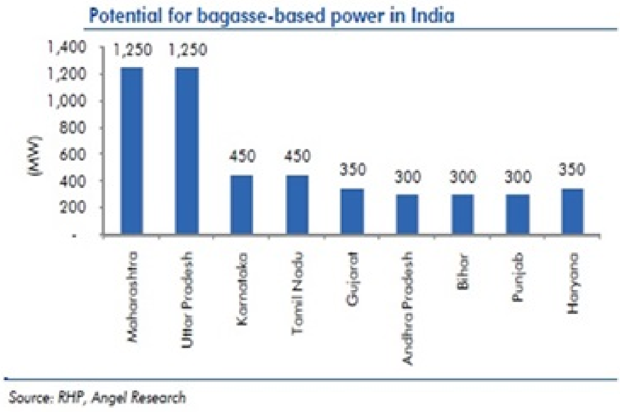

Figure 4.7: Potential for bagasse-based power in India

power generation have been taken up under biomass power and co generation program.

S.No.	State	Upto 2003	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	Total
1	Andhra Pradesh	160.05	37.7	69.5	12	22	33	9	20	..	363.25
2	Bihar		–	–	–	–	–	–	–	9.5	9.5
3	Chattisgarh	11	–	–	16.5	85.8	33	9.8	43.8	32	231.9
4	Gujarat	0.5	–	–	–	–	–	–	–	–	0.5
5	Haryana	4	–	2	–	–	–	–	1.8	28	35.8
6	Karnataka	109.38	26	16.6	72.5	29.8	8	31.9	42	29	365.18
7	Madhya Pradesh		1	–	–	–	–	–	–	–	1
8	Maharashtra	24.5	–	11.5	–	40	38	71.5	33	184.5	403
9	Punjab	22	–	–	6	–	–	–	34.5	12	74.5
10	Rajasthan		7.8	–	7.5	8	–	8	–	42	73.3
11	Tamil Nadu	106	44.5	22.5	–	42.5	75	43.2	62	92.5	488.2
12	Uttarakhand	–	–	–	–	–	–	–	–	10	10
13	Uttar Pradesh	46.5	12.5	14	48.5	–	79	172	194.5	25.5	592.5

14	West Bengal		–	–	–	–	–	–	16	–	16
	Total	**483.9**	**3129.5**	**136.1**	**163**	**228.1**	**266**	**345.4**	**447.6**	**465**	**2664**

Table 4.10: State Wise / Year-Wise List of Commissioned Biomass Power / Co generation Projects (as on 31.03.2011) (In MW)

Ministry of new & renewable energy, Govt. of India has started providing subsidies and CFA for the Biowaste to biogas Power Generation Plants in India. This is for the small communities like schools, hospitals, hostels, or for any organizations. Latest example is Potato waste biogas genearation plant in Lukhnow city of Uttar pradesh as shown in Figure 4.8.

Figure 4.8: 85 cubic meter Biowaste based Power Generation Plant

This is 85 m^3 K.V.I.C Floating drum type with water jacket, external guide frame for gas holder and a gas cleaning system. The value of the plant is equal to the sum of the

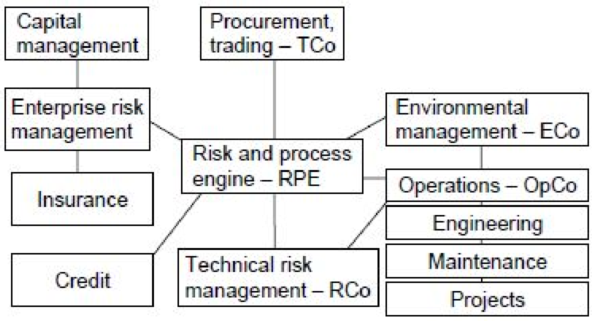

Figure 4.9: Cost structure of power plant

cash flows, discounted at the risk free rate, minus the cost of risk, applied individually to each profit centre, with a centralized aggregation of the risk diversity benefit, handled by capital management. These are shown in Figure 4.9.

HOMER Model

HOMER stands for the Hybrid Optimisation Model for Electric Renewables and was developed by the National Renewable Energy Laboratory in Golden, Colorado, USA. HOMER was developed as a hybrid system design tool accurate enough to reliably predict system performance, but simple and efficient enough to conveniently evaluate a large number of design options and then rank the results to find the optimum configuration (NREL, 2003). HOMER identifies the least cost system for supplying electricity to remote loads by performing hourly simulations of thousands of potential power systems and rank ordering them by life cycle costs. It also performs sensitivity analyses to evaluate the impact of a change in any of the input parameters and provides both annual and hourly outputs in tabular and graphic form. Hybrid system design is made difficult by the intermittency of renewable resources, the need to match electrical supply and demand, and the large number of potential component size combinations. It is also well tested and validated (Lilienthal, Flowers et al. 1995).

HOMER is a computer model that simplifies the task of designing hybrid renewable microgrids, whether remote or attached to a larger grid. HOMER's optimization and sensitivity analysis algorithms allow you to evaluate the economic and technical feasibility of a large number of technology options and to account for variations in technology costs and energy resource availability. Originally designed at the National Renewable Energy Laboratory for the village power program, HOMER is now licensed to HOMER Energy. HOMER provides the detailed rigor of chronological simulation and optimization in a model that is relatively simple and easy to use. It's adaptable to a wide variety of projects. For a village or community-scale power system, HOMER can model both the technical and economic factors involved in the project. For larger systems, HOMER can provide an important overview that compares the cost and feasibility of different configurations; then designers can use more specialized software to model the technical performance. HOMER is accessible to large set of users, including non-technical decision makers. Chronological simulation is essential for modeling variable resources, such as solar and wind power and for combined heat and power applications where the thermal load is variable. HOMER's sensitivity analysis helps determine the potential impact of uncertain factors such as fuel prices or wind speed on a given system, over time.

4.8 Conclusion

SEB, in the present situation, needs to adopt a multi-pronged strategy wherein all the following options could be utilized for improve power supply scenario in the State:

- Additional short-term power purchase from other States and traders to tide over the immediate supply shortage;
- Improving the distribution efficiency by reducing distribution losses; and
- Installation of short-gestation distributed generation facility.

The Government separately work on the first option in respect to a petition filed by SEB as well as in the Tariff Order as and when required. As regards second option, though SEB has undertaken Internal Reforms Programs, for improving the distribution efficiency; the results do not appear to be encouraging, as no tangible improvement has been noticed. Further, reforms is a necessary but long drawn process. Therefore, it is imperative that SEB identifies certain short term approaches to improve power supply scenario in the State. The third option indicated above envisages installation of short-gestation generation capacity either in the form of conventional sources of generation such as liquid fuel or non-conventional sources such as small hydro, wind, biomass, etc., to make more generation available as well as reduce technical losses by making generation available at consumer end. Further, if the generator takes responsibility for distribution in the area as a franchisee of the licensee, this integrated distribution franchisee could be instrumental in bringing much needed reforms in the sector.

In this context, this Hybrid Distributed Generation could also be useful in bringing in competition for private sector participation. In several States, distribution reforms have been initiated and implemented by adopting privatization and/or Franchisee models. Privatization with sale of equity of more than 51%, transfers the control of the organization to the majority equity holder. Franchisee option, on the other hand, retains the ownership of the system with the Distribution Licensee, while allowing the private sector to function with relative independence. Further, it is possible to implement franchisee structure with wide variety of other legal structures such as co-operative societies, industrial estates, panchayati raj institutions, local bodies, industrial associations, etc.

It is important to note that in Uttar Pradesh, it is essential to increase electricity generation locally without overloading the existing transmission system. Therefore, it is essential to identify an appropriate model, which would allow local (distributed) generation and distribution of power with the involvement of co-operatives, private sector, etc. Considering that distributed generation is likely to be more expensive than average power purchase cost of the utilities, cost reflective tariffs for such supply are bound to be higher than the average tariffs of the utilities. Therefore, such an arrangement would primarily suit urban and semi-urban areas, as well as dedicated industrial feeders, where ability to pay higher tariffs exists. Public-private partnership can play an important role in provision of these services.

Rural areas need not be left out as electricity is acknowledged as a basic necessity for improving the standard of living. Increasingly, agriculture and cottage industry are dependent on electricity as source of energy. Rural electrification is also a major thrust area identified by the Central Government. The concept of distributed generation based electricity distribution Franchisee can also be suitably adopted for rural areas, if beneficiaries demonstrate willingness to pay appropriate cost reflective tariffs or the State Government provides the necessary subsidy concession. Though, this Approach Paper is focused towards introduction of this Model in urban and industrial areas, it should be noted that benefits of this approach would be profound if it could be implemented in rural areas as this approach will obviate investment in network as well as technical losses over long drawn networks.

CHAPTER 5

Results & Discussion

5.1 Feasibility for Bottom UP Distribution Generation model, with respect to Developing countries

The provision of reliable electricity supply is vital to economic development in Third World nations. Apart from its important domestic and water pumping applications, electricity is a basic input into post-subsistence economic activity that allows communities to move from primary products into the processing of commodities, production of semi-finished goods and the creation of a manufacturing base. It also increases educational opportunities, improves the quality of life and permits access to information technologies. To the extent that it replaces traditional fuels, electricity improves indoor air quality, in turn leading to improved health and safety. In the long run, reliable electricity supplies connect remote rural communities to the wider manufacturing and service economies of a country.

The provision of electricity in rural areas of developing countries, however, continues to be beset by poor service and inefficient state-run utilities. In India, 40 percent of the population still does not have an electric connection, but an array of new energy technologies-called distributed generation for small-scale electricity generation near the site of use may provide the chance to leapfrog to a new stage where ample electricity is available to meet demand, reliably, and in an economically and environmentally sustainable manner. The economic viability of distributed generation in Kanpur, India, taking into account the economic, engineering and political factors that shape investment decisions.

Five Point feasibility approach is taken based on following points:

1. Market and Demand Analysis

2. Financial Analysis

3. Technical Analysis

4. Social Cost benefit analysis/Economic Analysis

5. Ecological Analysis

5.1.1 Market and Demand Analysis

Power Supply scenario of Uttar Pradesh provides a huge market and demand opportunity for power supply systems. With streamlined interconnection procedures, regulators can decide under what terms and conditions DG will be allowed access to the electricity grid, and how to meter and pay for such access. In a vertically integrated electricity market, distributed generation either displaces electricity from the grid or exports electricity back to the grid. Normally, this involves a long-term contract with the utility that includes special charges for backup power, ancillary services and the exported electricity.

Market liberalization in most developing countries is still in its early stages, DG grid access will likely operate in a more regulated context, at first through contracts with the utility or distribution company. Governments should facilitate DG power generation by industrial users, particularly the use of combined heat and power, and where possible the sale of excess power back to the grid during peak periods. DG growth in remote areas, through the establishment of micro-grids and home systems, also has tremendous potential. Gradually, as developing country electricity markets become more competitive and sustainable, DG can be allowed to compete with electric utilities in wholesale and perhaps eventually in retail markets. With greater market access, however, also comes increased structural, operational and price complexities that will have to be managed by independent regulators.

Under the State Electricity Act, 2003, the various state-level electricity regulators have

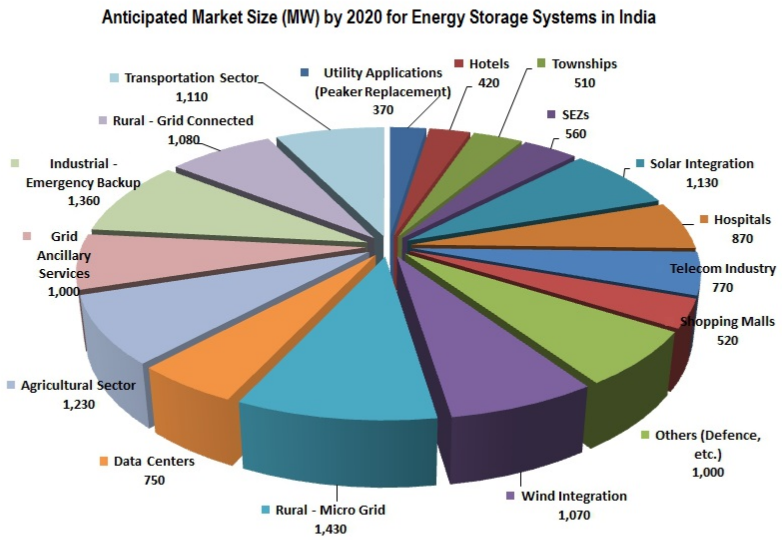

Figure 5.1: Anticipated Market size

specified a renewable purchase obligation. Accordingly, a set percentage of power must come from renewable sources. In case of UP this target has been set at 5%, of which 0.5% has to be from solar energy. However, UP has failed to achieve this target by falling short of about 50%.

Uttar Pradesh also lags behind other states in the country in production of electricity through solar energy. While Gujarat produces 850 MW of electricity through solar energy, followed by Rajasthan at 201 MW, in Uttar Pradesh this figure is a meager. The first megawatt-capacity solar power plant had become operational in Uttar Pradesh in January 2013 in Barabanki (a 2 MW project).

The majority of power generated in Uttar Pradesh is reliant on coal, while the limited availability and high prices of coal have aggravated the precarious power situation in UP. Hence, there is an obvious need to develop alternate sources of energy. Uttar Pradesh is rich in renewable energy recourses such as biomass, solar and bio-fuels, of which only biomass has been considerably exploited. Uttar Pradesh is blessed with a good solar irradiation to the tune of 1,800 KW/h per mš on an annual average basis, which is considered necessary for operating a solar photovoltaic power plant. Thus, there are immense possibilities in this sector. Growth of renewable energy would definitely help the state in meeting its energy requirements.

Small Hydro: Allotment of identified small hydro projects of a total capacity of 11 MW to the private developers under the small hydro policy of the State is in progress.

Solar Energy: Govt. of India has sanctioned, 5 grid connected solar power projects in Uttar Pradesh having a total capacity of 8 MW, to the private developers under the National Solar Mission. Biomass: With the demand for non-renewable sources increasing, the biofuels business is opening new opportunities for entrepreneurs. Several countries, including India, have started attending to biofuels to counter pollution and reduce their dependence on fossil fuels. The business potential of biofuels for entrepreneurship activities in India is huge, and can be expected to grow at a faster pace in the years to come. The potential of the biomass resources has been estimated at about 3757 megawatt in the State. Power generation capacity of 1331.14 megawatt has been achieved in the private sector sugar mills, rice mills, paper mills and other industrial units, out of which 969.18 megawatt is bagasse based.

Biomass Power in India - Now and Future

Parameter	Now (2012)	Future (2020)
Distributed electricity generation	Biomass Power (agro-wastes/residues) has a minor contribution of 13% of the total grid connected renewableăwhile it contributes to nearly 73% of off-grid power.	Estimates of potential in the future for power from biomass in India varies from about 18,000 - 50,000 MW
Use in co-firing in power plants	Fewer than 1% of power plants use biomass	A much larger proportion of plants will be powered by biomass
Use of feedstock	Primarily waste biomass and assorted	Dedicated energy crops

Related revenue streams	Some additional revenue streams already present	A more established end user market for co-products
Standalone renewable power source?	Primarily standalone mode	Will be used in conjunction with other renewable electricity sources

Table 5.1: Biomass Power in India - Now and Future

With low power availability for Agriculture sector in UP, it also opens an opportunity and standalone Distributed Power generation.

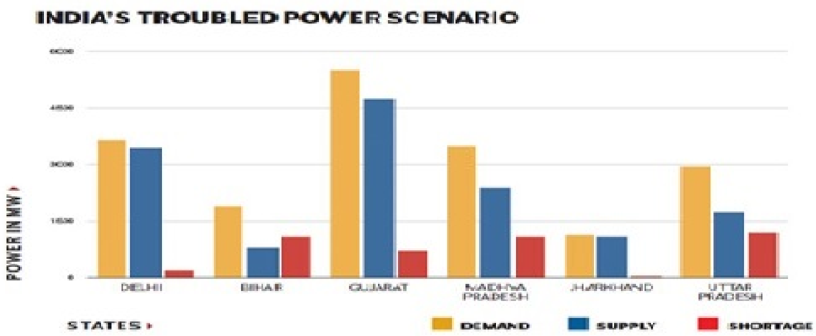

Figure 5.2: India's trouble

5.1.2 Financial feasibility

Electricity Pricing is a barrier to distributed generation is the utility tariff rate. With interconnection standards and expedited interconnect procedures for DG in place, developing country governments will need to adopt appropriate market signals to take into account the complete range of benefits provided by distributed generation. While DG should be allowed to fairly compete with central power, it must also bear its fair share of the costs imposed on the transmission and distribution system. A number of different factors need to be taken into account when developing an appropriate tariff and fees system for distributed generation.

Financial analysis is done based on Levelized cost of electricity (LCOE Levelized cost of electricity (LCOE) is often cited as a convenient summary measure of the overall competiveness of different generating technologies. It represents the per-kilo Watt hour cost (in real dollars) of building and operating a generating plant over an assumed financial life and duty cycle. Key inputs to calculating LCOE include capital costs, fuel costs, fixed and variable operations and maintenance (O&M) costs, financing costs, and an assumed utilization rate for each plant type. The importance of the factors varies among the technologies. For technologies such as solar and wind generation that have no fuel costs and relatively small variable O&M costs, LCOE changes in rough proportion to the estimated capital cost of generation capacity. For technologies with significant fuel cost, both fuel cost and overnight cost estimates significantly affect LCOE. The availability of various incentives, including state or federal tax credits, can also impact the calculation of LCOE. As with any projection, there is uncertainty about all of these factors and their values can vary regionally and across time as technologies evolve and fuel prices change.

It is important to note that, while LCOE is a convenient summary measure of the overall competiveness of different generating technologies, actual plant investment decisions are affected by the specific technological and regional characteristics of a project, which involve numerous other factors. The projected utilization rate, which depends on the load shape and the existing resource mix in an area where additional capacity is needed, is one such factor. The existing resource mix in a region can directly impact the economic viability of a new investment through its effect on the economics surrounding the displacement of existing resources.

Installed cost, Fixed O&M cost and Useful life Installed costs for small distributed generators are as follows:

Fixed Operations and Maintenance costs are as follows:

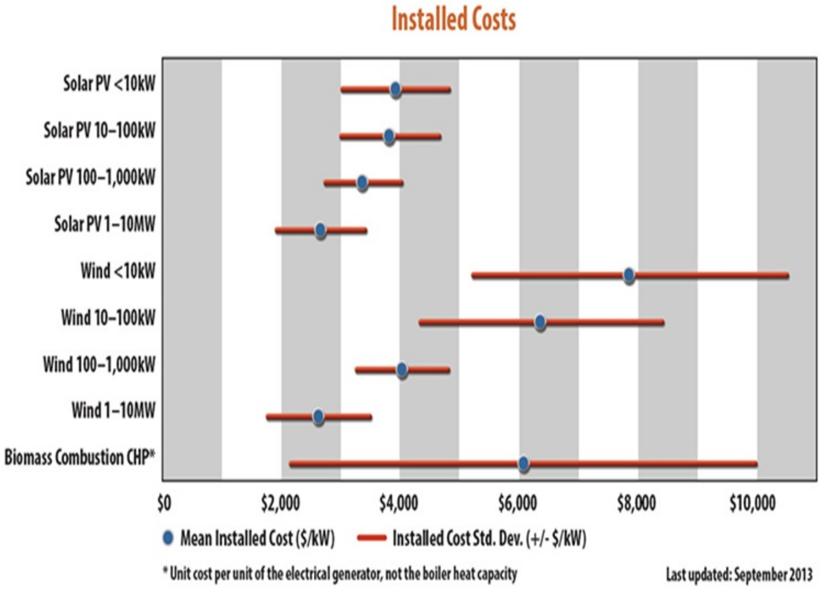

Figure 5.3: Installed cost

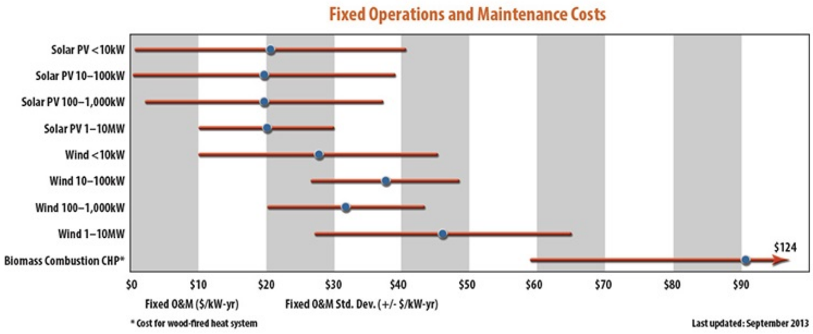

Figure 5.4: Fixed and maintenance costs

Based on above factors levelized Cost of Utility Electricity and Simple Cost of Utility Electricity is calculated as follows:

Levelized Cost of Utility Electricity for 1 MW

Factor	**UOM**	**Solar PV**	**Wind**	**Bio mass**	**Source**
Periods	Years	20	20	20	NREL
Discount rate %	%	0.1	0.1	0.1	Assumed
Capital Cost $/KW	$/kW	2800	2800	6000	NREL

Capacity factor	%	25	50	65	NREL
Fixed O&M cost	$/kW	20	46	90	NREL
Variable O&M cost	$/kWh	0	0.005	0.01042	NREL
Heat Rate	Btu/KWh	0	0	14500	NREL
Fuel cost	$/MMBtu	0	0	2	Literature review
Cost Escalation rate	%	3	3	3	Finance rate 10% and inflation 7%
Levelized Cost of Utility Electricity	(cents/kWh)	14	14	14	Calculated
Simple Levelized Cost of Renewable Energy	(cents/kWh)	7.4	4.8	10.9	Calculated
Levelized Cost of Utility Electricity	(INR/kWh)	8.4	8.4	8.4	Calculated
Simple Levelized Cost of Renewable Energy	(INR/kWh)	4.44	2.88	6.54	Calculated

Table 5.2: levelized Cost of Utility Electricity

5.1.3 Technical Feasibility

The detailed Review of literature revealed DG options can be classified either on the basis of the prime movers used like engines, turbines, fuel cells. The other option may be on the basis of fuel resources used. Renewable and non-renewable.

The technologies include biomass gasifiers, solar thermal and photovoltaic systems, small wind turbines (aero-generators), and small hydro-power plants. The economics and local suitability of a range of currently available DG technologies to Kanpur are summarized in Table 5.3. Biomass is then added for completeness because of its wide availability in other parts of Kanpur city. Technologies that require unavailable local energy resources, even if they offer excellent economic potential, will always be infeasible. A short description of each technology and the reason for their inclusion or exclusion from the shortlist are given in more detail below.

The electric power systems are undergoing major modernization process due to demands that are placed on the electrical grid, including environmental compliance, energy efficiency, improved grid reliability and customer-centric relationship management. All this has the effect on energy business from both technical and economic points of views.

Technology	**Efficiency %**	**O&M Cost ($/kWh)**	**Electricity Cost ($/kWh)**	**Technology Status**	**Suitability for Kanpur**
Microturbines	27-32	0.005	0.06-0.08	Commercial	No
Fuel Cells	40-60	0.0017	0.06-0.08	Pre-Commercial	No
Mico-hydro	80	0.001	0.09-0.15	Commercial	No
Biomass	25	0.01-0.12	0.07-0.14	Commercial	Yes
Photovoltaics	Jun-19	0.001	0.18-0.20	Commercial	Yes
Diesel	15-25	0.01	0.07-0.11	Commercial	Yes
Wind Turbines	25	0.01	0.03-0.07	Pre-Commercial	No

Table 5.3: Distributed Generation Economic Summary for Kanpur District

Fuel Cells:

Fuel cells convert hydrogen and oxygen into electricity, heat and water; and are an old technology that has been given renewed attention in the last two decades. However, the need for a high quality fuel supply, (e.g., natural gas), to produce the hydrogen limits their applicability in rural kanpur where no regular pipeline gas supplies exist. Fuel cells remain a pre commercial technology, and under even aggressive assumptions have capital costs that are too expensive for village electrification. Local maintenance capability is also nonexistent. For these reasons, fuel cell technology is not considered further for the case study.

Solar Photovoltaics:

The use of solar photovoltaics and solar thermal conversion technology was evaluated for kanpur and found to be expensive for small- and medium-scale power production. Capital costs of $3,000-6,000 per kW for solar technology (Barley, Meares et al. 1998; Bakos and Soursos 2002) mean it is applicable only in serving small or remote loads. High capital costs and a lack of local capacity to maintain the systems have also limited the opportunities to expand solar panel use. However, solar home systems (SHS) and small solar panel systems have been used in niche applications Malaviya and Ranade (1997); Ibrahim, Anisuzzaman et al. (2002), especially projects that require only lighting loads of 20-100 W. SHS systems do not have sufficient capacity to serve small rural industries and groups of villages with 50-100 kW demand profiles. However, for small, single village applications hybrid PV schemes may play an economical role, particularly when used in combination with other technologies in a hybrid scheme and when adequate power storage is available. PV in hybrid systems can be the most cost-effective solution in some situations, such as when the costs of diesel fuel delivery increase fuel prices by 15-50 percent Schmid and Hoffmann (2003).

Microturbines:

Microturbines operate on the same principle as gas turbines used in centralised power plants, by converting gaseous fuels into electricity using the expansion of hot combustion products. The advantage of the technology is that it is highly efficient compared to diesel gensets when the waste heat is used. Microturbines are available in many different sizes, from 75 kW - 1 MW. The disadvantage of microturbines is the higher relative capital costs, approximately $500 per kW compared to $200-$400 per kW for diesel Petrie, Willis et al. (2000). Microturbines also require a reliable and affordable fuel supply, preferably clean pipeline natural gas, which is not readily available in Kachchh. In addition, there is little experience in rural India with microturbines and no maintenance infrastructure exists. For these reasons they are not considered further.

Biomass & Biogas:

The use of biomass for energy needs in rural areas in India has been well documented Ravindranath and Hall (1995), AGL (1997) and many opportunities exist for further exploitation, depending on the local resources. Biomass energy systems take advantage of farm, manure and plant wastes which are normally readily available in rural areas, and either burn them for power or gasify them for fuel or electricity. The technology has been well tested and is technically feasible, but can require high levels of maintenance. For Kanpur, bulk of biomass available in the form of agriculture wastes, cattle wastes, permits the prospects of a biomass energy program in the district. The technology is therefore considered further for Kanpur with adequate biomass resources and is included in the modelling for comparison.

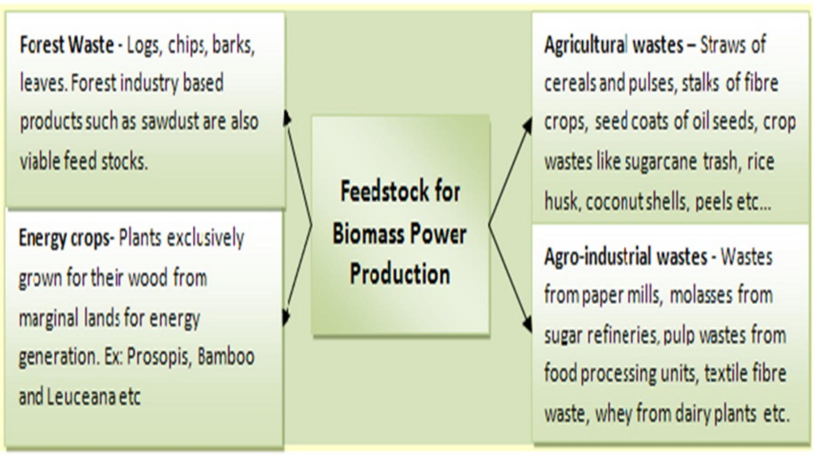

Figure 5.5: Feedstock availability

Diesel Generation:

Diesel gensets are the most commonly used system for DG and backup power applications in India. With relatively low up-front capital costs, easy installation, modularity, readily available technology, and a good maintenance infrastructure already in place, they are a viable option for many remote rural locations. Diesel fuel delivery systems are well developed across India because many irrigators use diesel gensets directly for water pumping, and small businesses and homes depend on gensets for power when the grid fails. However, high air and noise pollution, expensive fuel and constant maintenance costs for gensets translate into high unit power costs for rural users. As diesel is non renewable sourse it is not applicable for hybrid system.

Mini-hydroelectric:

Small-scale hydroelectric units have been used successfully in many parts of South Asia as a local energy solution (WEC 2000; Gunaratne 2002). The advantages of small hydro projects include: zero emissions, use of well-known and proven technology and the employment of local labour in their construction and maintenance (UN 1989). However, such projects require a steady flow of surface water, which is always available in Kanpur. Therefore this option is considered further.

5.1.4 Social Cost benefit analysis/Economic Analysis

According to International Energy Agency in Paris, France, in September 2002, over the next three decades, the investment needed for new power generation capacity in developing countries will amount to $2.1 trillion. Even if this investment is secured, in the absence of vigorous new policies, 1.4 billion people will still lack electricity in 2030. Four out of five people without electricity live in rural areas of the developing world, mainly in South Asia and sub-Saharan Africa. But the pattern of electricity deprivation is set to change, because 95% of the increase in population in the next three decades will occur in urban areas.

Some 2.4 billion people rely in traditional biomass like wood, agriculture residues and dung for cooking and heating, The number will increase to 2.6 billion by 2030. In developing countries, biomass use will still represent over half of residential energy consumption by 2030.

Lack of electricity and heavy reliance on traditional biomass are hallmarks of poverty in developing countries. Lack of electricity exacerbates poverty and con- tributes to its perpetuation, as it precludes most industrial activities and the jobs they create. In rural sub-Saharan Africa, many women carry 20 kilograms of fuel wood an average of five kilometers every day. The effort uses up a large share of the calories from their daily meal, which is cooked over an open fire with the collected wood. Poor people in the developing world are constantly exposed to indoor particulate and carbon monoxide concentrations many times higher than World Health Organization standards.

Traditional stoves using dung and charcoal emit large amounts of carbon monoxide and other noxious gases. Women and children suffer most, because they are exposed for the longest periods of time. Acute respiratory illnesses affect as much as 6% of the world population. The WHO estimates that 2.5 million women and young children in developing countries die prematurely each year from breathing the fumes from indoor biomass stoves.

In view of above observations Distributed generation can have following Social Cost benefits:

1. Green Jobs (20 Jobs per MW)
2. Reduced fossil fuel imports ($ 125 Billion Coal + Oil Import bill)
3. Energy Security (No coal in world market - OPEC, Geopolitical - Oil)
4. Local Community development
5. Economic Growth
6. Carbon Credits earned will help improving the NPV and IRR

Evaluation of Small-scale Electricity Generation

In order to better understand the potential for DG electricity systems, this work presents the results of fieldwork carried out in the Kanpur province of Utter Pradesh, both to quantify the problems in the power sector and to form a basis for comparison with hybrid, distributed systems. First part presents an overview of the resources available to supply power on a distributed basis in Kanpur, including: renewable, fossil fuel and hybrid systems that employ some combination of renewable and fossil fuel power, and often include battery storage. In second part, a scenario-based approach using the Homer optimization model is used to understand the costs of operating a hybrid power system in Kanpur within the constraints of rural environments. Inputs for the model are from existing data, pilot projects, and interviews with industry experts.

5.1.5 Ecological Feasibility

Distributed generation also raises important environmental issues. Fossil fuel DG technologies, for example, emit varying levels of emissions, including nitrogen oxides (NOx), sulfur dioxide (SO_2), carbon monoxide, carbon dioxide, particulate matter (PM-10) and unburned hydrocarbons. DG can also have noise, visual and land use impacts, particularly when used in densely populated urban areas. In India, for example, the most common use of DG has been on diesel generators, which are highly polluting. Similarly, other fossil fuel DG technologies, including gas turbines, are unable to compete environmentally with the low emissions levels from large combined-cycle natural gas fired plants with state-of-the-art pollution control technology. Proponents of DG note that distributed generation rarely displaces only one technology, such as natural gas. They contend that since DG tends to displace a mix of new and existing power generation with higher average emissions, environmental benefits are usually obtained. Gradually, developing country governments are becoming more sensitive to regional and global environmental concerns and are increasingly acknowledging the need to diversify their energy resources. An important question for policy makers is how to reduce the use of more polluting DG technologies and promote cleaner renewable DG technologies that are almost always more expensive.

India: Energy Sector GHG Emissions (million tonnes of CO_2 eq) in 2007

Sector	GHG emissions
Electricity	719.31
Transport	142.04
Residential	137.84
Other energy	100.87
Energy subtotal	**1100.06**

Figure 5.6: India's Energy sector

5.1.6 Conclusion

In order to better understand the potential for DG electricity systems, this work presents the results of fieldwork carried out in the Kanpur province of Utter Pradesh, both to quantify the problems in the power sector and to form a basis for comparison with hybrid, distributed systems. First part presents an overview of the resources available to supply power on a distributed basis in Kanpur, including: renewable, fossil fuel and hybrid systems that employ some combination of renewable and fossil fuel power, and often include battery storage. In second part, a scenario-based approach using the Homer optimization model is used to understand the costs of operating a hybrid power system in Kanpur within the constraints of mix urban and rural environments. Inputs for the model are from existing data, pilot projects, and interviews with industry experts.

The energy situation in rural India is characterized by a lack of access to modern fuels (oil, natural gas, propane, etc.), which leads to high use of locally available biomass and animal waste products to meet demand.

Access to a reliable supply of energy is one of the driving forces of development for rural communities in developing countries. However, state-owned electricity utilities often struggle to provide reliable service to remote rural areas due to lack of resources. In addition, the crumbling electricity grids cannot cope with existing connections, let alone expand into new areas. Large tariff subsidies have exacerbated the problem by diverting resources from the existing electricity supply industry, while simultaneously reducing the financial incentives for new entrants to produce power. One solution that has been used with some success in both the developed and developing world is to apply small-scale distributed generation (DG) technologies that utilize locally available energy resources.

DG has the advantage of reducing transmission and distribution losses, increasing local employment, utilizing local primary energy sources and allowing for incremental expansion of the electricity system with locally raised capital because of its small-scale modularity. However, cost per unit of power is normally higher for DG projects compared to large power plants. In addition to the technical T&D losses inherent in centralized power delivery models, there is the prevalence of power theft.

This builds the argument for using DG in India by summarizing the different technology options available for DG and comparing them with central, large power plant costs, including T&D. Focus is placed on Biomass hybrid system for the district of Kanpur in Uttar Pradesh.

5.2 Market presumption for Bottom UP Distribution Generation model

Electricity is not only one of the most important infrastructure sectors, but also a commodity that facilitates the development of an economy; bringing quality of life to people and creating necessary conditions for education levels improvement and health care facilities. Besides, the options chosen by a country to produce electricity have serious implications regarding tariffs, carbon emissions, environmental impacts, fossil fuel security from politically unstable regions, social inclusion, industry development, etc.

In this sense, policies to encourage or discourage the development of certain types of electricity sources must take into account a variety of reasons why they should be implemented and what would be their impacts, which can vary significantly according to the characteristics of the country and the electricity sector. This means that each country should evaluate its own particularities and establish what could affect, and be affected by, the deployment of a particular energy technology or a different source of electricity.

Among the different technologies for the expansion of electricity supply, countries have been encouraging the deployment of Distributed Generation REN21 (2010). This is because of possible better usage of electricity grids and, mainly, because DG usually is linked with renewable sources of energy (solar, wind, biomass) or more efficient ways of using traditional fuels (combined heat and power - CHP, or co generation).

The utilization of small, dispersed power plants in opposition to the traditional central generation schemes can often be justified by the potential benefits of these technologies. Or, as stated by Schumacher (1993), for his different purposes man needs many different structures, both small and large ones. However, this paradigm shift can hide negative impacts that are not always realized by policymakers when deciding which way to go.

Once the definition of distributed generation is explored, it has to be followed by the reasons why countries or states should support this and which of those could be applied to the Uttar Pradesh context to encourage distributed generation.

5.2.1 Reasons why Distributed Generation is Encouraged Worldwide

Ackermann et al. (2001) define Distributed Generation (DG) as an electric power source connected directly to the distribution network or on the customer side of the meter. However, national and regional regulations usually take into account other aspects when defining DG, such as the size of the power plants U.S. Energy Information Agency, (2002), type of connection and relationship with the distribution utility Bayod Rújula et al. (2005).

For the purpose of this research, DG is simply the generation plants that can be connected directly to the distribution grid, which denotes the lower voltage levels, up to 138kV in Brazil ANEEL (2008). This can include all kinds of sources of energy, renewable or not. However, in some low-carbon technologies, the source of electricity is usually close to the end-user and is expensive to be transported Jenkins et al. (2010), which creates a favorable scenario to the development of power plants that are renewable energy based, small scale and connected directly to the distribution grid.

Distributed Generation can potentially help the electricity system in many ways. However, since DG options are usually more expensive than the traditional sources of energy and demand high initial capital inputs and industry development, they need to be encouraged by policies so that these technologies can be competitive and well established. Additionally, the outcomes of these kinds of power plants depend strongly on the reasons why they are being implemented and on the characteristics of the electricity sector and the society where they are installed.

Climate change, fossil fuel prices volatility, the need to meet future demand of electricity and social awareness regarding energy consumption and environmental impacts have been changing the way countries explore and use energy resources.

Many countries have established targets for the reduction of greenhouse gases (GHG) emissions to cope with the tendency for better usage of resources and fight climate change REN21 (2010). Particularly in developed countries, most of the carbon emissions come from the energy supply, transport and heating DECC (2011). Amongst these causes of global warming, the easiest one to be dealt with and that can provide a quick and cheaper response for the demand of GHG emissions reduction is the electricity sector.

Hence, policymakers are trying to provide good scenarios for the development of renewable energy sources, as well as maximizing the usage of the electricity grid to avoid energy losses and unnecessary expansion of the transmission and distribution lines REN21 (2010). In this context, DG appears as a way of potentially producing electricity more efficiently (for example, via Combined Heat and Power), using renewable energy sources (such as hydro, wind and solar) and improving the capacity of the network by connecting the generation in the distribution grid, closer to the end- users Jenkins et al. (2010).

Additionally, countries are struggling to find ways of meeting future demand for electricity, either because the current sources are becoming scarcer (such as local coal and gas) or because sources that used to be imported from other countries are not as available as they were before or their origin is from politically unstable regions. Hence, the volatility of fossil fuel prices and the scarcity of coal and nuclear sources can also contribute to the encouragement of DG, in order to use other new and usually renewable sources of energy that can be found locally Lopes et al. (2007).

Another reason why the expenditure of public funds to finance the development of DG can be justified is to reduce other costs, such as those of transmission and distribution grids U.S. Department of Energy, (2007). Well-managed and well-placed DG power plants can potentially avoid (or at least postpone) investments on new transmission lines and make better usage of the whole grid Rawson, (2004).

Finally, new technology options can help generating industry development in a country, producing economic growth and creating new jobs. Hence, the opportunity to develop a new national or regional industry sector associated with clean electricity generation is an important reason that can lead policymakers to encourage the expansion of DG.

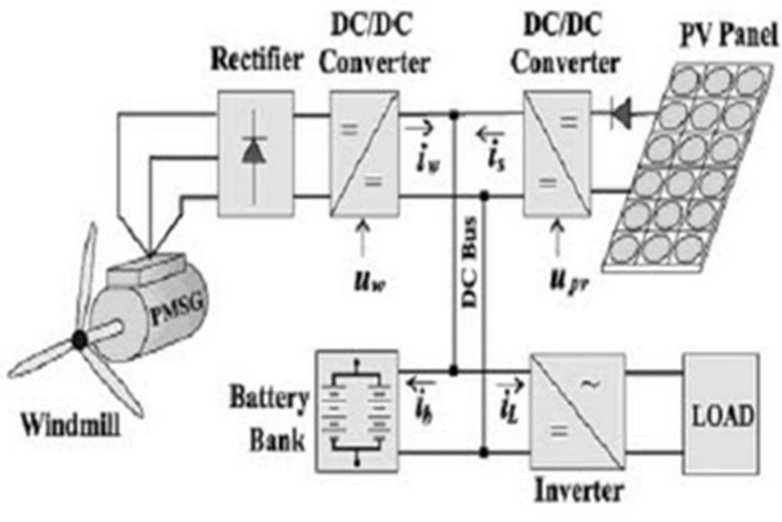

Figure 5.7: Models of Distributed Generation

5.2.2 Electricity costs

Costs of electricity are an important drive for the choice of energy sources and the policy that countries could apply to encourage them. In Brazil, the distribution system is responsible for a big share of the total cost of electricity, and generation costs are also relevant 5.8. Conversely, transmission costs are relatively low.

The electricity price analysis is important to the present study because it shows that options of energy sources that could reduce the price of generation or make better use of the distribution system should be supported. In contrast, impacts on reduction of transmission costs are not as relevant as those on the distribution system costs. Transmission

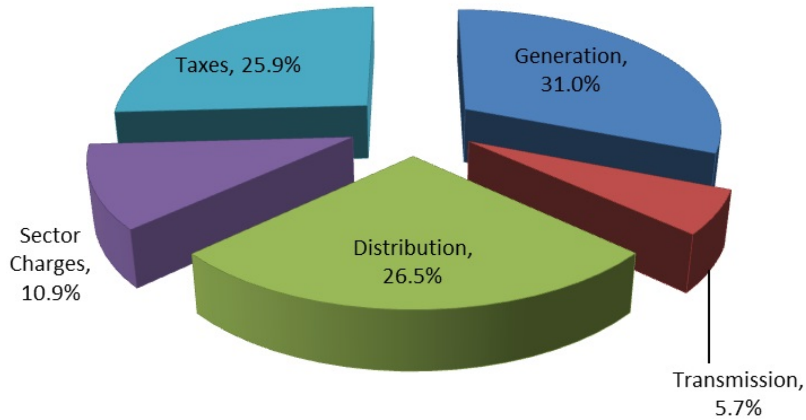

Figure 5.8: Electricity costs breakdown (ANEEL, 2011)

and Distribution sectors, which are natural monopolies, are strongly regulated, with tariffs defined by the regulatory body and grid connection requirements and availability closely controlled by the State. On the other hand, generation and commercialization are open markets, where investors can freely participate (to a certain extent), choosing whether or not to build a power plant and who to sell the energy produced to CCEE (2011).

Current regulation also puts a huge bureaucratic burden on generators. Their obligations include: installing the metering system; accessing the grid; executing the contracts with consumers and transmission and distribution companies; registering at the Chamber of Electricity Commercialization (CCEE); complying with very accurate and costly standards. These procedures are justifiable when regarding big generators, which deal with enormous amounts of energy and need very close regulation. However, they are a barrier to the connection of small scale power plants to the grid.

Finally, in this scenario, among other things, Government is responsible for (MME,2011):

- planning the market growth to keep the energy mix relatively low in carbon
- emissions promoting the development of certain technologies
- guaranteeing best practices and usage of natural resources
- ensuring fair electricity tariffs and sustainability

5.2.3 Which of the Reasons could be applied to Uttar Pradesh?

The reasons why some countries establish policies to promote DG, presented in chapter, is that it allows them to (in summary):

1. Increase the amount of Renewable Energy sources
2. Meet future demand for electricity
3. Reduce transmission (high voltage) costs
4. Reduce distribution (medium and low voltage) costs and increase grid capacity
5. Promote industry development

However, developing countries should not only copy and paste what is being done in other countries and just assume that it would be suitable for their own reality. Each region needs to be assessed with the intention of finding the appropriate technology Darrow & Saxenian (1993). In this sense, the present section discusses which of those reasons could possibly be a motivation to encourage the progress of certain DG technologies in Brazil.

The Uttar Pradesh economy is growing fast and energy consumption follows the same pattern. Hence, the need for future cheap and clean electricity sources is a reasonable concern.

The analysis of the final costs of electricity shows that the costs associated with transmission lines represent only around 5.7% of total costs. This means that their share is not very big when compared to the other costs and, hence, increasing generation costs with DG to reduce the transmission costs might not be reasonable.

On the other hand, distribution costs and Loss account for more than 26% and 30% respectively which makes it very attractive to encourage DG in order to improve the capacity of the distribution systems and avoid loss in Uttar Ptradesh.

Along with this reason, a developing country should analyze industry options very carefully with the purpose of creating opportunities for the population and bringing social and economic development.

In conclusion, from the five reasons why countries worldwide might encourage the increase of DG, almost all are really applicable to the Uttar Pradesh case.

5.2.4 Support of policies on Distributed Generation for Uttar Pradesh

The severe fiscal and electricity supply squeeze in Kanpur has helped to propel ESI liberalization and restructuring to the forefront of state politics, but there is a strong possibility that interest group politics may subvert the process or dilute its effectiveness. The reform process in Kanpur has been criticized for being too slow and thus perpetuating a financial and performance crisis in the electricity sector. The regulatory uncertainty of the Kanpur situation, as well as the poor financial position of the SEB has left urban, rural and industrial power consumers poorly served. The high industrial tariffs that have been steadily increasing over the past decade, have led many larger industrial concerns to produce their own electricity. The continued dominance of the KESCO, which has proven incapable of supplying rural areas adequately, encourages more industrial and small scale generators to partner with local communities to deliver services. The SEB is working hard to protect its interests within the legislation, and the recent report by the KESCO that defends the level of agricultural use suggests that the SEB has created the conditions that will allow it to maintain its continued dominance in the sector. Active industrial and consumer groups are working to counter the SEB political muscle.

Captive and distributed generation can provide an important part of the solution in addressing the weaknesses inherent in the Kanpur ESI. The political economy of power in Kanpur also includes the availability of fuel supplies, the most important being imported coal and the continued development of new gas supplies in Northern India. Each will have a significant impact on electricity markets and new investments in power, fertilizer and other industrial sectors. However, rising international oil and gas prices and the preponderance of gas contracts benchmarked to crude prices have increased the prices of imported gas supplies and may reduce demand growth. At the same time, a run up in imported coal costs and domestic coal shortages have made newly proposed large central station projects much more expensive than anticipated.

In a competitive electricity market, it is necessary and important to develop an appropriate risk management scheme for trade with full utilization of the multi-market environment in order to maximize participants benefits and minimize the corresponding risks.

Fiscal and financial incentives

- Reservation of Area for Distributed generation plant like Biomass Power Plants.

- Power Project with grid interactivity of less than 5MW capacity can be set up any where in the State.

- The Distribution licensee will enter in to PPA with the Project Developer at tariff rates fixed by the Uttar Pradesh Electricity Regulatory Commission (UPERC)

- The biomass power project will be entitled of getting CDM benefit.

Land policies

• The government land will be leased to developer at Rs.1/-per sqm for the period of 33 years.

• There will be no conversion cost in land use change.

Administrative Support

• The GoUP will facilitate expeditions grant of permissions, approvals no objection certificates, recommendations etc.

Government Support

• Faster approvals and Single window clearance mechanisms

• Sustainability of policies environment for a longer term (10 years or more)

• Constructing evacuation Infrastructure and facilities for storage of electricity not injected into the grid

• Zero duty on imports, excise duty waiver and tax benefits for distributed generation

Availability of capital for Investments

• IREDA to provide soft loans for renewable energy projects, particularly for demonstration and private sector projects

• Availability of capital at attractive rates of interest similar to what is extended to priority sector projects

• Moratorium on interest payments for the first few years of project go-live.

•Financial Institutions willing to lend to distributed projects as priority sector for Uttar pradesh

Availability of local expertise

• Expertise and availability of EPC contractors for commissioning of the Distribution Generation

• Growth of ancillary units

- Superior program execution skills and capabilities

Fiscal and Quota based incentives

- Feed Tariff (Higher tariff for off grid vis -a-vis Grid connected Distributed Generation)

- Accelerated depreciation, Generation based incentives (GBI)

- Enforcement of Renewable purchase obligations (RPO)/Renewable energy certificates (REC)

5.2.5 Sustainability Analysis of Distributed Generation Impacts

In a holistic view of the demand for electricity, one should take into account the entire context in which the development is to be made. Hawken et al. (2000) state that, when solving a problem, we should aim to solve many others at the same time. This statement can be applied to the scope of this dissertation meaning that a developing country that aims to establish economic growth and meet its future demand for electricity should choose energy policies considering the impacts it could have in creating jobs, establishing a sustainable industry, promoting equity, etc., while preserving natural resources and potential for future developments.

One of the aims of this approach is to try to establish a balanced set of DG alternatives that should be encouraged by policymakers in Brazil. This means that the solution sought should not be one that generates significant environmental harm, that generates social disquiet or that generates economic loss or spends public funds inefficiently Dodds & Venables (2005).

Hence, to each of the sustainability pillars (economic, environmental, social and technical) a set of areas where DG could have impacts is analysed. These areas, shown in Figure 5.9, were chosen considering the key development strategies specified in Brazilian Laws and reports, potential segments where DG is more likely to cause benefits or harms and technical aspects linked to the technologies.

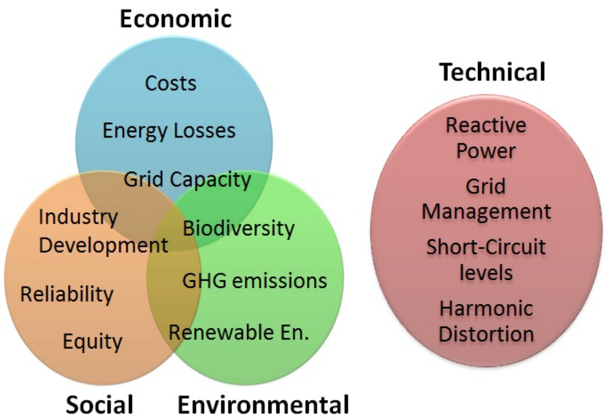

Figure 5.9: Sustainability examination of possible impacts of DG

5.2.6 Economic Impacts

The economic impacts of DG are an important aspect that should be carefully taken into consideration, particularly in a developing country where access to electricity can bring health and education improvements that could later help the country maintain its development, reducing the importance of economic impacts and increasing the significance of social and environmental aspects.

Costs

The first economic aspect to be taken into consideration in this report is the costs of electricity production. Levelized cost of electricity (LCOE) is often cited as a convenient summary measure of the overall competiveness of different generating technologies. It represents the per-kilowatt hour cost (in real dollars) of building and operating a generating plant over an assumed financial life and duty cycle. Key inputs to calculating LCOE include capital costs, fuel costs, fixed and variable operations and maintenance (O&M) costs, financing costs, and an assumed utilization rate for each plant type. The importance of the factors varies among the technologies. For technologies such as solar and wind generation that have no fuel costs and relatively small variable O&M costs, LCOE changes in rough proportion to the estimated capital cost of generation capacity. For technologies with significant fuel cost, both fuel cost and overnight cost estimates significantly affect LCOE. The availability of various incentives, including state or federal tax credits, can also impact the calculation of LCOE. As with any projection, there is uncertainty about all of these factors and their values can vary regionally and across time as technologies evolve and fuel prices change. Data source: International Renewable Energy Agency

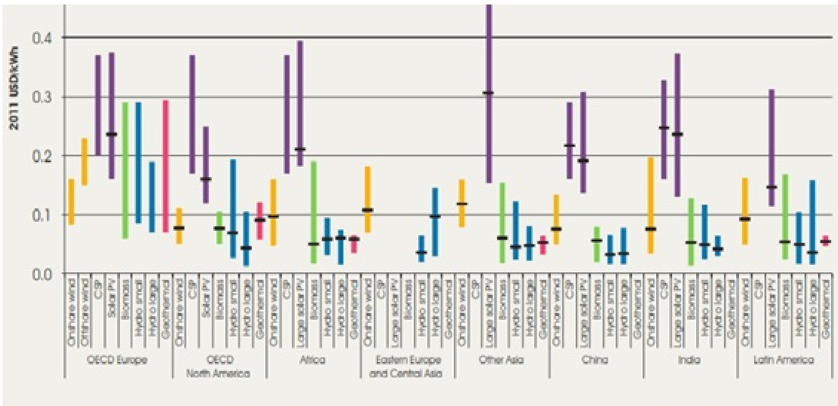

FIGURE ES.1: TYPICAL LCOE RANGES AND WEIGHTED AVERAGES FOR RENEWABLE POWER GENERATION TECHNOLOGIES BY REGION, 2012

Note: *The bars represent the typical LCOE range and the black horizontal bars the weighted average LCOE if enough individual project data are available. Figures assume a 10% cost of capital and biomass costs of between USD 1.3 and USD 2.5/GJ in non-OECD countries and between USD 1.3 and USD 9/GJ in OECD countries.*

Figure 5.10: Typical LCOE Ranges and Weighted averages for Renewable Power Generation Technologies By Region, 2012

Even considering the learning curves and costs reduction with the large spread of new technologies, Solar PV would still be considerably more expensive in the near future. For instance, a study conducted in Australia showed that the costs of solar rooftop panels by 2030 might still be up to four times more expensive than wind and biomass technologies McLennan Magasanik Associates, (2009).

Energy Losses Reduction

One of the potential benefits of DG is to reduce losses in power capacity and in energy. In this sense, the current section will assess how better one technology is to reduce energy losses when compared to another. It does not use values of energy losses for each, but rather classifies them so that their ability to reduce losses can be compared, regarding energy. For assessment of power losses, the Grid Capacity criterion is used.

If the electricity generated by certain type of DG matches the demand profile in the region where it is installed, all the energy generated will be consumed locally, reducing losses. Additionally, even if the demand is still higher than the sum of the DG in that region, the extra amount of energy that would have to be transported from the central station to the end-users (and then subjected to losses) would still be reduced.

For that reason, the alternatives score is made as a combination of the indices demand following and operating reserves delivering presented by Moya et al. (2008). This ranking

Technology Option	**Demand following**	**Operating**	**Energy Losses Reduction**
Small Hydro	Very bad	Normal	**Bad**
Biomass	Very good	Very good	**Very good**
Solar PV	Very bad	Very bad	**Very bad**
Wind	Very bad	Very bad	**Very bad**
CHP	Very good	Very good	**Very good**

Table 5.4: Assessment of the potential for energy losses reduction for the five DG alternatives

is compatible with that presented by Quezada et al. (2006) and also with the comparison between CHP and solar PV in losses reduction that can be drawn from Cao et al. (2006).

It is important to highlight that energy losses might reduce with the insertion of some DG and reach a minimum for a certain amount. However, excessive levels of distributed generation penetration can increase losses to values that can be up to five times higher than the losses without any DG Quezada et al. (2006).

Grid Capacity

This aspect is also related to the environmental impacts, since when one avoids expanding the electricity grid, the current assets are used better and less additional raw material is needed, as well as less land for transmission lines being required.

Technologies of power plants that can be dispatched can improve grid usage better than intermittent ones for which the time of electricity production cannot be controlled. In this sense, the thermal ones (CHP and Biomass) have the biggest potential for better use of the system Jenkins et al. (2010). In addition, these alternatives are usually generating electricity at the same time as the load attached to them is higher.

Small hydro power plants are quite predictable and, in theory, can be dispatched Xue et al. (2007). However, the location of the power plant is determined by where the natural resources are located and usually new distribution network have to be built in order to reach these places. On the other hand, the predictability of this source of electricity can help utilities and the system operator to manage the distribution/transmission grids better, improving their capacity.

Regarding wind energy, the intermittency of the technology and the need of new distribution lines can also make it not very attractive when it comes to grid capacity improvement.

Finally, solar PV systems have to be carefully analyzed when assessing their ability to provide better usage of grids. Some advocates of the technology might state that they can be useful in alleviating the grid since their production follows basically the pattern of the national load (the load of the entire interconnected system altogether)

A comparison of electricity production and consumption should be made in the distribution grid where they are supposed to be installed, namely, feeders of residential end-users or small commercial ones.

In conclusion, the potential of the 5 different technologies to improve grid capacity can be **ranked** as follows:

Technology Option	**Potential for Grid Capacity Improvement**
Small Hydro	Medium
Biomass	High
Solar PV	Low
Wind	Medium
CHP	High

Table 5.5: Potential for grid capacity improvement of the five DG alternatives

Impacts on Biodiversity

This criterion aims to take into consideration the aspects related to impacts on flooding areas, deforestation to build the power plant or to yield the source, water requirements, pollution (non-CO_2 emissions) and waste generation.

Table 5.6 was created to assess the impacts for each of the sub-aspects, assigning numbers according to the level of impact of the technology in the aspect (green=0,yellow=1 and red=2). Subsequently, the total impacts were calculated as the sum of the sub-aspects. The last column of the table is then used as an input for the PROMETHEE model.

Technology Option	Flooding	Deforestation	Air Pollution	Water requirements	Waste generation	**Total Impacts on Biodiversity**
Small Hydro	2	1	0	1	0	**4**
Biomass	0	2	2	2	2	**8**
Solar PV	0	0	0	0	0	**0**
Wind	0	1	0	0	0	**1**
CHP	0	0	1	1	0	**2**

Table 5.6: Assessment of impacts on biodiversity for the five DG alternatives. Sources: (EPRI, 2010)

Environmental Impacts

The environmental impacts of the five DG technologies are assessed through three indicators: greenhouse gases emissions, impacts on biodiversity and whether or not the source is renewable.

Greenhouse Gases Emissions

The emissions of Greenhouse Gases (GHG) are evaluated according to data found in different reports DECC (2011), POST (2006), Lenzen (2008). It is important to note that there are some variance on the total CO_2 equivalent emissions per KWh amongst the references due to different methods used and the assumptions made in each of them.

Renewable Energy

Table 5.7: CO_2 emissions per KWh for different sources of electricity. Sources: Lenzen (2008), DECC (2011), POST (2006)

Technology Option	**Emissions (g of CO_2-e/KWh)**
Small Hydro	15
Biomass	80
Solar PV	106
Wind	21
CHP	510

The aim of this section is to give extra weight to the technologies that use a renewable source of energy to produce electricity.

Hydropower plants, solar photovoltaic systems and wind power use renewable sources of energy to produce electricity - water flow, solar irradiation and wind Bergerson & Lave (2002). Nevertheless, a deeper discussion of Biomass and CHP is necessary:

Biomass: when using biomass to produce electricity, particularly from plants, the carbon emitted in the atmosphere by the combustion of the biomass is again captured when new plants grow, making it a low-carbon technology. Additionally, other nutrients are also again captured by plants in the growth process. The source of energy is then renewable, as long as the ratio of biomass usage to produce electricity is not higher than the ratio of plants cultivation process. The UNFCCC provides a definition of when biomass can be considered renewable UNFCCC (2006).

Cogeneration: Although the efficiency of this kind of generation makes it more attractive than regular thermal plants and also more environmentally friendly Jasmab et al. (2006), the source used to produce electricity considered in this study is non-renewable natural gas.

Technology Option	Renewable Energy
Small Hydro	Yes
Biomass	Yes
Solar PV	Yes
Wind	Yes
CHP	No

Table 5.8: Renewable energy DG alternatives

Social Impacts

The potential effects of the DG technology options in the social aspects of sustainable development are assessed in this study with three indicators: improvement in electricity reliability that can be provided by DG, impacts of the alternatives in generating industry development and potential influences of the technologies to promote equity. The justification for the choice of each criterion is explained within their own sections.

Electricity Reliability

Still today India faces a power shortage in some of the most developed areas of the country due to lack of investments in generation and transmission. This led to an emergency rationing of electricity that affected all end-users, from industries to small residential consumers Eletrobras (2008). After the rationing, society became very concerned about the reliability of the electricity system.

Even blackouts that last for small periods of time can trigger the fear of another rationing and suspicion amongst people. Hence, the potential of the different DG technologies to avoid blackouts is another key sustainability aspect to be analyzed. In this report, this potential is assessed by the availability of the different technologies, as stated by Jenkins et al. (2010). The availability factors are shown in Table 5.9 They represent the contribution that each technology can give to the distribution network security and depend on the type of energy source and on the number of generation units.

Technology Option	Availability Factor (%)
Small Hydro	36
Biomass	65
Solar PV	14
Wind	64
CHP	73

Table 5.9: Availability Factors for the different technology options

Industry Development

The potential of each of the technology options to promote industry development is hard to quantify by a single index. Hence, it is analyzed in this report the impacts of each technology in stimulating development of national industry, that could create jobs, drive local economic growth and improve quality of life. The results are shown in Table 5.10.

Technology Option	Industry Development
Small Hydro	Very High
Biomass	High
Solar PV	Very Low
Wind	High
CHP	Medium

Table 5.10: Potential impacts on Industry Development for the DG alternatives

Technical Impacts

In addition to the three basic pillars of sustainable development (economic, social and environmental aspects), a complete analysis of DG options demands the examination of some key technical features, such as:

- the potential reactive power provision from each of the alternatives,
- their impacts on grid management,
- changes on short-circuit levels and system protection and
- increase of harmonic distortions.

Reactive Power Provision

Alternating current power systems have, apart from the active power that is transferred to the loads, a component of the total power called reactive power that is related to establishing and maintaining the electric and magnetic fields in the power system IEC (2011). Additionally, reactive power control is important in the regulation of voltage levels.

The provision of reactive power is related to the type of generator and how it is coupled to the grid.

Technology Option	Reactive PowerProvision
Small Hydro	Yes
Biomass	Yes
Solar PV	Yes
Wind	No
CHP	Yes

Table 5.11: Reactive power provision from the five DG alternatives

Grid Complexity and Management

Distribution grids were originally designed to work with current flows in one direction (from the central generation or substations to the loads). With the introduction of power plants along the network, current flows can now be in both directions. This means that the protection systems, voltage control regulations, power quality equipment, etc., might be affected and operate erroneously.

This item assesses the impacts of the five options considering their ability to solve problems of congestion, regulate voltage levels and perform islanded operation9 (Table 5.12). The values are obtained from Braun (2007) taking into account the following considerations:

- Small hydro, Biomass and CHP uses synchronous generators10
- PV is always coupled to the grid with an electronic converter
- Wind energy is produced with induction generators

Technology Option	Congestion Management	Voltage Quality	Islanded Operation	Total Potential Contribution
Small Hydro	4	0	3	**7**
Biomass	4	0	4	**8**
Solar PV	4	4	3	**11**
Wind	2	0	0	**2**
CHP	4	0	4	**8**

Table 5.12: Assessment of the potential contribution of the five DG alternatives to grid complexity and management

Impact on Short-Circuit Levels

Rotating machines connected to the grid without electronic converter (all the technology options in this study except for Solar PV and some wind plants) can increase the short-circuit level of the grid Boutsika & Papathanassiou (2008) Brenna et al. (2009) and, hence, have the potential to raise the short circuit current to values higher than the supported by some grid components Cazzato & Botton, (2009).

Solar PV systems are connected to the grid with static converters, which limit the short circuit current Jenkins et al. (2010). In this case, the problem of potentially exceeding the rated current limits of medium and low voltage grid equipment is alleviated. Similarly, some of the variable speed wind turbines can be connected via converters, which would also minimize this problem.

As a result, technology options with rotating machines that are connected directly to the grid were categorized as having a **high** impact on short circuit levels (Table 5.13). To solar PV, which is connected through converters, it was assigned a **low** potential of increasing fault currents. Since wind turbines can be coupled to the grid with or without converters depending on the technology used, their impact on short circuit currents was written off as medium.

Technology Option	Impacts on Short Circuit Levels
Small Hydro	High
Biomass	High
Solar PV	Low
Wind	Medium
CHP	High

Table 5.13: Impacts on short circuit levels of the different technology options

Increase in short circuit currents might also cause problems to the distribution grid protection system. Distribution power system protection is formed by several different elements that are coordinated to each other to disconnect the smallest part of the grid in the shortest period of time. Hence, the short circuit current provided by several small scale power plants, according to the network topology, can be perceived by one of the elements of protection in the grid (such as a fuse) and not by another element to which the first one is coordinated (like a circuit-breaker). When that happens, the protection of the grid is jeopardized Barker & De Mello, (2000). Other impacts of DG on grid protection and further explanations can be found in Jenkins et al. (2010).

Increase of Harmonic Distortion

Electrical systems are designed to work with voltage and current profiles that alternate in a sinusoidal profile with a determined frequency (usually 50 or 60Hz). When non- linear loads (such as electronic equipment) are connected to the grid, this sinusoidal shape can be distorted, causing alterations in the voltage or current profile, called Harmonic Distortions (Leonardo Energy, 2007). When a generator uses electronic devices to connect to the grid (such as inverters) the power plant can also cause harmonic distortion.

However, harmonics caused by small scale generators connected directly to the distribution grid are more difficult to quantify since the levels of distortion can be affected by previous distortion on the grid produced by non-linear loads from consumers in that area. For that reason, it was chosen to classify the alternatives by levels of influence in harmonic distortion (high, medium or low) rather than via numbers - Table 5.14. Alternatives that

Technology Option	Harmonic Distortion
Small Hydro	Low
Biomass	Low
Solar PV	High
Wind	Medium
CHP	Low

Table 5.14: Potential of Harmonic Distortion generation by the different technology options

produce electricity using synchronous or asynchronous generators (small hydro, biomass and CHP) do not inject high levels of harmonic distortion in the grid and so are classified as having **low** impacts on voltage and current steady-state profiles Joos et al. (2000).

Wind turbines, however, are connected through induction generators with electronic converters to control the speed. For this reason, it was categorized as producing harmonic currents in a medium scale Jenkins et al. (2010).

Finally, solar photovoltaic panels can have **high** impacts on harmonic levels since they produce direct current electricity and are always connected to the grid through inverters that can distort voltage profiles more than the other generation technologies analysed Salamoni (2004).

5.2.7 Conclusion

The cost of energy in the fossil fuel-based power stations consists of the generation, transmission and distribution costs, whereas in the decentralized power generating system energy cost is primarily the generation cost. Conventional centrally- managed approaches to electricity distribution have been expensive and unsustainable Perera et al. (2001) and the financial analysis presented in this Chapter makes the case for a distributed approach in remote using hybrid power systems.

This chapter set out to answer the question of whether hybrids would be a cost-effective way of providing energy services in rural Uttar Pradesh and encourage bottom up sector reform. In the case of Kanpur, the economic results suggest that the answer is yes and thus more research is needed to flesh out the business plan and regulatory steps that will be needed to overcome the financial and institutional barriers.

The scope for DG to be a market opening and innovative force in the Indian electricity sector is potentially vast and hybrid systems should not be restricted to allow the SEB insulation from competition. The rural sector needs reliable power, and hybrids can fill the void in many situations. The most urgent need is to create an enabling regulatory scheme for small-scale generators and reduce the subsidies to boost demand-pull for rural power. Until targeted subsidies and supportive policies are in place, the demand pull will not be enough to overcome all of the financial and operational issues. However, as rural incomes increase there will be more opportunities for private players to capitalize as risk adjusted margins grow for rural energy business models. Areas isolated from the grid with renewable energy have high potential, but high prices for capital and many other competing priorities for capital allocation have meant hybrid DG projects are stuck with no clear scalable business model and thus have low penetration rates in India.

5.3 Distributed Generation Model for Uttar Pradesh

5.3.1 Hybrid Power Systems - An Introduction

Hybrid Power Systems incorporate several electricity generating components with usually one major control system which enables the system to supply electricity in the required quality.

Components for electricity generation can utilize renewable energy sources like wind turbines, photovoltaic, solar thermal, hydro power, wave power or biomass power stations, etc. Furthermore, fossil power plant like diesel generators, gas turbines or fuel cells etc. can be added. The term Hybrid Power System does not give any information about the size of the energy system. Generally, Hybrid Power Systems are considered to supply loads in the size of several watts up to several megawatts. They usually supply island networks that are not connected to an integrated grid covering countries or even continents - but represent small grids with a limited number of consumers. Due to the resulting fluctuating consumption pattern several specific features are required concerning the electricity supplying Hybrid Power System.

In integrated electricity grids the load equalizes due to the large number of consumers and its statistical application. This is how base, medium and peak load are defined which are covered by dedicated base, medium and peak load power plant to minimize the electricity cost price. Base load is needed continuously 24 hours per day, medium load is required in consecutive 3 to 6 hours and peak load is required in shorter sequences. Unfortunately, this cost effective procedure cannot be transferred to Hybrid Power Systems in most of the cases. On the contrary, Hybrid Power Systems have to cope with much more severe short term variations in power demand. Thus, different energy management structures have to be applied. These energy management structures vary with the size of the Hybrid Power System depending on the financially optimal system design.

Depending on the magnitude of the Hybrid Power System, different storages for equalization of load variations are applied. For Megawatt class systems pumped storage plants are most appropriate, for medium sizes of several hundred kilowatts the application of compressed air storage plant and for small scale systems the application of battery storages is advisable considering the economic point of view.

In larger systems, often geographical constraints prevent the application of appropriate storages. Thus, in these cases the storage component is replaced by a dynamically controlled generator driven by a fuel engine. The necessity for this operation results from the requirement to match demand and supply in electrical grids for each moment in time for stable grid operation. In order to avoid short term voltage drops and flickers power storages are applied. These storages provide high power for short periods. In contrast, the stored energy in such storages is rather small. Fly wheel storages, capacitors and special kinds of batteries belong to this group of storages.

In the range of up to 30 kW mainly classic DC-coupled systems are established; in larger systems AC-coupling is more common. However, even in small scale systems the little bit more complex but easily extendable AC-coupled systems are gaining market share. Even mixed AC and DC systems are being offered. The discussion about advantages and disadvantages of specific system types is being continued.

In general, Hybrid Power Systems have to meet different requirements depending on the appliances served, the consumer behaviour, the consumer's demands on the power quality and the energy sources available locally. While mobile phone antennas need to be supplied with almost constant power of high quality, small villages have a fluctuating and usually growing energy demand while short term power outages are not critical. The integration of wind power at a gusty site requires different features of a Hybrid Power System than a continuously operating hydro power plant. To realize cost efficient power supply with the required power quality an individual system design considering all site specific aspects is essential.

For Hybrid Power Systems all areas without electricity supply from integrated networks but demand for electrification can be identified as potential markets. Large potential for rural electrification especially with renewable energy sources can be found in developing countries. Unfortunately, the market for such systems has not materialized to a substantial scale yet due to a lack of structures in financial and political aspects. Furthermore, in many countries the required infrastructure for assembly, operation and maintenance of complex technical systems is not available locally.

5.3.2 Biomass-diesel hybrid system

The economic feasibility of a hybrid system is determined by local conditions and resource availability. Based on survey and feasibility result a Biomass-diesel hybrid system is recommended for the Kanpur. In line to this different hybrid distribution system can be executed across Uttar Pradesh based on the availability of local fuel resources.

For establishing a Biomass-diesel hybrid generation system, the economics depend on six key variables as follows:

1. Available waste biomass resources
2. Delivered price of diesel fuel
3. Capital costs of the waste biomass, genset and auxiliary equipment
4. Life-cycle operating costs, including maintenance
5. Value of secondary load
6. Reliability of demand and revenue collection

5.3.3 Biomass Energy Uttar Pradesh Policy support

Uttar Pradesh New and Renewable Energy Development Agency, (UPNEDA) Biomass Energy policy 2010, initiatives helps to promote the Biomass power generation. Some of the important initiatives are as follows:

1. Biomass Power Projects (including project based on urban solid waste) only up to 15MW capacity shall be eligible for the benefits under this policy.

2. Reservation of Area for Biomass Power Plants:

Capacity in MW	**Area Reserved (Radius in km)**
5	40
More than 5 and up to 7.5	50
More than 7.5 and up to 10	60
More than 10 and up to 12.5	70
More than 12.5 and up to 15	80

Table 5.15: Reservation of Area for Biomass Power Plants

3. Biomass Power Project with grid interactivity of less than 5MW capacity can be set up any where in the State after registration in UPNEDA

4. In case of municipal solid waste (biomass) project, the raw material will be provided by the local body at a single point, free of cost.

5. The land requirements for the power plant under this policy are to be identified by the developer. State Government shall facilitate land assembly for setting up of the plant, as per the current policy of the State Government 6. The government land will be leased to developer Rs.1/-per sqm. for the period of 33 years.

7. There will be no conversion cost in land use change.

8. In case of private land purchase, 50% exemption in stamp duty will be admissible. The exemption on the stamp duty of the land will be admissible @ 1.5 acres/MW.

9. All new biomass power projects will be treated as **Industry** in terms of Industrial Policy of the State and all the incentives available to industry will also be available to new biomass power projects as per Industrial Policy of the State.

10. The project will be entitled to get Ministry of New & Renewable Energy (MNRE), Government of India (GoI) incentives as per MNRE, GOI rules.

11. The State will encourage setting up of biomass power projects. The Distribution licensee will enter in to PPA with the Project Developer at tariff rates fixed by the Uttar Pradesh Electricity Regulatory Commission (UPERC).The incentive admissible to co-generation plants under energy policy2009 will also be admissible to biomass power plant

12. Electricity generated by Project Developer will be exempted from Electricity Duty for a period of 7 years from the date of commissioning.

13. The biomass power project will be allowed banking, open access, third party sell. The wheeling charges for biomass project will be as per UPPCL/UPPTCL/DISCOM existing norms or decided by UPERC.

Ministry of new and renewable energy, Govt. of India has started providing subsidies and CFA for the Biowaste to biogas Power Generation Plants in India. This is for the small communities like schools, hospitals, hostels, or for any organizations.

Figure 5.11: 85 cubic meter potato waste power generation plant

5.3.4 Load Profile

15 places visited in Kanpur city during data collection to understand the load profile apart from other applicable information. List of areas visited are as follows:

Sr. No.	Place	Sr. No.	Place
1	Prerna Vihar	8	Panki
2	Barra - I	9	Pareda
3	Barra - II	10	Gumti
4	Barra - III	11	Sarvodya Nagar
5	Barra - I	12	Kalyan Pur
6	Gujani	13	Kakadev
7	Daboli	14	Chamanganj
		15	Bakarganj

Table 5.16: List of places visited for sampling

Survey revealed the Domestic load profile for 50 Domestic users is as follows: The high

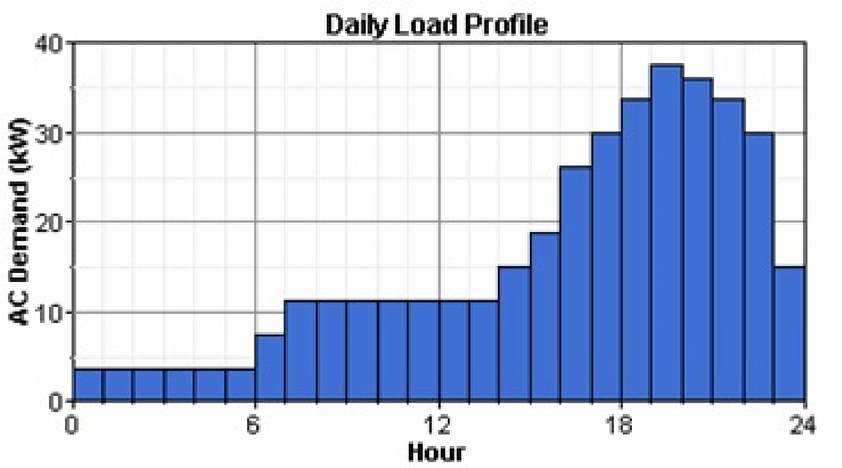

Figure 5.12: Load Profile for domestic users

use during the evening hours reflects the high demand for lighting and power for radio and television and the lower relative demand for industrial uses in rural areas.

As small scale factory (small concrete parts factory) operates seven days a week from 7:00 AM to 11:00 PM, with two shifts of workers. The equipment requires a reliable three-phase supply during all operating hours and the demand is near the full capacity of the genset. The engineer in charge commented that the addition of more than a light bulb would trip the system and he estimates that the load factor during operating hours was near 95 percent.

Load profile of the Industries comes out to be as follows:

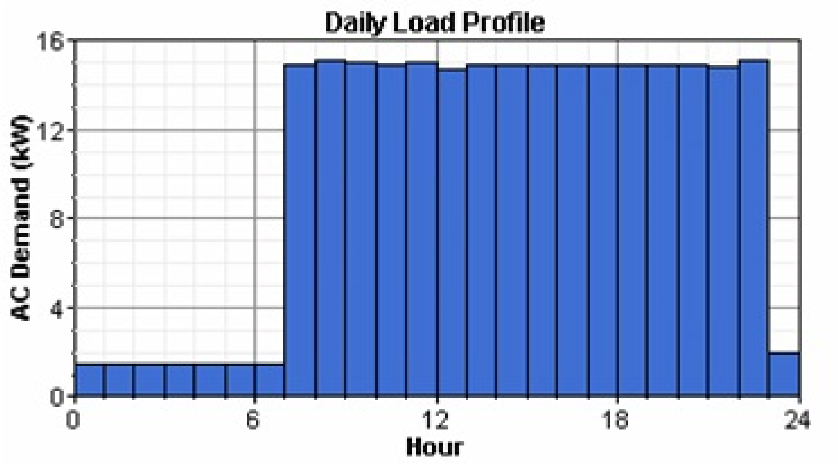

Figure 5.13: Load Profile for Industries

5.3.5 Biomass fuel availability and sensitivity

Bio mass fuel availaibility changes depend upon the fuel type and the climatic condition. Hence the Bio mass power availability during different part of year comes out to be a critical factor. To understand the same a sample biomass power plant is considered.

• The plant is installed for the generation of 10 kW of using up to 85 cubic meters per day gas generation capacity.

• K.V.I.C Floating drum type with water jacket, external guide frame for gas holder and a gas cleaning system.

• A power generation unit comprising of 30 kVA 100% Biogas generator set has been installed near the plant whereas the electricity line has been laid for almost 1 km distance to the potato cold storage for its use to power lights.

The most important variable in determining the viability of a hybrid system is the Biomass usage. In mentioned figure the sensitivity results are shown for a Biomass based 30 - 40 cubic meter against changes in primary load levels. Focusing on the x-axis, the winter days, not surprisingly, show the only-diesel option as the most economical, but that dominance only lasts to biogas production.

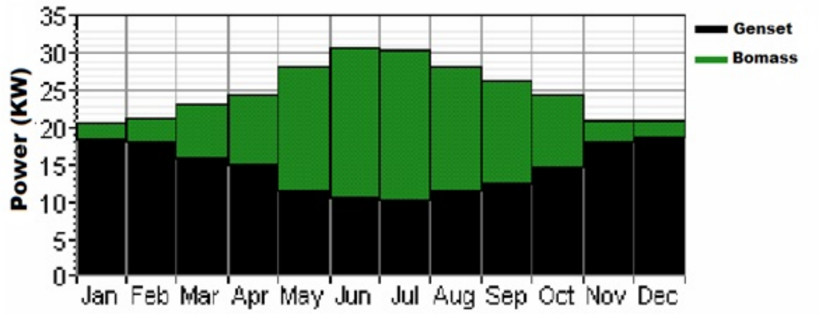

Figure 5.14: Sensitivity results for Biomass based 30 - 40 cubic meter plant

5.3.6 Hybrid Modeling using HOMER Model

HOMER stands for the Hybrid Optimisation Model for Electric Renewables and was developed by the National Renewable Energy Laboratory in Golden, Colorado, USA. HOMER was developed as a hybrid system design tool accurate enough to reliably predict system performance, but simple and efficient enough to conveniently evaluate a large number of design options and then rank the results to find the optimum configuration (NREL, 2003). HOMER identifies the least cost system for supplying electricity to remote loads by performing hourly simulations of thousands of potential power systems and rank ordering them by life cycle costs. It also performs sensitivity analyses to evaluate the impact of a change in any of the input parameters and provides both annual and hourly outputs in tabular and graphic form. Hybrid system design is made difficult by the intermittency of renewable resources, the need to match electrical supply and demand, and the large number of potential component size combinations. HOMER provided an excellent platform on which to test hybrid viability in Khadir and eliminated the need to spend time building an optimization model from scratch. The HOMER model is also well tested and validated (Lilienthal, Flowers et al. 1995).

The formulae details for the three most important output variables of the model are below.

Net Present Cost

The net present cost is the discounted value of all the cash flows needed to operate and purchase the hybrid system over its lifetime of 20 years. The following formula was used:

$$C_{NPC} = \frac{C_{ann,tot}}{CRF(i, R_{proj})} \tag{5.1}$$

Where

$C_{ann,tot}$ = total annualized cost (dollars per year)

CRF = capital recovery factor

i = interest rate (percent)

R_{proj} = project lifetime (year)

The first variable is the total annualized cost of the system, which is equal to the sum of each component's annual operating cost plus its annualized capital cost over its useful lifetime plus the annual fuel cost, if applicable (NREL, 2003). By adding the results for all components, the total annualized cost can be calculated, C_ann, tot. The capital recovery factor is a function of the real interest rate and the project lifetime and is used to discount the cash flows to time zero.

Cost of Energy

The cost of energy (COE), in dollars per kWh, is the level of tariff needed to recoup the net present cost (NPC) of the hybrid project. However, differential tariff structures can be used to aid poor clients, so the COE figure is only indicative of the median level of charges that must be supported by the host community:

$$COE = \frac{C_{ann,tot}}{E_{prim} + E_{def}} \tag{5.2}$$

Where

$C_{ann,tot}$ = total annualized cost (dollars per year)

E_{prim} = primary load served (kWh per year)

E_{def} = deferrable load served (kWh per year)

Breakeven Grid Distance

The breakeven grid distance is calculated to indicate the length of grid extension and grid- supplied power that is financially equivalent to the service provided by the optimal hybrid system. This calculation relies on three input variables: grid capital cost, grid operation and maintenance (O&M) costs and the price of grid-supplied power. The total load is also tested for variability.

$$D_{grid} = \frac{C_{NPC} \times CRF(i, R_{proj}) - C_{power} \times L_{total}}{C_{cap} \times CRF(i, R_{proj}) + C_{om}} \tag{5.3}$$

Where

C_{NPC} = total net present cost of the standalone power system (hybrid) (dollars)

CRF = capital recovery factor

i = real interest rate (percent) R_{proj} = project lifetime (year)

L_{tot} = total primary and deferrable load (kWh per year)

C_{power} = cost of power from the grid (dollars per kWh)

C_{cap} = capital cost of grid extension (dollars per km)

C_{om} = O&M cost of grid extension (dollars per year per km)

Life cycle cost analysis calculates the total expected costs of ownership over the lifespan of the system. LCC allows the direct comparison of the costs of alternative energy systems, such as hybrids with grid power. “The cost minimization approach eliminates the need to measure the value of the benefits provided and assumes that a given level of demand must be met at a uniform quality of supply. The question then becomes simply selecting the lowest cost method of supplying rural electric consumers (Munasinghe 1987): 61).” By not evaluating the social benefits, the model is much simpler to execute, but does not capture the entire extra gain from hybrids in rural areas. In other words, the results underestimate the total returns from implementing a hybrid system, which methodologically is a better error to make than overstated false positive.

5.3.7 Homer Simulation

In the present work, the sizing and selection of components of a hybrid power system has been done by using NREL’s HOMER software. HOMER is general purpose hybrid system design software that facilitates design of an electric power system for stand-alone applications. The input information that are provided to HOMER includes electrical loads, renewable resources, etc. HOMER designs an optimal power system to meet out the desired loads requirement. HOMER is a simplified optimization model, which performs hundreds or thousands of hourly simulations over and over in order to design the optimum system. The model has been tested for PV, Diesel and a biomass generator.

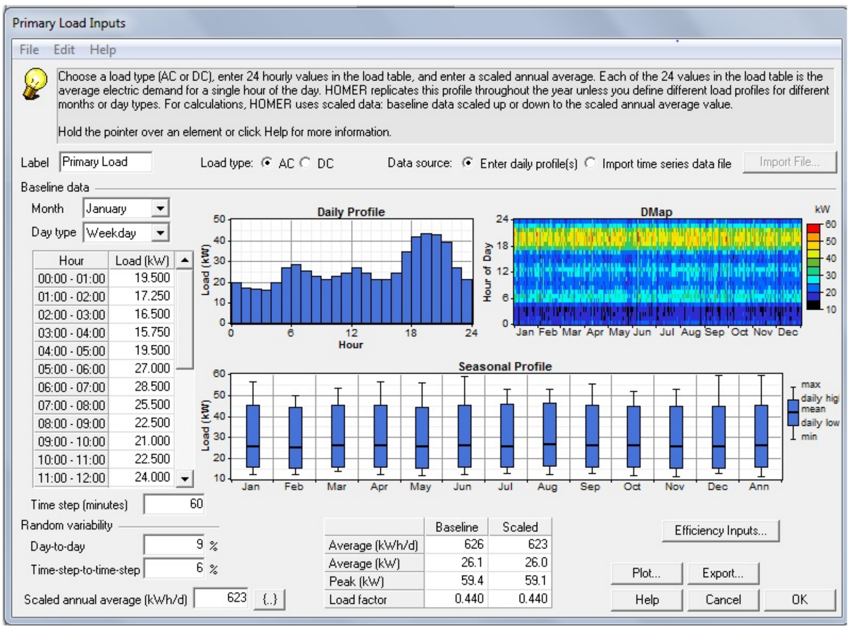

Figure 5.15: HOMER tool with Primary Load input

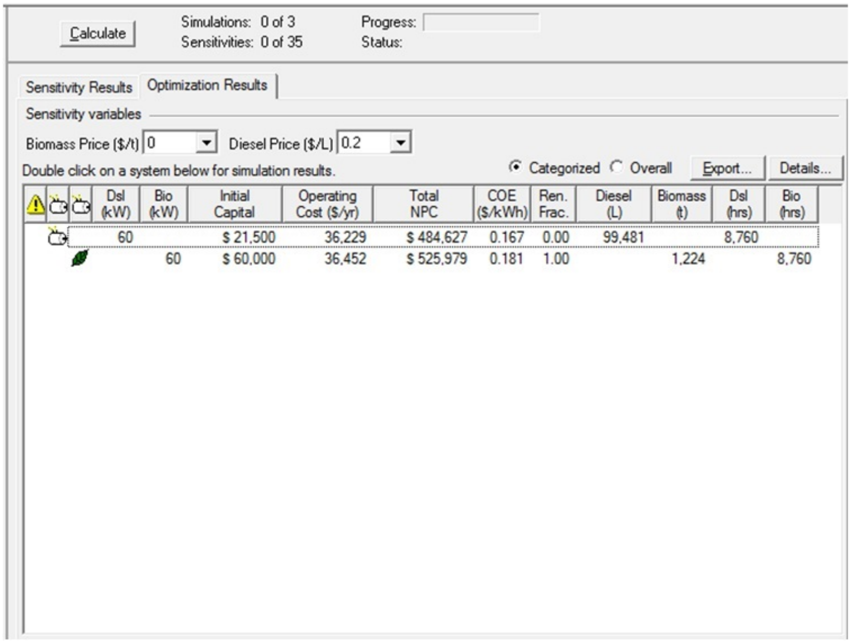

Figure 5.16: COE for Biomass as per Homer Calculation

SIMULATION RESULTS

The simulation results for hybrid system are presented in Figure 5.17 and 5.18. The first row shows the optimum hybrid system consisting of Diesel generator and Biomass generator to meet the load demand. The cost of energy for purposed hybrid Diesel/biomass generator has been found to be is 0.167 (US$/kWh) as shown in table III. The annual electric energy production and annual electric energy consumption is shown in table IV and table V respectively.

HYBRID SYSTEM COMPONENTS

Diesel generator set	Biomass generator set
Size : 60kW	Size : 60kW
Capital cost : 21,500$	Capital cost : 60000 $
Operating Cost$/year : 36229	Operating Cost$/year : 36452

Table 5.17: Values of Diesel and Biomass based generator

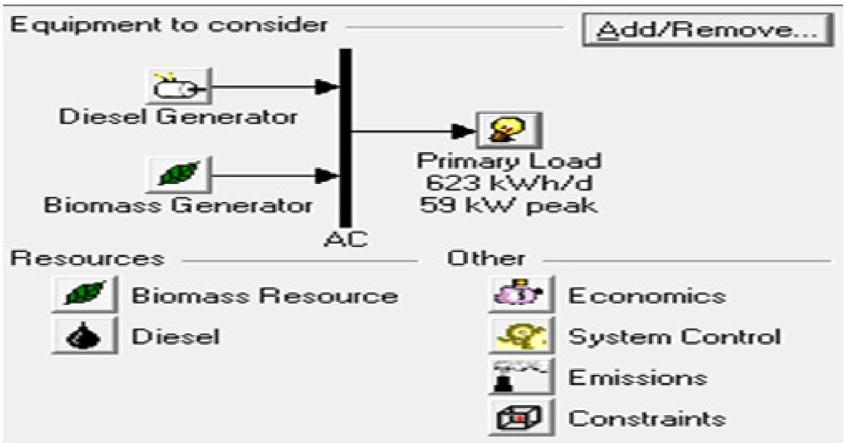

Figure 5.17: Inputs for Primary Load in HOMER

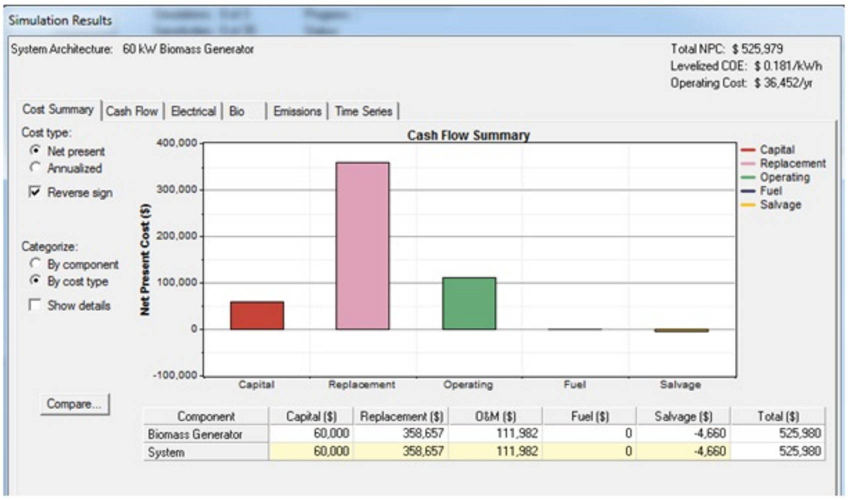

Figure 5.18: Values for 60 KW Biomass Generator

5.3.8 Conclusion

This work investigates the economic feasibility of the use of a hybrid energy system consisting of biomass/Diesel for energy requirement of a remote area. Here, biomass generator is chosen as a major source of power in the rural areas due to its high efficiency and cost effectiveness.

Hybrid Model Operation

SEB, in the present situation, needs to adopt a multi-pronged strategy wherein all the following options could be utilized for improve power supply scenario in the State:

- Additional short-term power purchase from other States and traders to tide over the immediate supply shortage;
- Improving the distribution efficiency by reducing distribution losses; and
- Installation of short-gestation distributed generation facility.

The Government separately work on the first option in respect to a petition filed by SEB as well as in the Tariff Order as and when required. As regards second option, though SEB has undertaken Internal Reforms Programs, for improving the distribution efficiency ; the results do not appear to be encouraging, as no tangible improvement has been noticed. Further, reforms is a necessary but long drawn process. Therefore, it is imperative that SEB identifies certain short term approaches to improve power supply scenario in the State. The third option indicated above envisages installation of short-gestation generation capacity either in the form of conventional sources of generation such as liquid fuel or non-conventional sources such as small hydro, wind, biomass, etc., to make more generation available as well as reduce technical losses by making generation available at consumer end. Further, if the generator takes responsibility for distribution in the area as a franchisee of the licensee, this integrated distribution franchisee could be instrumental in bringing much needed reforms in the sector.

In this context, this model could also be useful in bringing in competition for private sector participation. In several States, distribution reforms have been initiated and implemented by adopting privatization and/or Franchisee models. Privatization with sale of equity of more than 51%, transfers the control of the organization to the majority equity holder. Franchisee option, on the other hand, retains the ownership of the system with the Distribution Licensee, while allowing the private sector to function with relative independence. Further, it is possible to implement franchisee structure with wide variety of other legal structures such as co-operative societies, industrial estates, panchayati raj institutions, local bodies, industrial associations, etc.

It is important to note that in Uttar Pradesh, it is essential to increase electricity generation locally without overloading the existing transmission system. Therefore, it is essential to identify an appropriate model, which would allow local (distributed) generation and distribution of power with the involvement of co-operatives, private sector, etc. Considering that distributed generation is likely to be more expensive than average power purchase cost of the utilities, cost reflective tariffs for such supply are bound to be higher than the average tariffs of the utilities. Therefore, such an arrangement would primarily suit urban and semi-urban areas, as well as dedicated industrial feeders, where ability to pay higher tariffs exists. Public-private partnership can play an important role in provision of these services.

Rural areas need not be left out as electricity is acknowledged as a basic necessity for improving the standard of living. Increasingly, agriculture and cottage industry are dependent on electricity as source of energy. Rural electrification is also a major thrust area identified by the Central Government. The concept of distributed generation based electricity distribution Franchisee can also be suitably adopted for rural areas, if beneficiaries demonstrate willingness to pay appropriate cost reflective tariffs or the State Government provides the necessary subsidy concession. With introduction of this Model in urban and industrial areas, it should be noted that benefits of this approach would be profound if it could be implemented in rural areas as this approach will obviate investment in network as well as technical losses over long drawn networks.

Advice to the State Government

The Electricity Act 2003 (EA 2003), provides for the State Commission to advice the State Government, under Section 86 (2), which stipulates:

(2) The State Commission shall advise the State Government on all or any of the following matters, namely:

I. Promotion of competition, efficiency and economy in activities of the electricity industry;

II. Promotion of investment in electricity industry;

III. Reorganization and restructuring of electricity industry in the State;

IV. Matters concerning generation, transmission, distribution and trading of electricity or any other matter referred to the State Commission by that Government.

The Commission is of the opinion that the State Government's policies could be suitably evolved to promote distributed generation based franchisees for electricity distribution. This would result in better service to consumers prepared to pay cost reflective tariffs and competition in the sector.

Franchisee Concept

The role of Franchisee is a well-established concept in the consumer goods and services sectors. A Franchisee provides products or services on behalf of a Franchisor and, in return, is paid fees/charges for the service provided. The Franchisee, under the arrangement, follows standards of services (or product specifications) while delivering the services (or products) such as maintaining the quality standards of the Franchisor, which helps to strengthen the latter's image in the market. On the other hand, the Franchisee offers products/services as per the prices decided by the Franchisor. In turn the Franchisee pays to Franchisor an amount on the basis of sales (fixed percentage of sales achieved per month) as per the terms of the Franchisee Agreement.

The Franchisee concept applied to electricity distribution will function as follows: Distribution Licensee and Franchisee would enter into a Franchisee arrangement under which the Franchisee will manage the electricity distribution function in the designated area within the license area of the distribution licensee. The main elements of such an arrangement would include:

a. Distribution Licensee will supply electricity to the Franchisee at a pre-determined price as per the Franchisee Agreement.

b. The Franchisee will supply electricity to consumers of the Licensee in the allocated area (a part of the total area of supply of licensee) as per the tariff (including reliability surcharge) approved by the Commission.

c. The Franchisee will manage the electricity distribution system of the Licensee in the allocated area. The Franchisee will not only undertake maintenance of the distribution system, but also upgrade and strengthen the distribution system as per the requirements of the Licensee, with its approval.

d. The Franchisee will manage metering, billing and collection with the help of the existing staff of the licensee (in addition, Franchisee will be required to add its own staff to manage any increase in business).

e. Franchisee will remit a pre-determined share of the revenue collection at regular intervals to the Licensee, as per the Franchisee Agreement. The Franchisee will retain a portion of the revenue collection from consumers after deducting amount payable/paid to the licensee.

f. Franchisee will operate under the overall guidance of the Licensee.

g. The Franchisee will also generate electricity locally to meet any shortfall (i.e. demand supply gap) in its designated area, under the proposed scheme of Distributed Generation (DG) based Electricity Distribution Franchisee.

h. In the interim, the Franchisee may also procure power from outside the State to supplement the existing captive capacity and ensure zero load shedding.

i. Sale of surplus power to the grid, if any.

CHAPTER 6

Conclusion

The bottom-up reform approach proposed in this thesis has been developed through a critical analysis of the Indian ESI, with a particular focus on the state of Uttar Pradesh. The case example is used to demonstrate that the bottom up appropriate model can be adopted as an alternative against current to provide a better path going forward.

The primary objective of this thesis has been to establish the feasibility of a bottom up approach to liberalization of electricity markets for Uttar Pradesh. This has been achieved by studying the options for and impact of small-scale distributed generation and captive power plants. The study addresses the research questions mooted as follows:

1. Is bottom up Distributed Generation approach is correct for Uttar Pradesh similar to other developing countries?

2. Are there a set of Market motivations in select Developing countries and can be adopted by Uttar Pradesh, leading to substantial growth of the Distributed Generation sector.

3. Are there a set of Distributed power generation models, identified for Uttar Pradesh

The thesis, through a case study in Kanpur district, demonstrates the advantages of using DG and CPP in a bottom-up model to change the demand and supply functions. Figure shows the three main markets for power and helps clarify how DG and captive units implement the bottom up model of reform.

The figure 6.1 helps to capture the main points of the thesis in a compact format. Starting from the bottom left, DG electricity production can be sold either directly to small consumers such as agricultural producers, rural households and rural small manufacturing facilities or to power distribution companies. For the rural consumers, DG

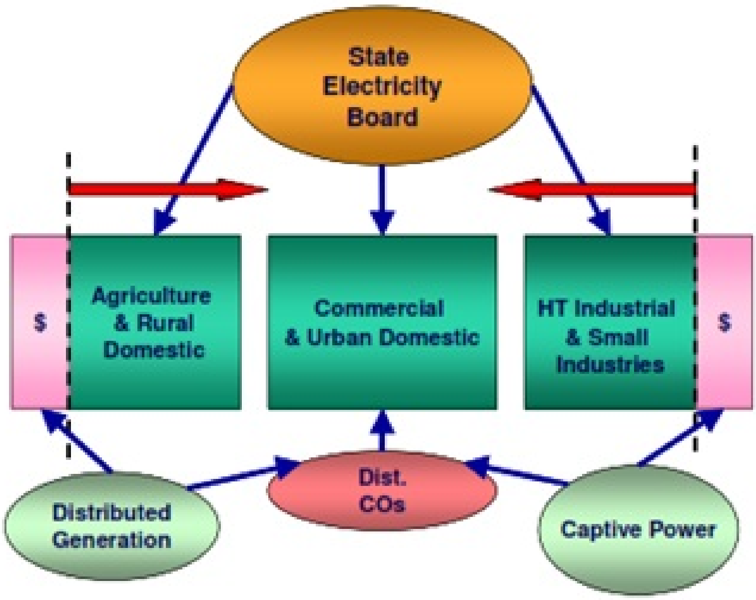

Figure 6.1: Uttar Pradesh power market with Distributed Generation

helps to address those parts of the market with the highest willingness to pay and those that need better levels of reliability than the grid alternatives can deliver. This concept is represented by the light colored bar on the far left hand side of the figure with the dollar sign. As DG decreases in price due to economies of scale and decreased renewable energy technology costs, the part of the market that will support DG approach expands along the customer spectrum, as indicated by the arrow to the left. DG can also sell directly to distribution companies to provide power and services during both peak and non-peak times as the market matures.

There are several conclusions that can be drawn from this study:

• State utility commissions as well as local and regional electric system planning processes, models, and analytical tools could be modified to include DG as potential resource options, and thus provide a mechanism for identifying opportunities for integrating DG into the modern electric system.

In geography like Uttar Pradesh, with a fast growing urban population, a dispersed rural population and a nascent heavy industrial sector, the bottom-up model is uniquely suited to address the market needs.

• HOMER provides the detailed rigor of chronological simulation and optimization in a model that is relatively simple and easy to use. Its adaptable to a wide variety of projects. For a village or community-scale power system in Kanpur, HOMER can model both the technical and economic factors involved in the project. As distributed generation and renewable power projects continue to be the fastest growing segment of the energy industry, HOMER can serve utilities, telecoms, systems integrators, and many other types of project developers - to mitigate the financial risk of their hybrid power projects.

• The current framework was established to meet the needs of large centralized generation and aspects of the system disadvantage smaller distributed generators. A number of Government policies changes to market arrangements will act to level the playing field for DG. To complement this work we have developed a package of additional measures that will go further to enable DG to compete freely and effectively with larger-scale, centralized generation.

• In the context of the GovernmentŠs overall energy policy goals, It is believe that any action to address the market failures described above should:

1. stimulate cost-effective low-carbon forms of DG;

2. provide a means of enabling distributed generators to realize a reasonable economic value from their schemes;

3. reduce the complexity involved in setting up as a distributed generator;

4. ensure requirements on these smaller players are proportionate to their size and the use they make of the wider public network; and

5. encourage, where possible, further development of DG within the licensed framework, rather than outside of it.

• In the light of these principles, the Government propose a bottom up, which have been discussed in the analysis chapter of this Report. These measures will help provide a basis on which DG can continue to grow alongside centralized generation.

- The new market and licensing arrangements will open up the opportunities for individuals and community generation schemes to make more extensive use of DG. This will have carbon benefits through the use of low carbon generating technologies including CHP, reduced network losses and the potential to exploit local, renewable sources of energy.

- Distributed generation is being more widely implemented worldwide as countries and local jurisdictions work to reduce the barriers. Working to streamline the process and adopt fair, cost based standby rates for DG is a good starting point for the developing countries.

6.1 Contribution to the Literature

This thesis has direct implications for re-framing the theoretical debate of power restructuring by providing a robust example of how an alternative reform path, the bottom-up approach, can deliver electricity services more effectively than traditional top-down programs. The power crisis under top-down methods in many developed and developing economies has led to an intense search for alternatives in the academic literature. The responses from the World Bank, academia, NGOs and think-tanks have ranged from improving the timing of reforms to pushing for more cost reflective tariffs supported by targeted subsidies. All of these ideas are valuable responses, but few have addressed how to better incorporate both small and large private power producers into the ESI.

The thesis also makes several direct contributions to the literature that expands coverage of under-scrutinized areas. First, there is only a thin body of work on the political economy of the power sector in Uttar Pradesh, thus the characterization and capturing of the major forces at work in the state through the case study portion of this thesis are an addition to the field. Uttar Pradesh is one of the only states in India that combines a strong industrial presence with large and important rural/agriculture voting blocks plus huge irrigation power requirements. This results in a unique mix of factors for the power sector to address.

Second, there are limited published work on the use of hybrid energy systems in Uttar Pradesh, India, and limited study of the energy situation in Kanpur district. As a mix of Urban and rural population, Kanpur has not been part of any published rural energy studies that evaluate hybrid energy system options.

Third, the conclusion that CPP and distributed power can be used effectively to help reform the electricity sector in Uttar Pradesh challenges the existing literature by arguing for more private operators in all parts of the ESI (not only generation) and by calling for the avoidance of a wholesale shift to private ownership in generation.

6.2 Limitations and Further research

• Completely different factors can emerge if this study is repeated after few years in India.

• Hypothesis testing can be a part Future Research

• Force majeure conditions are not considered in the study

• Detailed research can be carried out in subsequent studies by other scholars to identify other options of Hybrid DG Models.

• Detailed study can be carried out for each of the feasibility area

List of Publications

- **Lov Kumar Mishra**, Dr. Avanish K Tiwari, Dr. Krishan K. Pandey, Dr. Neelesh Chandra Aggarwal *Comparative assessment of Energy Management System & strategies in Kanpur city of Uttar Pradesh: A Bottom Up Distributed Generation approach* International Conference on Management of Infrastructure (ICMI) February, 2014

- **Lov Kumar Mishra**, Dr. Avanish K Tiwari, Dr. Krishan K. Pandey 2014 *Comparative assessment of Energy Management System & strategies in Kanpur city of Uttar Pradesh: A Bottom Up Distributed Generation approach* International Journal of Advanced Research in Management (IJARM), Volume 5, Issue 4, Pages:32-47.

- **Lov Kumar Mishra**, Dr. Avanish K Tiwari, Dr. Krishan K. Pandey *Business Viability of off Grid Hybrid Biomass model over on Grid Solar Generation for RE in Developing countries* International Journal of Engineering Sciences & Research Technology, ISSN: 2277-9655, Volume 4, Issue 8.

References

[1] John J. Conti. Annual energy outlook. Technical report, National Energy Information Center, EI-30, Energy Information Administration, 2007.

[2] Hoff, T.E., Wenger, H.J., Farmer, B.K., Distributed generation: an alternative to electricity investments in system capacity. Energy Policy, 24 (2): 137-147, 1996.

[3] Duong Quoc Hung, N. Mithulananthan, R.C. Bansal, An optimal investment planning framework for multiple distributed model units in industrial distribution systems, Applied Energy, 124: 62-72, 2014.

[4] Carmen, Djalma MF. Optimal distributed generation allocation for reliability, losses, and voltage improvement. International Journal of electric Power Energy System, 28(6):413-20, 2006.

[5] North Carolina and Zuyi Li. Market Operations in Electric Power Systems: Forecasting, Scheduling, and Risk Management. Wiley-IEEE Press, 2002. [6] T Logenthiran and Dipti Srinivasan. Multi-agent system for market based micro grid operation in smart grid environment. Computer Engineering, 6: 591-596, 2007.

[7] M. Siahi, S. Porkar, A. Abbaspour, Tehrani Fard, P. Poure, and S. Saadate. Competitive distribution system planning model integration of dg, interruptible load and voltage regulator devices. Iranian Journal of Science & Technology, 34:619-635, 2010.

[8] Rajendra Prasad Payasi, Asheesh K. Singh, and Devender Singh.Review of distributed generation planning: objectives, constraints, and algorithms. International Journal of Engineering, Science and Technology, 3:133-153, 2011.

[9] Ximing Wang, Hongwen He, Fengchun Sun, Xiaokun Sun, and Henglu Tang. Comparative study on different energy management strategies for plug-in hybrid electric vehicles. Energies, 6:5656-5675, 2013.

[10] Chris Harris. Electricity Markets: Pricing, Structures and Economics. John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex PO19 8SQ, England,

2006.

[11] Rahmatallah Poudineh, Tooraj Jamasb Distributed generation, storage, demands response and energy efficiency as alternatives to grid capacity enhancement. Energy Policy 67: 222-231, 2014.

[12] Kristopher A Pruitt, Sven Leyer, Alexandra M. Newman, and Braun. A mixed-integer nonlinear program for the optimal design and dispatch of distributed generation systems. Springer Optim Eng, 23: 319-334, 2013.

[13] Masoud Honarvar Nazari. Making the Most out of Distributed Generation without Endangering Normal Operation: A Model Based Technical-Policy Approach. PhD thesis, Carnegie Mellon University, 2012.

[14] Rajkumar Viral and D.K. Khatod. Optimal planning of distributed generation systems in distribution system: A review. Renewable and Sustainable Energy Reviews, 16:5146-5165, 2012.

[15] Zhang YinFang, David Parker, and Colin Kirkpatrick. Electricity sector reform in developing countries: An econometric assessment of the effects of privatisation, competition and regulation. Journal of Regulatory Economics, 33:159-178, 2008.

[16] N Leemput, J Van Roy, F Geth, P Tant, B Claessens, and J Driesen. Comparative analysis of coordination strategies for electric vehicles. In IEEE PES ISGT Europe 2011 location: Manchester, United Kindom, 2011.

[17] C. Battistelli, A.J. Conejo, Optimal management of the automatic generation control service in smart user grids including electric vehicles and distributed resources. Electric Power Systems Research, 111: 22-31, 2014.

[18] Thomas B Smith. Electricity theft: a comparative analysis. Energy Policy, 32:2067-2076, 2004.

[19] Varanasi Misra Singh, D. Banaras Hindu Univ. Effect of load models in distributed generation planning. Power Systems, IEEE, 22:2204 -2212, 2007.

[20] Kristopher A Pruitt, Sven Leyer, Alexandra M. Newman, and Braun. Optimal design and dispatch of distributed generation systems. Technical report, Argonne National Laboratory, 2012.

[21] Mahmood Sheidaee and Mohsen Kalanter. A comprehensive distributed generation planning optimization with load models. International Journal of Scientific & Engineering Research, 2:1-6, 2011.

[22] Peter Kind. Disruptive challenges: Financial implications and strategic responses to a changing retail electric business. Technical report, Edison Electric Institute, 2013.

[23] Y. K. Tomsovic Zhu. Optimal distribution power flow for systems with distributed energy resources. Electrical Power and Energy Systems, 29:260-267, 2007.

[24] Sudipta G, Ghoshal SP, Saradindu G. Optimal sizing and placement of distributed generation in a network system. International Journal Electric Power Energy System, 32(8): 849-856, 2010.

[25] Anoop Singh. Private investment in power sector in developing countries: Lessons from reforms in asian and latin American countries. 2010.

[26] Singh D, Misra RK. Multiobjective optimization for DG planning with load models. IEEE Trans Power System; 24(1):427-436, 2009.

[27] Vogel, P., Efficient investment signals for distributed generation. Energy Policy 37, 3665-3672, 2009.

[28] Darrow, K. & Saxenian, M., 1993. Appropriate Technology Sourcebook. Online Edition ed. Village Earth. Available at www.villageearth.org.

[29] De Keyser, W. & Peeters, P., 1996. A note on the use of PROMETHEE multicriteria methods. European Journal of Operational Research, (89), pp.457-61.

[30] DECC, 2011. UK Climate Change Sustainable Development Indicator: 2010 Greenhouse Gas Emissions, Provisional Figures. London: Department of Energy and Climate Change National Statistics. Available at www.decc.gov.uk

[31] Dodds, R. & Venables, R., 2005. Engineering for Sustainable Development: Guiding Principles. London: The Royal Academy of Engineering The Royal Academy of Engineering.