"SAVE ENERGY'

# Electric Times

**EEE- AITS RAJAMPET**

VOL.II. . . No.1 *MAY 2018* EDITORS : S.MUQTHIAR ALI::M.RAMESH

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| We envision the Department as one of the best in the region with a stimulating environment to make an impact on and lead in the field through its Education and Research. | The mission of the Department is to provide an excellent and comprehensive education in the field of Electrical & Electronics Engineering which in turn moulds the students for a wide range of careers and to exhibit a high level of professionalism, ethical behavior and social responsibility. |

**Student Article:**

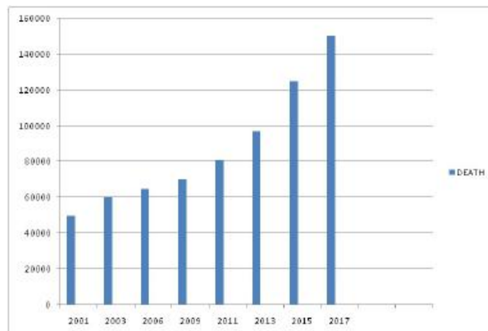
## 1. SMART HELMET USING IOT-by Ayub khan

ABSTRACT:
An accident is unexpected,unusual unintended external action which occurs at time and place. Carelessness of the driver is the major factor for accident.The government has made rules that rider should compulsory wear the helmet and not consume alcohol and drive. Still the riders do not obey the rules. These accidents are caused due to negligence of the rider.

Not wearing the helmet causes the rider with head injuries which may lead to death of the rider. In order to overcome this an intelligent system is introduced called smart helmet. The vibration sensors are placed in helmet where the probability of hitting is more when rider met with the accident the vibration sensor detects and by using wireless transmitter GPS forward the location of the victim to the nearest hospital for medical assistance or aid. This system has a pair of transmitter and receiver, the transmitter is placed in the helmet and the receiver is placed at the bike ignition. There are different sensors to ensure the helmet is on the head. An alcohol sensor is placed near mouth of the rider. The alcohol sensor detects the presence of alcohol in rider's breath. The data of the detection of helmet and alcohol is coded with RF encoder and then transmitted through radio frequency transmitter. The receiver at the bike receives the data and the data is decoded using RF decoder. The result of presence of helmet and the alcohol detection is analyzed by the microprocessor and it shut down the ignition system.

**1. INTRODUCTION**

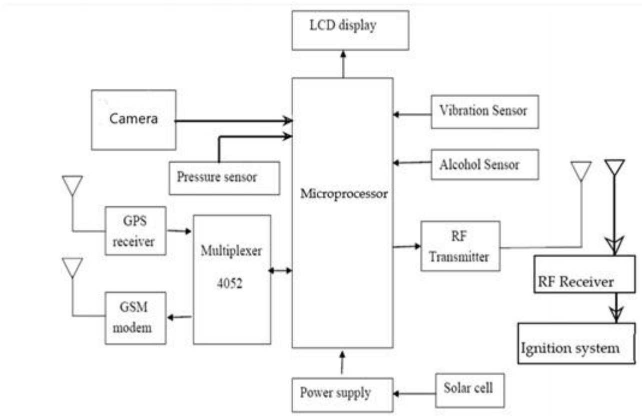
According to 2017,the global status report safety by WHO states that every year nearly 1.5 million people die in a road accident and in that 1.5 million deaths one-third of the death are due to drink and drive accident. Nearly one fourth of the accident is from motorcyclists. Some of the cause of the accidents is due to the reckless driving, over speeding and alcohol consumption driving. Many people lose their life within first one hour of the accident because Late reporting of an accident and Inaccurate GPS location due to this unable to provide ON-SITE medical assistance




The objective of the project is to build an IOT (Internet of Things) which increase the connectivity, data, and sensing analytics that are the basis of IOT applications. The IOT involves of smart machines cooperating and interacting with other devices, objects, environments and infrastructure. The huge amount data that is generated and processed into useful action that can "command and control" things, to make our lives safer and easier. IOT has application has various benefits like remote monitoring, manage and control the IOT device in real time data. The base of the project lies in the brilliance of the microprocessor. Thus IOT application must be able to provide support for the following
Reading data streams directly from the sensors.
Transparent and scalable processing of data.

**2. PROPOSED SYSTEM**

2.1 BLOCK DIAGRAM: Following figure fig2 shows the block diagram for "SMART HELMET" microprocessor play important role in smart helmet sensor, GPS, GSM, transmitter. The operating voltage of the microprocessor is 3.3V which fed by the solar cell. When rider met with accident the pressure sensor sense the intensity and forward to the microprocessor which shown in Fig.




2.2 DESCRIPTION OF BLOCK DIAGRAM: 1. TYPES OF SENSORS USED I. PRESSURE SENSOR: Pressure sensor has a sensing element of constant area and respond to force applied to this area. The force applied will deflect the diaphragm inside the pressure sensor. The deflection of the internal diaphragm is measured and converted into an electrical output. This allows the pressure to be monitored by microprocessors Pressure sensor placed in the maximum probability of hitting on the helmet.

II. ALCOHOL SENSOR: Alcohol sensor shown in Fig. 4 which is placed near the mouth region of the helmet interfaced with the raspberry pi, it is high sensitivity to organic solvent vapors such as ethanol detects whether the rider is alcoholic or not, only when the rider is non alcoholic the bike will start (i.e.) ignition system will enable, if alcoholic level is detected then it will disable the ignition system and the microprocessor send the location of the rider to the family members.

III . VIBRATION SENSOR:
Vibration sensor placed inside of the helmet which measure how much intensity hit the rider head when met with accident and it is also used to confirming when helmet accidentally fall from height the pressure sensor sense and send the signal to microprocessor for rechecking it check the vibration sensor if it is negative then the microprocessor block to forward the message. Sensor shown in Fig.


IV. CAMERA: Camera connected to the microprocessor for security and checking purpose a small spy camera placed on the helmet when rider met with accident spy camera take the photo and it forward along with the message to the hospital for confirmation that rider met with an accident. the spy camera was shown in Fig.


PRINCIPLE The armor a cheap, effective alcohol, accident detection and notification system to address the foretasted problems. Though integrating sensors with a raspberry pi-3 that provides a rapid alcohol and accident detection, they are limited in terms of processing and notification capabilities. The raspberry pi-3 is a WI-FI and Bluetooth enabled mini-computer which is used to interact with cloud computing and with the bike. This expands the computational and cloud storage capabilities of the system. The system on helmet communicates with both the cloud based incidence response and the bike and then notified via RESTful architecture over HTTP using JSON.

3.1. ALCOHOL AND ACCIDENT DETECTION SYSTEM: An alcohol sensor MQ-3, a tri-axial accelerometer, GPS GSM module are connected in raspberry pi-3 and the entire setup is present in the helmet. Alcohol sensor will detect the BAC through the rider's breath and a threshold value is defined in the system, consumption if the sensor detects alcohol content more than the threshold value then the processor will detect alcohol in rider's breath. The accelerometer ADXL345 is a digital accelerometer that detects the variation in spatial components along 3 orthogonal directions X, Y, and Z. A threshold value is set giving allowance for minor level head tilt not pertaining to an accident.

When the accelerometer detects any sudden change in threshold values in all 3 directions is observed simultaneously, the change in resultant acceleration values is calculated. Average variation of acceleration values is calculated over time and then compared with the threshold values if the value is exceeded then the processor will detect a crash which is shown in Fig. 14.

3.2 BIKE IGNITION CONTROL SYSTEM: Ignition control system is between the helmet and the bike the alcohol sensor in the helmet will detect the alcohol content and if the BAC is more than the limit it will tell the raspberry pi-3 will send a command to the bike, raspberry pi having an inbuilt Bluetooth module it will send a command to the bike. The bike ignition system is connected to receiver, a Bluetooth receiver is connected to the system so that it will receive the commands from raspberry pi and further action will be taken Accident notification system.

3.3 ACCIDENT NOTIFICATION SYSTEM: The notification system is split into two parts the client and the server. Raspberry pi acts as client and server is a cloud based web service. The monitoring system makes the use of the values gathered from accelerometer and GPS to send data to the cloud-based notification system.

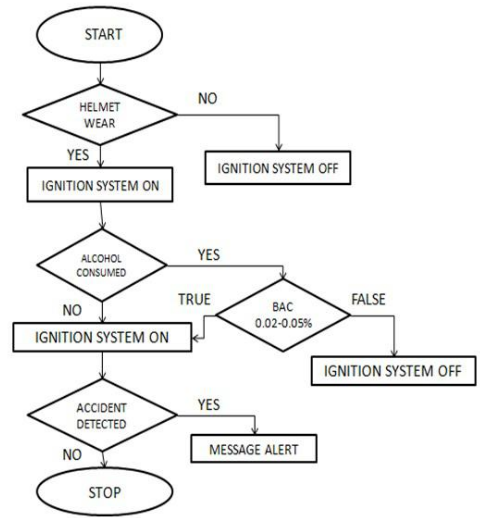



Figure show the flowchart of the smart helmet. The helmet is designed to detect alcohol content in the rider's breath and if it exceeds the standard limits then it will disable the ignition system of the vehicle. An MQ-3 alcohol sensor is mounted on the helmet and it's used to monitor the alcohol content in the rider's breath if the BAC (blood alcohol content) if the rider's breath is more than 0.02 percentage to 0.05 percentage in 100 ml blood [12] then the helmet will trigger the ignition system and it will disable the ignition of the vehicles. The helmet is also designed to detect an accident and instantly alert emergency contacts. A 3-axis accelerometer is used to regularly monitor the head orientation of the rider and the helmet position and thus calculate the possibility of the accident. When the threshold limit is exceeded then a text message containing the GPS location of the rider is automatically sent to the emergency contacts. The text messages are repeatedly sent again at a regular interval of time to locate the rider's position.

**CONCLUSION**

To give notification of the accident and area, GPS and GSM is used thus cloud acts as server and raspberry pi acts as a client. If this has been implemented in the real time then it will prevent the person from the accidents and encourages him to ride in the safety way. It makes the person to ride in a way that even he met with an accident he can save his life as well.GPS send data to cloud based services where image can be accessed and send to the receiver contact. By implementing this type of helmet in future, more than 3/4th of the accidents can be avoided. This helmet ensures the safety of the rider and helps in preventing the accidents. Though this helmet has lots of restrictions it should be known as these restrictions are the only way to prevent accidents to be occurring.

**Student Article**

**2. STABILIZATION OF WIND POWER GENERATION USING ENERGY STORAGE TECHNOLOGY**

1.Introduction

Sustainability and efficient use of energy resources is an urgent issue today. Reasons lie not only in the growth of demand and production, but also in the present level of resource exploitation leading to exhaustion of energy resources and related environmental impacts. The sustainable use of energy requires applications and methods that could increase efficiency. This is especially important in converter applications.

Traditional methods of energy conversion in power plants have some disadvantages, such as impact on the environment. Some new unconventional methods of energy generation have less impact on the environment. The cost of power generation is one of the main criteria when choosing a method for its production. Today traditionaltechnologies seem to be cheaper than the alternativeones. Energy produced from renewable sources lacks the cost of fuel, however, it has higher capital costs.

The predicted costs and cost price of electricity production based on renewable sources have been given in Table 1. The use of renewable energy and storage offers prospects of significant decrease in fossil fuel extraction and accompanying environmental pollution. Unpredictable winds make it difficult to plan production (Fig. 2), complicating parallel operation with other power plants, intended for compensating the instability of wind power production. Due to unpredictable wind the difficulty in forecasting periods of excess energy as well as lack of energy occ.

2.Hydrogen Technology As A Buffer For Stabilization OfWind Power Generation:

The Department of Electrical Drives and Power Electronics has introduced the concept of using hydrogen for compensating the instability of wind production. A typical Configuration of a wind farm connected to the transmission grid is formed by the set of wind generators, electrically connected through a medium voltage network, sharing one single infrastructure for access and control. A block diagram of the hydrogen buffer system for the stabilization of wind power generation is presented in Fig

Fig.2.1. Block diagram of the proposed hydrogen buffer: 1-Blades;2-Gearbox;3-Generator;4-Rectifier;5-Interface DC/DC converter;6-Electrolyser; 7-Storage tank;8-Fuel Cells;9-Interface DC/DC converter;10-Inverter;11-Transformer. Because of unregulated energy production (Fig. 2), the fluctuation of wind speed leads to a fluctuating output. It means that at some moments excess energy and energy lack appear. As mentioned above, a hydrogen buffer is used to stabilize unregulated energy production, consisting of the following main components; 1.Hydrogen production stage 2.Hydrogenstorage and delivery stage 3.Electricity production stage. In periods of excess energy, the hydrogen generation system is connected to the internal grid. In this stage, electrical energy from the wind generator is converted into chemical energy by using water electrolysis. Because of low input voltage of an electrolyser it is necessary to decrease high output voltage of the grid with the help of interface DC/DC converter with a step-down isolation transformer. The hydrogen generation system consists of two main parts: 1. Interface DC/DC converter with a step-down isolation transformer, which allows interfacing the high voltage DC output of converter with a low voltage input of the electrolyser, 2. Electrolyser, allowing electrical energy storage and producing hydrogen from water electrolysis using excess electricity from the wind generator. 3.1 General Classification of Electrolysers: Electrolyser 1.Alkaline 2.Proton Exchange 3.HighTemparature Solid Oxide Alkaline electrolysers could be subdivided into unipolar or bipolar electrolysers (Fig. 4). The unipolar design is composed of a series of electrodes, anodes and cathodes alternatively suspended in a tank, filled with a 20–30

The bipolar electrolysers have alternating layers of electrodes and separation diaphragms, which are clamped together. The cells are connected in series and canresult in higher stack voltages. Since the cells are relatively thin, the overall stack can be Considerable smaller in size than the unipolar design

Fig.3.1.1 Proton Exchange Membrane Electrolyser

In the PEM electrolysers the electrolyte is contained in a thin, solid ion conducting membrane as opposed to the aqueous solution in the alkaline electrolysers. This allows the H+ ion to transfer from the anode side of the membrane to the cathode side and serves to separate the hydrogen and oxygen gasses. Oxygen is produced on the anode side and hydrogen is produced on the cathode side. PEM electrolysers use the bipolar design and can be made to operate at high differential pressure across the membrane. High-temperature electrolysis (HTE) is different from the conventional electrolytic process. Some of the energy needed to split water is provided as thermal energy instead of electricity. It occurs because conventional electrolysis usually operates at temperatures below 100ºC.

HTE generally refers to an electrolytic process operating at temperatures above 100ºC. As HTE curtails the relatively inefficient step of conversion of heat to electricity, it is more efficient than the conventional electrolysis .In a HTE system using nuclear energy, a nuclear reactor supplies thermal energy that both generates electricity and heats up the steam needed for electrolysis. The HTE system is supported by nuclear process heat and electricity has the potential to produce hydrogen with overall system efficiency near that of the thermochemical processes. HTE cells consist of two porous electrodes separated by a dense ceramic electrolyte. HTE cells with oxygen ion conducting ceramic as electrolyte are often called solid oxide electrolysis cells (SOEC)

**3.2 Hydrogen Storage:** In an ideal system, supply will match demand. Energy storage enables the supply to be shifted to meet the demand. Electricity can be drawn from the primary supply during periods of excess availability, stored and then returned during periods of excess demand. Correct sizing of the storage should allow the generation plant to operate closer to its optimal efficiency, making thus better economic use of the existing assets. According to the International Energy Agency classification, hydrogen storage methods can be divided into two groups:

The first group includes physical methods which use physical processes (compression or liquefaction) to compact hydrogen gas. Hydrogen being stored by physical methods contains H2 molecules, which do not interact with the storage medium. The following physical methods of hydrogen storage are available:

1. Compressed hydrogen gas, 2. Liquid hydrogen: stationary and mobile cryogenic reservoirs

The second group includes chemical (or physical-chemical) methods that provide hydrogen storage using physical chemical processes of its interaction with some materials. The methods are characterized by an essential interaction of molecular or atomic hydrogen with the storage environment. The chemical methods of hydrogen storage include:

1. Adsorption,
2. Bulk absorption in solids (metal hydrides),
3. Chemical interaction.

Comparison of hydrogen storage methods in accordance with the above mentioned methods. 3.3.Hydrogen Delivery:

Between the two ends of the economic chain, hydrogen has to be packaged by compression or liquefaction to become a commodity. In the transportation, hydrogen has to be produced, packaged, transported, stored, transferred to cars, then stored and transported again before it is finally admitted to fuel cells.

There are two possibilities of hydrogen delivery

1. Road delivery,
2. Pipeline delivery Because of the low density of the gaseous energy carrier, transport of pressurized or liquid hydrogen is extremely inefficient. Forty-ton trucks can carry only 350 kg of hydrogen at 200 bars in the gaseous or 3,500 kg in the liquid state.

The energy required to deliver the gas is part of the production costs. Parasitic energy losses reduce the amount of available energy. Hydrogen transport by pipelines has to compete with electricity transport by wires.

Design and construction of large, long-distance, high pressure gaseous hydrogen pipelines and conventional natural gas (NG) transmission lines are similar. Four technological aspects differentiate the gaseous hydrogen (GH2) line from the NG line and need to be addressed for the concept to be attractive to industry

1. The volumetric energy density of hydrogen is one third of that of methane, 2. High pipeline utilization is critical for economic feasibility, 3. Hydrogen embrittlement of pipeline steel must be prevented and controlled, 4. Compression is very costly.

Most of the analyses show that pipelining GH2 costs approximately 1.3 to 1.8 times more per unit energy-distance than NG, because of these four factors. Pipelines are very expensive to design and construct, which is why they must have high utilization to justify the initial capital cost. newline

**Article**

## 3. Restructuring the Indian Power Sector: Some Issues-Mr. S. Muqthiar Ali

Abstract: The power sector is undergoing a structural change in many parts of the world, involving dismantling of public monopolies. In India, power policy has changed since 1991, but the progress has been slow and uneven. The response of the private sector has been disappointing, mainly because of the financial weakness of the State Electricity Boards. Public investment on power development should not be scaled down.

Corporatisation of SEBs will not bring about any improvement without tariff rationalisation and a change in the style of their functioning. Large-scale privatisation is neither feasible nor desirable. The credibility of the regulatory authorities is important, but the state governments must play a supportive role. It is unrealistic to expect the emergence of an electricity market in India in the near future. Serious thought should be given to the creation of a new legal framework for future power development in India.

Power sector reform has been under way in many countries though the pattern varies from one country to another. India has also made a start in restructuring its power sector. This figures prominently in current public discourse as well as in the media, and rightly so, as it concerns every citizen of the country. Electricity plays a ubiquitous role in the modern world; it touches every segment of the economy and the life of every individual. It is a crucial component of infrastructure; at the same time, it is highly capital-intensive. Over the years, massive investments have been made the world over to attain high levels of economic advancement. For a developing country like India, a healthy, vibrant and expanding power sector is an imperative need. As estimated by the Planning Commission in the Ninth Five Year Plan document, the

Electricity-GDP elasticity was as high as 1.36 during 1990–96, indicating that GDP growth rate of 7-8 per cent per annum cannot be achieved without an increase of close to 10 per cent a year in electricity consumption. There is another aspect. The Indian economy is getting integrated rapidly with the global economy. The Indian consumer must benefit from competition following the process of liberalisation instituted since the nineties. At the same time, the domestic economy has to grow stronger and bigger. For this, adequacy of supply is not enough; energy must be available at a reasonable price, which can happen only if the electricity industry displays high efficiency and productivity. It is equally important that, even in a market economy, underprivileged sections of society are enabled to have some access to the benefits of electricity. These must be the criteria by which to assess the outcome of the restructuring process taking place in the Indian power sector. The process of reform of the power sector is still in its initial stages and it would be premature to assess the outcome. The steps taken in the last few years have, however, brought to light several problem areas that need to be resolved before the sector is fully restructured and the expected impact is felt.

The paper attempts to highlight the more important among them and suggest how they should be dealt with. The next section begins by tracing the genesis of reform of the power sector worldwide and proceeds to set out the developments in this sector in India since 1991, when there was a marked shift in the country's economic ideology. The progress so far is briefly reviewed. This is followed by a section in which the major issues and problems having a bearing on the content and direction of reform are discussed. The concluding remarks are presented in the last section of the paper. Reform: Process and Progress Paradigm Shift India, as mentioned earlier, is not the only country in which power sector reforms are being carried out. Indeed, it was in the industrialised West that impulses for change originated. If we look across different countries, we see a paradigm shift taking place in varying degrees from the United States at one end to Australia at the other. In order to appreciate the underlying reasons, it is useful to take a quick look at the evolution of the power sector in the last sixty years or so. We see that during the first four decades after the end of the Second World War, in industrialised and developing countries alike, power development took place almost wholly in the public sector. USA was a notable exception, but the industry was subject to strict regulation. Broadly, one can identify four reasons (Chandran 1998) for the development of the power industry in the public sector:

First, power systems provide a classic example of a natural monopoly. Unlike other commodities, electricity cannot be stored and, at all times, supply must match demand. Consequently, it is desirable that the three components of a power system, namely, generation, transmission and distribution are vertically integrated. Having regard to the diurnal and seasonal variations of demand, system efficiency and reliability can be optimised through grid operation, preferably under single ownership. Every consumer must have a dedicated delivery system. Therefore, the industry is characterised by high sunk cost, making it difficult for an existing operator to exit and setting up a high entry barrier to new players. The larger the operational network of a power system, the smaller the marginal cost of service to a new consumer—another characteristic of a natural monopoly. If an important component of infrastructure like power is inherently monopolistic, it was argued, a public monopoly is preferable to a private monopoly.

Secondly, power development requires large and lumpy investment. Among all the components of infrastructure, the power industry has the highest incremental capital-output ratio. At the same time, as it mostly provides an intermediate good, electricity tariff must be kept low in order that the final product is not priced out. As a result, capital amortisation requires a relatively long time. These make it difficult to mobilise requisite investments from the private sector. Third, the socialist ethos held sway over most countries of Europe in the aftermath of the Second World War. It was believed that public interest would be maximised by public ownership of the vital means of production. This philosophy spread to colonial countries newly securing independence.

Lastly, in the developing countries, there was another policy angle, namely, the role of electricity as an instrument to enhance the welfare of the poorer sections of society and accelerate the development of backward areas. Public monopoly of infrastructure development began to be questioned seriously around the seventies. Economists and political scientists put forward different theories like Public Choice theory, Contestability theory and Principal- Agent theory; while the arguments advanced were different, the net conclusion was that under exclusive public ownership of infrastructure, the citizen could not get economic and responsive service and that only market competition could ensure efficiency and optimal allocation of resources. This perception was strengthened by the global recession of the early 80's. There was a growing feeling in western countries that public monopolies were inefficient, unresponsive to citizens' needs and not accountable, whereas the private sector was perceived as being capable of providing better service.

The growing importance of international financial markets, which could help the private sector to mobilise large funds, was a supportive factor. Some technical developments occurred in parallel favouring demonopolisation. These were spectacular in telecommunications where satellite communication made a dedicated delivery system unnecessary.

In the power sector, the discovery of abundant reserves of natural gas made it possible to add capacity in smaller increments. This meant less lumpy investment, which made it easier for private players to step in. The lead in dismantling public monopolies was taken by UK in 1989 when Prime Minister Margaret Thatcher launched an aggressive programme of privatisation of electricity, coal, gas and telecommunications. Since then, a large number of countries are pursuing a similar course. The arguments in favour of a greater role for the private sector in infrastructure mentioned earlier, no doubt, have relevance to developing countries also; but the major compulsion of these countries is the acute scarcity of investment funds in the public sector and the priority to be given to social development in the utilisation of available resources. They have no option except to welcome private investment.

As domestic capital markets are small and weak, this means, in effect, attracting foreign investment, especially into power and telecommunications, which need and have the potential to absorb funds on a large scale. Policy Changes in India Policy changes in India have followed a similar two-stage pattern. When we attained Independence in 1947, socialist beliefs were widespread in the country. The Industrial Policy Resolution of 1948 (reiterated in 1956) placed power, among others, in the list of areas reserved for the public sector. The Electricity (Supply) Act was enacted in 1948 to provide the legal framework for power development, including the establishment of State Electricity Boards (SEBs) and Central Electricity Authority (CEA). Without question, there has been a large expansion since then. Creditable as this may be, the fact remains that capacity and energy shortages have become rampant.

The utilities are in financial disarray: on the one hand, their costs tend to be high because of inadequacies in operating efficiency, overstaffing and poor management. On the other hand, they operate under an irrational tariff regime characterised by distortions in the charges borne by different categories of consumers and, overall, under-recovery of cost. The tables below present a quick picture.

We have a situation in which the higher the energy production of a power utility, the higher the loss. Also, certain categories of consumers are overcharged while others are subsidised indiscriminately. The distortions appear even more pronounced when the figures are examined statewise. For their part, the Central and state governments, which have been the main source of investment funds, are themselves under financial strain and are required to reduce the fiscal deficit. The fact that in the Eighth Five Year Plan period, the actual addition to generation capacity was only 17,600 MW against the target of 30,500 MW is a clear indicator that, without harnessing private funds, expansion of the sector commensurate with ambitious economic growth targets will not take place. It was against this background that under the new economic policy initiated in 1991, the power sector was thrown open to private investment, domestic as well as foreign. This was a part of a range of measures to a competitive market economy.

| Category | 1996–97 | 1997–98 | 1998–99 |
|---|---|---|---|
| Domestic | 118.5 | 133.9 | 131.1 |
| Commercial | 291.5 | 333.3 | 345.3 |
| Agriculture | 21.1 | 27.7 | 29.7 |
| Industry | 282.4 | 284.8 | 297.5 |
| Traction | 352.9 | 374.8 | 398.9 |
| Outside State | 148.1 | 146.9 | 156.7 |
| Overall | 163.0 | 184.5 | 197.9 |

Since then, further steps have been taken to break up the public sector monopoly of the power industry and to facilitate an increasingly larger role for the private sector.

Broadly, reform of the power sector has four components: unbundling, establishment of regulatory mechanisms, corporatisation of SEBs with a redefined role and privatisation. Let us examine what these imply. Unbundling. Unbundling of the power system means segregating the monopolistic and the non-monopolistic components of the system. Clearly, generation is an activity, which permits multiple players, is amenable to market competition and can be opened for private investment. Distribution in a given area does partake of a monopoly, but the element of competition can be brought in two ways—first, the right to distribute power to consumers in the area may be allotted to private parties through competitive bidding ensuring at the same time that the consumer gets supply at minimum price. Second, yardstick competition, i.e., comparison of the performance of different distribution agencies, can be used to drive efficiency improvement and, where possible, bring down the tariff. As for transmission, private parties can own individual lines but, operationally, there is room for only one player in a given region and it remains a monopoly. What is needed in the case of transmission is to establish institutional arrangements, which guarantee equal access to power producers and fairness in load dispatch during periods of congestion.

| Year | Average Cost (paise/kwh) | Average Revenue (paise/kwh) | Revenue as a Percentage of Cost |
|---|---|---|---|
| 1996–97 | 207.1 | 163.0 | 77.4 |
| 1997–98 | 225.2 | 184.5 | 80.1 |
| 1998–99 | 242.9 | 197.9 | 78.8 |

Regulatory Mechanism. The primary function of the regulator is to balance the interests of the consumer in getting energy at as low a price as possible with the interests of the producer in earning a reasonable return on his investment. The regulatory authority has also to lay down the guidelines for a smooth technical and financial interface between the monopolistic and the non-monopolistic elements of the power system. Where, as in India, both public and private entities are engaged in a similar activity such as generation, the regulator must see to it that there is a level playing field. For regulation to be credible, the regulatory body should be independent, should give opportunity to all the stakeholders to present their views and function in a transparent manner (Expert Group 1996).

Corporatisation of SEBs. While generation and distribution may be taken over by separate entities, the SEB will be the appropriate agency to look after transmission. It will be the intermediary between producers and distributors of power, purchasing power from the former and selling to the latter (or to consumers until the distribution entities come into existence). Load forecasting and system planning will be their other functions. In order that SEBs perform their role effectively in the new environment, they will be corporatised, which will, hopefully, give them greater functional and financial autonomy.

Privatisation. This does not require any elaboration. The idea is that over a period, government will divest itself of ownership of public enterprises in favour of the private sector. However, there is as yet no official policy on privatisation, except in respect of distribution. The advantages perceived in placing distribution under private ownership are – first, pilferage of power will be brought under control through elimination of unauthorised connections, metering, regular billing and rigorous collection of dues. Second, the private operator will be more consumer- friendly and responsive to their needs.

The measures listed above could lead eventually to the development of a market in electricity in which a consumer can choose his supplier and there will be all round improvement of efficiency as a result of competition.
While appraising the reform strategy, we should bear in mind that the overall goal is to make the power sector technically and financially sound. The consumer must get good quality service at a reasonable price. Competition-driven price of electricity should help our export industries to hold their own in the global markets. The reforms should provide an environment conducive to a large inflow of private funds for investment in the power sector, so that the growing demand can be met.
What has been presented above is the framework of reform. We will now briefly review how far we have actually moved ahead in the last ten years. It should be borne in mind that under our Constitution, electricity is a concurrent subject and the Central and state governments share responsibility for implementation. The important developments since 1991 were as follows:
(a) In 1991, Electricity (Supply) Act was amended to permit private sector entry into power generation.
(b) In 1992, the policy for thermal power generation was announced. It allowed licence for thirty years with possible further extension, 100 per cent foreign equity, tax holiday for five years plus tax rebate of 30 per cent for the next five years and protection against rupee depreciation.
The two unique features were guarantee of a return of 16 per cent on equity at 68.5 per cent PLF, with incentive for better performance and inclusion of ‘take or pay’ clause1 in the power purchase agreement. Initially, the Memorandum of Understanding (MOU) route was permitted so that there could be a quick start on new power stations, but as there were apprehensions of cost-padding, competitive bidding was made mandatory (except for small projects).
(c) In 1995, Orissa passed legislation for restructuring the State’s power sector. The State Regulatory Commission started functioning in 1996. Power distribution was subsequently privatised.
(d) In 1996, at a Conference of Chief Ministers, the Common Minimum National Action for Power was agreed upon, which included setting up of State Regulatory Commissions, rationalisation of tariff and private sector participation in distribution.
(e) In 1998, Parliament passed laws enabling private sector entry into transmission, designating the Central Transmission Utility (Powergrid Corporation) and State Transmission Utilities (SEBs or their successor bodies) and for setting up Regulatory Commissions at the Centre and in the states. Modified guidelines for hydropower projects were issued to make investments in such projects more attractive to the private sector. Government recast its policy on mega power projects, which would cater to the power needs of more than one state. These projects would enjoy additional tax concessions; the sharing of power by a state would be conditional on its implementing reforms.
(f) Some states have passed their own reform laws, set up Regulatory Commissions and converted their SEBs into companies. A few states have set up regulatory bodies under the Central law. The rest of the states have not moved at all.
(g) In order to persuade state governments to implement reforms, an incentive has been held out in the form of World Bank assistance and facilitation of private investment. Power Finance Corporation and Infrastructure Development Finance

Corporation have started linking their assistance with milestones in the completion of the reform process. Two facts stand out from the foregoing account. The first is that Central initiatives have been fitful and piecemeal. One does not see a grand design and the time lags have been excessive. The second is that progress in the states is uneven. Apparently, to give a push to implementation of reforms at the state level, the Union Cabinet gave approval, in December, 2000, to the Accelerated Power Development Programme to fund projects aimed at reform and restructure of the power sector. An outlay of Rs.1,000 crores was provided in the financial year 2000-01; in the budget for 2001–02, the provision has been raised to Rs.1,500 crores.

In the ten years that have passed since the new policy was adopted, the contribution of the private sector to power development in India has remained limited. Soon after the policy announcement in 1991–92, a large number of private parties from within the country and outside showed interest and state governments signed dozens of MOUs. If all of them had been implemented, the installed generation capacity in the country would have almost doubled! In actuality, capacity addition in the last ten years in the private sector was only about 5,500 MW. This apart, other issues have cropped up in the course of implementation of reforms. The more important among them are examined in the next section.

Some Issues Role of Private Sector If one may repeat, an attractive package of terms and conditions was offered to private investors. India has a well-established legal system and an independent judiciary. India should therefore be a preferred destination for foreign investment. International capital markets are flush with funds and heavy electrical equipment manufacturers look upon the developing world as their main market. Yet, there has been only a trickle of foreign direct investment (FDI). The most important reason is the extremely weak financial position of the SEBs (in the rest of the paper, the term SEB should be taken to include its successor bodies). If the sole purchaser of power is on the verge of bankruptcy and already has large outstandings towards purchase of power and coal, investor confidence is bound to be weak. Investment in power means a long-term commitment and the investor must have reasonable assurance of regular cash inflow during the licence period. This will not be forthcoming unless tariffs are rationalised so as to make the SEB operation commercially viable.

As restoration of the financial health of power utilities will take some time whereas the need for investment is immediate, a solution would be to offer sovereign guarantee; in the Indian context, it translates into state government guarantee backed by counter guarantee by the Central Government. At first, there was an inclination to give such a guarantee. But it was soon realised that this was not a sustainable arrangement, as it shifted the burden to government and therefore indirectly to the non-consumer also. Moreover, governments are themselves required to reduce their deficit. Government of India restricted the facility of counter guarantee to a small number of fast-track projects (which are in fact still lingering) and, as an alternative, asked SEBs to offer escrow cover to independent power producers (IPPs). Even this has proved unworkable for two reasons: first, the proportion of energy consumed by large industrial consumers who are regular in payment is relatively small, thereby restricting the escrow capability of an SEB. Second, the escrow arrangement will further weaken the SEB, as it creams away its best customers. It is clear that there are no soft options. No industry can run indefinitely at heavy loss, nor can (or should) government prop up such an industry diverting funds, which are badly needed elsewhere. Rationalisation of tariff based on normative performance standards is the only solution. The determination of tariff will hereafter be with the regulatory authorities. But this will have to be backed by strong political commitment and the willingness to deal firmly with vested interests, which have been enjoying undeserved benefits.

Among other factors inhibiting the inflow of FDI in the power sector is the lack of coherence in policy. The power sector is open for private investment, but coal and railways continue to be in the public sector. Captive coalmines can be under private ownership, but private investors desiring to set up a power station do not want to go into a business in which they have no expertise and which means raising additional capital, besides having to deal with a host of other problems. This asymmetry creates a serious problem for investors in thermal power generation based on domestic coal.

The IPP has to achieve the specified normative level of generation if it is to recover fixed costs and get a return on investment. The IPP therefore needs a fuel supply guarantee from the coal company, which produces coal and from the railways, which transport coal from the pithead to the power station. But, neither the coal company nor the railways are willing to enter into a legally enforceable agreement with the IPP. The result is that the project is non-bankable and remains a non-starter. This is not a hypothetical example, but is the case of one of the ‘fast-track’ projects. We have a situation in which our country has fairly abundant reserves of coal, but IPPs opt for coastal locations so that they can import LNG or Australian coal – a clear distortion of energy policy, not to mention the outgo of foreign exchange. It is high time that the coal industry was thrown open to private merchant producers. In our federal set-up, several agencies at the Central and state levels are involved in the processing of IPP proposals. Examination by each agency tends to be sequential and time consuming. Some clearances are mandatory and necessary, such as those from safety and environmental angles. But, in general, as there is no appreciation that time costs money, negotiations drag on interminably. A power project involving large investment has many technical, financial and legal ramifications and the power purchase agreement has to cover all kinds of eventualities, which could arise over a thirty-year period. Having had no experience of negotiating such complex agreements, officials have had to pass through a learning curve. There is also the problem that, more often than not, negotiators on the government side are drawn from the very same organisations whose monopoly is being taken away.

It is perhaps too much to expect that their mindset will be proactive to the devising of arrangements for the curtailment of their own powers and functions. An IFC-World Bank document (Sader 2000) says, ‘India’s electricity sector is by now infamous for the difficulty it presents to those interested in developing private power generation projects’. It is significant that of the projects initially identified by Government of India as fast-track projects, not one of the major projects has got off the ground. It is imperative that deadlines be set at both Central and state levels for processing by the different agencies.

Among the public, there is a feeling that the tariff of private power producers is higher than that of their public sector counterparts. Therefore, there is lack of enthusiasm for the concept of IPPs. Factually, it is true that private power is generally costlier. Primarily, this is because the private investor evaluates his risk and tries to minimise it. An investor is expected to bear the 'commercial risk' (e.g. non-performance of equipment according to specifications, shortcomings in maintenance, etc.), but it is mainly the 'country risk' that accounts for higher cost. Country risk includes foreign exchange variation, changes in taxation and labour laws, and civil unrest.

This is partly covered by host country guarantee. For the rest, the investor protects himself to the extent possible by insurance, which adds to the cost. Even the rate of interest on foreign borrowing depends on the credit rating of the host country, which in turn takes into account the prospects of policy consistency. The World Development Report 2000/2001 has some interesting data on Institutional Investor Credit Rating of different countries. India's rating is 45.3 while that of Singapore is 80.4; the figures speak for themselves. In contrast, in the case of a public sector project, there is no such 'add on', as all risks are absorbed by the exchequer. Therefore, a one-to-one comparison of cost between 'public' and 'private' power will not be strictly correct. Whatever be the explanation, it must be noted that the fervour for IPPs has abated a little in some developing countries. We in India do need large private investment, at least in generation, to ensure adequate availability of power. To allay public misgivings regarding the purchase price and to enable consumers to understand the basis for pricing, the Power Purchase Agreement entered into by the SEB with the IPP, should be placed in the public domain, with all supporting documents. This will be taken care of when the Regulatory Commission steps in, as their approval of the purchase price is mandatory and the procedures of the Commission provide for public hearings. What does this add up to? It means that we should not put all our eggs in the private sector basket. We should not act on the assumption that private finance can substitute for public investment; it can only be a supplement. We should remember that neither has nuclear power generation been opened to the private sector nor would international financial markets support nuclear power projects.

Hydropower does not attract private capital, because of hydrological and geological uncertainties inherent to such projects. Private investment in transmission lines has not been forthcoming even in western countries, as there is little room for the investor to improve profitability through higher efficiency.

Thermal generation and distribution do provide avenues for private capital, but there are hurdles, as explained earlier. Both the Central and the state governments must move quickly to minimise these hurdles. Role of Public Sector The limitations of private investment referred to above mean that the primary responsibility for power development remains with the public sector. The World Development Report 1994 (its theme is 'Infrastructure') estimated that 90 per cent of annual investment on infrastructure in developing countries is derived from government revenues or intermediated by governments. Besides, the point merits repetition that in a country like India where poverty is pervasive, electric power plays a dual role—while, in the main, it is a vital infrastructure for productive economic activity, it can be harnessed through appropriate policies, to alleviate poverty and enhance the welfare of those living at the subsistence level. Electricity can help to improve farm productivity and stimulate growth of non- farm employment.

Electrification of households makes a significant difference to the quality of life, facilitates the spread of education of the growing generation and reduces human drudgery. In the words of the World Development Report referred to above, 'The lack of access to infrastructure is a real welfare issue'. This is a responsibility that the private sector will not take over. Therefore, public sector investment on power development must be maintained at a high level. This does not mean that investment funds must be mobilised solely by government through revenue or borrowing. The power industry under the public sector, which will continue to be large, must generate a surplus that will at least partially meet investment requirements; this takes us once again to the key issue of properly designed tariffs. The financial aspect apart, the style of functioning has to change. Public sector entities can no longer be treated as subordinate agencies of government. We will revert to this aspect while dealing with the question of corporatisation. The point to be underscored is that there should not be any abdication of responsibility on the part of the Central and state governments in ensuring adequate resource availability to public sector power entities even after corporatisation. In the words of A.A. Churchill, 'International capital flows, both private and official, can support domestic effort to raise resources, but they are seldom substitutes.

The energy sector and, in particular, the requirements of electric power are far too large relative to the overall size of the national economies to be dependent exclusively on external savings' (Churchill 1999). Latterly, there is some improvement in the Plan outlay on power in the Central sector, but viewed across states, the picture is not encouraging. This needs to be rectified. Subsidies in the Power Sector It is well known that the financial difficulties of the power sector emanate mainly from subsidies to the agriculture and domestic sectors. The projections for the year 2001–02 as given in the Economic Survey 2000–01(Government of India 2001) are revealing: The losses on agricultural supply are, clearly, very heavy. What is also significant is that in spite of overcharging industry, the extent of cross-subsidisation that can be achieved is limited. The need to reduce the subsidy burden has been recognised for many years, but competitive populism hindered remedial action in most states. Under the Electricity Regulatory Commissions Act passed by Parliament, cross- subsidisation is not ruled out, but within three years, no category of consumers should be required to pay less than fifty per cent of the average cost of supply. For agricultural consumption, a minimum of 50 paise per unit has been prescribed. There are no corresponding explicit provisions in the Karnataka Electricity Reform Act, where the only requirement, as in the Central Act, is that in case the State Government requires the grant of subsidy to any class of consumers, it must bear the consequential financial burden. Possibly, the position is similar under the reform laws of other states. The legal position is thus somewhat tenuous and will have to be clarified soon. The basic question is, can we do away with subsidies? The answer is, by no means, simple. Looking first at subsidy to domestic consumers, there is no case for a general subsidy to this category of consumers. The poor, we all agree, must have access to electricity, since, as stated earlier, electric lighting makes a difference to the quality of life and confers other benefits. Then again, merely because the cost of delivery of power to rural areas is high, the rural domestic consumer should not be placed at a disadvantage. We should bear in mind that the hard core of poverty lies in the rural areas.

However, losses on this account could be made up through a well-designed reverse block tariff, as consumption by poor households accounts for only a small fraction of total domestic consumption. Subsidy for agricultural consumption is a more complex issue. In the first place, losses on agriculture as reported by SEBs are generally inflated; as the supply is unmetered, losses arising from theft of power are also ascribed to agriculture. This is clearly borne out by the fact that, in the proceedings of the Regulatory Commissions which have issued tariff orders, the SEBs' filings before their respective Commissions disclosed altogether higher transmission and distribution losses than what they had been reporting in their Annual Reports. For instance, the losses declared by Karnataka Power Transmission Corporation were — 18.56 per cent in 1997–98, 30.19 per cent in 1998–99, 38.00 per cent in 1999–2000 and 36.50 per cent in 2000–01 (projected) (Karnataka Electricity Regulatory Commission 2000).

The sudden jump in 1998–99 is significant. Second, the subsidy accrues, in the main, to relatively better off farmers. The fact that many of them have diesel backup indicates that capacity to pay is not a real issue. On the other hand, the cost of cultivation has a link with the minimum support price paid by government to maintain buffer stocks of food grains and run the Public Distribution System, which caters to the essential needs of low-income consumers.

This is not to suggest that there is no scope for reduction of subsidy to agriculture. It should be possible to keep the quantum of subsidy within limits by imposing tariff in the manner envisaged in the Electricity Regulatory Commissions Act, metering of supply and institution of programmes to encourage installation of high-efficiency pump sets. This apart, there is scope for increasing revenue by controlling theft and reducing technical losses in transmission and distribution. But this will take time, as there is a large backlog of investment on these components of the power system. However, it will not be possible to eliminate subsidy altogether for quite some time. Meanwhile, the subsidy burden should be borne squarely and clearly by the state government, as the subsidy subserves public policy.

SEBs as Corporate Bodies Corporatisation is not a panacea for the basic problems of SEBs. The main purpose of moving over to the corporate form of organisation is to professionalise the management, endow it with functional and financial autonomy free from political interference and introduce commercial orientation. But will this happen once the SEB puts on a new garb? The manner in which public sector companies are run even today, whether at the central or state levels, does not inspire confidence. They continue to be treated as agencies on a par with field departments. There have been several high-level committee recommendations to change the nature of the interface between public sector enterprises and government, as also of control by Parliament (or State Legislature), audit, etc. But the substantive recommendations remain unimplemented. A determined effort needs to be made by the political leadership and the bureaucracy to develop a new model of relationship with public sector enterprises.

Merely because an SEB ceases to be a statutory body and becomes a company, its financial position will not alter. No purpose will be served by replacing one loss-making organisation by several such organisations (as has already happened in Orissa). If annual losses continue, government will have to bail them out as in the past. How the balance sheet will turn out will depend on the decisions of the Regulatory Commission. Ultimately, the balance sheet can be cleaned up only through higher efficiency and proper pricing of power. There is also the question of the outstanding liabilities of the SEB, which are quite large. Securitisation appears to be the best way as it provides immediate relief, but the State government must shoulder the burden of discharging the liability. Otherwise, tariff increases will reach unacceptable levels. The Privatisation Question There is a view that as the Central and state governments are heavily indebted and interest payments take away a large proportion of current revenues, existing assets should be sold to the private sector and the proceeds used to retire public debt. Without any doubt, privatisation can attract FDI on a large scale. Out of a global FDI inflow of dollar 138 billion for infrastructure between 1990 and 1998, Latin America was the largest recipient with dollar 79 billion; of this, dollar 67 billion was towards privatisation (Sader 2000). Do we want to follow the same route? This is an issue that calls for debate on a wide scale, as its implications are serious and sensitive. In my view, wholesale privatisation is neither desirable nor feasible. Given the limited scale on which capital can be raised domestically, privatisation will inevitably mean sale to foreign private parties.

One cannot be comfortable with a situation in which a vital segment of the country's infrastructure is under foreign ownership. As mentioned earlier, investment in transmission is not interesting to private investors. In relative terms, distribution is manpower-intensive and the scale of investment is not large; Indian parties will be willing to enter when there is a resolution of the tariff issue. It is the generation sector which can attract a large inflow. What Government of

India has done so far is to effect piecemeal disinvestments in Central power undertakings. Such an approach does not fetch the best price for the shares, nor is there any benefit in terms of change in the style of management. On their part, the states have not moved at all. India has a number of thermal power stations of old vintage, which could be hived off to parties who are willing to undertake renovation and modernisation. Our focus should be on greenfield projects that add to capacity, and it is here that we should create an environment that makes it possible to secure private investment on a substantial scale. The Regulatory Regime As already stated, the Centre and several states have set up Electricity Regulatory Commissions. With the exception of Orissa, other Commissions have been in existence for only a short period. According to information available, the Orissa Commission had passed three tariff orders, and the Andhra Pradesh, Uttar Pradesh and Maharashtra Commissions one order each by June 2000. The Karnataka Commission passed its first order in December of that year. It will be premature to judge performance, but comments may not be out of order on two aspects, viz., functions entrusted and credibility. Referring to functions first, the main task assigned to the Regulatory Commissions at both national and state level is the determination of tariff.

The Central Act contains enabling provisions for a state to entrust other functions to the State Commission, notably, licensing of generation. But, to the best of our knowledge, no state has done so. The Commission comes into the picture only for determination of the purchase price of energy by the Transmission Utility. This must be regarded as a lacuna, as it leaves the coverage of regulation incomplete. When we look at countries where the power sector is being deregulated or restructured, we see two broad approaches to tariff regulation—cost-plus approach and price cap approach. The cost-plus approach has been followed in USA for a long time. It involves a detailed scrutiny of costs and the monitoring is close and continuous, but has the merit of ensuring financial viability and minimising market risk.

The complaint of some American utilities has been that it does not permit generation of financial surpluses of the order needed for fresh investment. Under the price cap approach which originated in UK, the regulation is light-handed and lays down only an upper limit for the tariff for a specified period (three to five years). After initial benchmarking, indexation is allowed on the basis of the formula 'RPI-X', where RPI is the Retail Price Index and X is a factor that represents improvement in efficiency. The price cap approach is closer to market competition and allows higher profit to those who achieve better levels of efficiency. Consumers in UK have benefited from lower tariffs, but in the initial stages, the regulator was apparently too liberal, with the result that the biggest beneficiaries were the shareholders in the privatised companies (Newberry 1998). In the literature on regulation, one finds reference to a third approach to regulation, namely, the Performance-based approach. In my view, the distinction is semantic rather than substantive, as under both cost plus and price cap approaches, performance norms are built in. In India, there was hardly any debate on the choice of methodology of tariff determination, which is the main function of the regulatory authorities. Under both the Electricity Regulatory Commissions Act and state reform laws, the State Commissions are required to follow Sections 57 and 57A and the Sixth Schedule of Electricity (Supply) Act. If the Commission wants to make a deviation, it has to give reasons to justify it. This means that we have implicitly adopted the cost-plus approach. As it happens, this is the right choice in our context. It gives greater comfort to the private investor. Also, fixing a price cap in a situation where new capacity is being added all the time is difficult.

The more important question is, does the experience so far confirm that the regulatory bodies in India enjoy the requisite measure of independence? This question is important, as the experience of the first regulatory body constituted under the new economic policy, namely, Telecom Regulatory Authority of India (TRAI) was not happy. When certain recommendations of the Authority were not to their liking, Government of India had the law amended to dilute the powers of TRAI. Judging by the brief experience of the State Electricity Regulatory Commissions which have passed orders, it is encouraging that they have affirmed their autonomy, as evidenced by the fact that all the five State Commissions scaled down the T D loss projected by the Transmission Utility and exercised their own judgment for purposes of tariff determination. Assertion of independence is all right, but it has to be blended with pragmatism. There have been critical comments on the Orissa Commission's orders on the ground that unachievable efficiency improvements were assumed while deciding the tariff. If the tariff is pitched too low and there is under-recovery, private parties that take over distribution will be unable to function, as they cannot finance losses indefinitely. A quotation each from two recent studies will give a flavour of the observations.

'The regulatory commission is limiting itself to regulation and appears to consider that the development of the sector is beyond its responsibilities. In Orissa, the state government too has absolved itself of all its responsibilities leaving the power sector in a lurch' (Sankar T.L. and Usha Ramachandra 2000). 'Where governments are co-operative as in the case of A.P., the allowed revenue requirement is much closer to a real level. In contrast, in Orissa, where the government has not actively assisted in the process of transition, the efficiency improvements required are much more dramatic' (Ahluwalia 2000). In Karnataka, the pattern of events has been a little different. In the first order issued by the Karnataka Electricity Regulatory Commission towards the end of last year, the Commission raised the tariff by about 17 per cent on an average. The increase in the agricultural tariff was modest; it was set at 50 paise per unit for most farmers. The Commission introduced an innovation by distinguishing affluent farmers and imposing a tariff of Rs.1.35 per unit on them. The Commission also issued several directives intended to improve the operational efficiency of the power utility.

Karnataka Government went along with all the tariff increases, except for the agricultural consumers (including rich farmers), but committed itself to providing additional subsidy. Karnataka Electricity Board's successor, Karnataka Power Transmission Corporation, has gone up in appeal to the High Court questioning the jurisdiction of the Regulator to issue those directives. In Maharashtra, the State Government has responded to the Regulatory Commission's order on tariff for agriculture (and powerlooms) on the same lines as in Karnataka. These are not encouraging signs; they signify lack of readiness to put in place a credible regulatory regime. What is more, as a truly independent regulatory body enjoying the confidence of both the power suppliers and consumers is a cornerstone in the rebuilding of the power sector, it raises the question whether at all there is political commitment to set right the technical and financial ills of the sector.

Electricity Market In industrial countries that have embarked on deregulation of the power sector, the emergence of an electricity market in which electricity is traded like any other commodity with competition among suppliers is regarded as the ultimate goal. The UK has been the pioneer in this respect. It introduced a pool system, with half-hourly price bids offered by different power producers; the highest accepted price would be paid to all the suppliers during the particular time period. As explained earlier, the UK adopted a soft regulatory system. It will be interesting to look at a couple of other models.

New Zealand restructured its power sector as a part of a changeover (which began in 1986) in the pattern of governance to conform to the principles of New Public Management. The new regime only mandated disclosure of operational and financial information; reliance on market competition was total and regulation was considered unnecessary. California passed a law in 1996 making elaborate provisions to make the power industry market- based. These included the Power Exchange for wholesale trading in electricity and the Independent System Operator (ISO), who not only looked after load dispatch, but also operated the balancing market for emergent purchases of electricity in case of mismatch between supply and demand (Sioshansi and Morgan 2000).

A new class of electricity traders who mediate between merchant generators and distributors (or large consumers) came into being. As in other states of USA, the California Public Utilities Commission had been in existence for several decades, the style of regulation being hands-on; inter-state electricity trade came under the purview of the Federal Energy Regulatory Commission (FERC). In all the countries referred to above, consumers were given the freedom to choose their suppliers. In all the three countries, the functioning of the electricity market has not been without problems. We may take a quick look at them:

1) UK – When UK denationalised the power industry, generation was taken over by two large companies (National Power and Powergen). Though a number of merchant generators came up later and nuclear power was under another company, these two large players dominated the electricity market and dictated prices. There was even criticism of manipulation of the market. The UK has decided to give up the pool arrangement and let suppliers and consumers enter into direct arrangements. But, according to Richard Green, 'Abolishing the pool in favour of a less transparent market, at greater risk of manipulation by the dominant generators, does not seem a rational policy' (Green 1999).

2) New Zealand – The market was, no doubt, competitive, but it led to a situation in which investments were not made to maintain adequate reserves. Some time ago, a part of Auckland, the capital city of New Zealand, went without electricity for some weeks; a power cable had developed a fault, but there was no redundant capacity. Lack of a proper arrangement for system planning was evident.

3) California – Since around May 2000, California has been facing a power shortage and the problem has reached crisis proportions 3 . When reform measures were introduced, there were three investor-owned utilities, two of which, namely, Southern California Edison (SCE) and Pacific Gas and Electric (PGE) were large and served the major part of the State. Under the law of 1996, the utility tariff was frozen till March 31, 2002, before which the utilities were required to sell their own plants and convert themselves into distribution companies buying power in the wholesale market.

The new system worked well to begin with. But the demand forecast had underestimated the rate of growth and no new major plant had been built in California for the last ten years. When the demand started rising sharply last year, the utilities had to buy wholesale power from outside sources. As the power shortage grew, electricity traders jacked up the prices, while the income of the utilities remained frozen. The suppliers even resorted to gaming – withholding offers to the Power Exchange and selling power at higher rates in the balancing market. FERC refused to intervene. By the end of the year, the two utilities together had lost dollar 13 billion and the banks were unwilling to lend them any more money. Large parts of California suffered rolling blackouts in January this year. In order to retrieve the situation, Government of California had to start funding the utilities to the tune of dollars 50 million per day to enable them to buy wholesale power. Towards the end of March, California Public Utilities Commission finally allowed a tariff increase of 46 per cent for PGE and 42 per cent for SCE in respect of non-domestic consumers; the increase in the case of households was less sharp. Government is planning to recover its money by floating bonds to the tune of dollars 12.4 billion .The situation is expected to ease fully only by 2003, when new capacity is expected to be commissioned in California. The experiences mentioned above offer important lessons to countries embarking on restructuring of the power sector. These are: 1) There must be institutional arrangements for system planning and ensuring that the required capacity additions take place. 2) Regulatory mechanisms are necessary. Tariff determination should not lose sight of the need to generate funds required for maintaining sufficient reserves. The Regulator should respond quickly to evolving situations. 3) The Electricity

Market will work well only if supply exceeds demand at all times and there is a multiplicity of players. Otherwise, the ugly side of market power will show up (This is the most important lesson).

What is the prospect for an electricity market in India? No doubt, this may benefit the consumer, but is it feasible in our situation? As rightly observed by Central Electricity Regulatory Commission (CERC 1999), the conditions are unfavourable. Unlike many western countries that have excess capacity, we have and will continue to have supply shortages for many years to come. We do not have a multiplicity of generators. There are transmission constraints. The 'take or pay' clause insisted upon by IPPs cannot fit into a market situation. There are many old power stations which may have to exit in case the market is wholly competition-driven; this could mean loading 'stranded costs' on the consumers. For all these reasons, it is unrealistic to talk of an electricity market in India.

We may not have an electricity market in the real sense, but some limited inter-state trade has been taking place for many years. Recently, the Power Trading Corporation promoted by public sector entities has been set up to buy power from mega projects and sell it to state utilities. It is clear that it can survive only if it can keep its receivables under control; this will depend, once again, on tariff rationalisation in the states. It is not surprising that the Corporation has not been successful in reaching financial closure on even the first mega project that it has proposed to take up.

Negative Fallout of Reform Markets operate on a short time horizon, which means that energy sources that are not cost-competitive cannot survive. The development of renewable sources of energy, which have long-term potential will suffer unless it receives special support. It is reported that in California where a big push had been given to renewables under the Public Utility Regulatory Policies Act (PURPA) enacted in 1978, 26 per cent of biomass capacity and 11 per cent of wind capacity closed down after deregulation (Wiser et al. 1998). A distribution surcharge had therefore to be imposed. In the UK, renewables are supported by Non-Fossil Fuel Obligation Orders issued from time to time under which electricity suppliers are required to purchase electricity at specified rates from generators using renewable sources of energy. We in India need to give sufficient thought to this aspect.

To encourage development of renewable energy resources, Ministry of Non-Conventional Energy Sources (MNES) has issued guidelines indicating the rate of payment to be made by SEBs to producers of electricity from renewable sources. The period covered is ten years from commencement of purchase; appropriate escalations are allowed during this period. The purchase price is no doubt higher than the price of power from conventional sources, but the share of renewables in the total generation is small and therefore not burdensome to the SEBs. The Regulatory Commissions, which have so far passed tariff orders, have not all accepted the MNES guidelines. It is necessary that they do so in order that investment in renewables does not suffer an immediate setback. The long-term solution lies in the imposition of a statutory levy. Most industrial countries have reduced their national (public and private) investments on energy RD after the deregulation of their energy sectors. To give an example, total RD investment in USA has come down from dollar 7.6 billion in 1976 to dollar 4.3 billion in 1996. The cuts have been sharper in several European countries (Dooley 1998, Margolis and Kammen 1999). This is unfortunate, since the bulk of technology generation takes place in the developed countries. The scale of investment on energy R and D is quite low in India; there is an imperative need to step it up. The Electricity Bill 2000 The power sector developed in India entirely under the aegis of the states, to begin with, and the Centre stepped in later. The legal framework, starting with the Act of 1948, has been subject to modifications from time to time, but it remains in its essence a law designed for operating the power industry in the public sector. As the economic environment has changed radically, it is time to think of a new statute appropriate to the present time. At the request of Ministry of Power, National Council of Applied Economic Research has prepared The Electricity Bill 2000

'for evolving a framework for enabling the restructuring and modernisation of the electricity industry in India'. It visualises the unbundling of SEBs into horizontally separated entities, whether public or private. It aims at insulating the industry from government intervention in day-to-day functioning, but leaves room for policy directives. CEA's role in national planning and technical development is sought to be restored.

Strong regulatory mechanisms are provided. Provision is made for levy of a cess by the Union Government to promote non-fossil fuel sources. In brief, it takes care of many of the issues referred to earlier and provides a coherent framework for the development of the sector. Undoubtedly, there are political sensitivities, as there will be some curtailment of the extent to which a state government can influence operational decisions. It is desirable that the need and content of fresh legislation is debated widely and the ground prepared for its being considered seriously. Conclusion The power sector has many dimensions and complexities. Reshaping it is by no means an easy exercise, all the more so in a federal set-up where the Centre and the states share responsibility. There is no universally applicable model of reform; each country has to evolve a pattern to suit its circumstances. The reform process in India has made some headway, but the movement is slow and not orchestrated. The private sector has yet to become a significant presence and foreign capital seems shy of entering India.

Policy and procedural hurdles need to be removed quickly. The role of the public sector in terms of investment and otherwise will continue to be important and the tendency to play it down should be resisted. Regulatory Commissions should be allowed to play their part, as tariff rationalisation linked with performance standards will play a crucial role in making the industry efficient and viable. Power shortages are presently crippling the economy. The sector has to expand rapidly if the country's economic growth is to be accelerated and the lot of the masses at a subsistence level is to be improved. Reform of the power sector has therefore become imperative. The need of the hour is sustained political commitment to push through a coherent and effective programme of restructuring the sector.

**Project**

## 4. Simulation of PV array fed source inverter

1.INTRODUCTION

1.1 INTRODUCTION: Due to increase in energy consumption and depleting of fossil fuels the renewable energy sources have become cynosure of all eyes. Nowadays solar and wind energy power generations are rapidly grown when compared to other renewable source. In India solar potential is high and wind power generations have the limitation of medium wind profile, low plant factor and saturation of optimal wind locations. Solar irradiation is abundant in India per day in all over thecountry with 300clear sunny days in a year. The 70Two methods are available as shown in below figure1.1 to convert solar energy into alternating current (AC) supplies are 1.)Single stage conversion 2.) Two stage conversions. These days single stage conversions are more popular than two stage conversion because of reduced system size, cost and high efficiency.

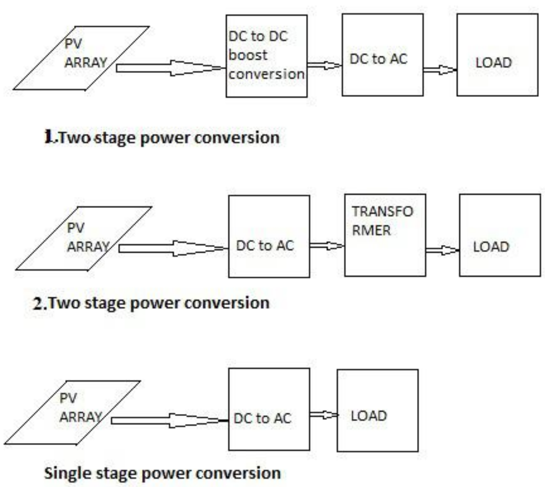



Figure1.1:Stages of power conversion

Conventional methods of photovoltaic energy conversion systems are suffer from voltage buck boost apability in single stage. It is possible with Z-source inverter, but this type of inverter has some limitations like more reactive components, high ripple contents and occupies more space. When compared to z-sourceinverter T-source inverter has few reactive components and high voltage gain. High voltage gain is possible by adjusting the number of turns in coupled inductor of T-network. This T-source inverter has the L and C impedance network in T-shape combined with Voltage source inverter (VSI). 1.2 PHOTO VOLTAIC EFFECT: Photovoltaic is a term which covers the conversion of light into electricity using semi conducting materials that exhibit the photovoltaic effect, a phenomenon studied in physics, photochemistry and electrochemistry. A typical photovoltaic system employs solar panels, each comprising a number of solar cells, which generate electrical power. PV installations may be ground-mounted, rooftop mounted or wall mounted. The mount may be fixed, or use a solar tracker to follow the sun across the sky. The operation of solar PV generates no pollution. The direct conversion of sunlight to electricity occurs without any moving parts. Photovoltaic systems have been used for fifty years in specialized applications, standalone and grid-connected PV systems have been in use for more than twenty years. They were first mass-produced in 2000, when German environmentalists and the Eurosolar organization got government funding for a ten thousand roof program. PV systems have the major disadvantage that the power output is dependent on direct sunlight, so about 10-25 percent is lost if a tracking system is not used, since the cell will not be directly facing the sun at all times. Dust, clouds, and other things in the atmosphere also diminish the power output. This may be made up by other power sources, usually hydrocarbon. Advances in technology and increased manufacturing scale have reduced the cost, increased the reliability, and increased the efficiency of photovoltaic installations. Net metering and financial incentives, such as preferential feed-in tariffs for solar-generated electricity, have supported solar PV installations in many countries. More than 100 countries now use solar PV. After hydro and wind powers, PV is the third renewable energy source in terms of globally capacity. In 2014, worldwide installed PV capacity increased to 177 Gigawatts (GW), which is two percent of global electricity demand. China, followed by Japan and the United States, is the fastest growing market, while Germany remains the world's largest producer, with solar PV providing seven percent of annual domestic electricity consumption. With current technology (as of 2013), photovoltaic recoups the energy needed to manufacture them in 1.5 years in Southern Europe and 2.5 years in Northern Europe.

2. T-SOURCE INVERTER 2.1. INTRODUCTION: An inverter is an electric apparatus that changes direct current(DC) to alternating current (AC). Direct current is created by devices such as batteries and solar panels. When connected, an inverter allows these devices to provide electric power for small household devices. The inverter does this through a complex process of electrical adjustment. From this process, AC electric power is produced. This form of electricity can be used to power an electric light, a microwave oven, or some other electric machine. An inverter usually also increases the voltage. In order to increase the voltage, the current must be decreased, so an inverter will use a lot of current on the DC side when only a small amount is being used on the AC side.Inverters are made in many different sizes. They can be as small as 150 watts, or as large as 1 megawatt (1 million watts). The inverters are classified into 4 types. They are: 1) Current source inverter, 2) Voltage source inverter, 3) Z-Source inverter, 4) Proposed inverter is T-source inverter. T – Source inverter (TSI) overcomes the limitation of traditional voltage source inverter and current source inverter. Both inversion and boost function are being

accomplished in a single stage using theTSI, thereby reducing conversion loss. Unlike the traditional inverter, TSI utilizes a unique impedance network that links the inverter main circuit with the PV (or DC) source. Figure.2.3 P-Characteristics of PV panel with irradiation of 1000 w/m2 and different temperature. P-V Characteristics of PV array with constant irradiation and variable temperature is shown in figure.2.3. Byincreasing temperature output voltage and maximum power point get decreased; the maximum power and open circuit voltage are inversely proportional to temperature at constant irradiations.

2.2. OPERATING STATES OF TSI: The DC voltage (from source) is fed as input to the impedance network of the TSI which helps to achieve both voltage buck and boost. The voltage across the impedance network is applied to the bridge inverter. The voltage buck-boost capability in TSI is facilitated by shoot through time period. Voltage boost capability of TSI is due to the energy transfer from capacitors to inductors, during the shoot through state. The diode D prevents the discharging of capacitors through the source Strzelecki et al (2009). Table3.1. Three phase switching TSI switching table Switching state S1 S4 S3 S6 S5 S2
Active[100] 1 0 0 1 0 1
Active[110] 1 0 1 0 0 1
Active[010] 0 1 1 0 0 1
Active[011] 0 1 1 0 1 0
Active[001] 0 1 0 1 1 0
Active[101] 1 0 0 1 1 0
Null[000] 0 1 0 1 0 1
Null[111] 1 0 1 0 1 0
Shoot Through-1 1 1 S3 S 3 S5 S 5
Shoot Through-2 S1 S 1 1 1 S5 S 5
Shoot Through-3 S1 S 1 S3 S 3 1 1
Shoot Through-4 1 1 1 1 S5 S 5
Shoot Through-5 1 1 S3 S 3 1 1
Shoot Through-6 S1 S 1 1 1 1 1
Shoot Through-7 1 1 1 1 1 1

2.3. CIRCUIT DIAGRAM OF T-SOURCE INVERTER: The TSI can handle shoot through states, when both switches in the same phase leg or any two phase legs or three phases are turned on. In the TSI, T-network is used instead of the lattice impedance-network, for boosting the output voltage by inserting shoot through in the pulse width modulation (PWM) schemes. Three phase TSI has nine acceptable switching states but three phase voltage source inverter (VSI) has eight switching states out of which six are active states and two are zero states. The shoot through state gives the unique feature of buck –boost operation to the inverter. Operating states of TSI are given in table 3.1.

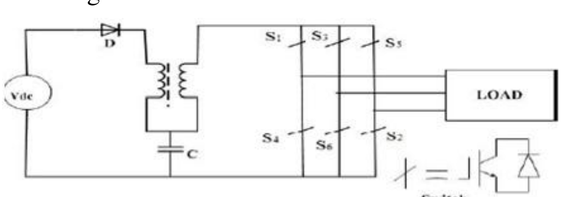



Figure.2.1: Circuit diagram of T-Source Inverter 2.4. WORKING PRINCIPLE: The DC voltage (from PV) is fed as input to the impedance network of TSI which helps to achieve voltage buck and boost properties. Then the output of the impedance network is applied to the inverter main circuits which comprising of six switches. The voltage boost capability of TSI is facilitated by turning ON both the switches in the same phase leg simultaneously. Voltage boost capability of TSI is due to energy transfer from capacitors to inductors, during the shoot through state. Since, the capacitors may be charged to higher voltages than the source voltage, the diode 'D'prevents discharging of capacitors through the source. As with conventional ZSI, the TSI can handle shoot through states when both switches in the same phase leg are turned on. The T-network is used instead of the lattice impedance-network, for boosting the output voltage by inserting the shoot through states in the pulse width modulation (PWM) schemes. The operating principle of T – Source Inverter is same as that of conventional ZSI but it differs from number of capacitor being used. In proposed TSI, only one capacitor is enough to handle shoot through state where as in ZSI two capacitor were used. The detailed operation of TSI is explained in two modes as: A) Non Shoot through mode B) Shoot through mode 2.4.1. A) NON – SHOOT THROUGH MODE:

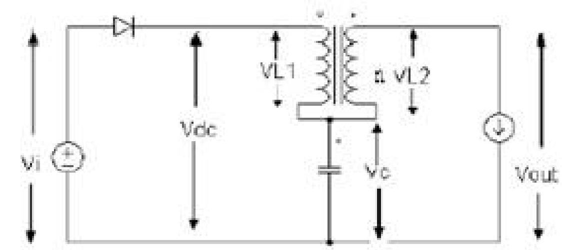
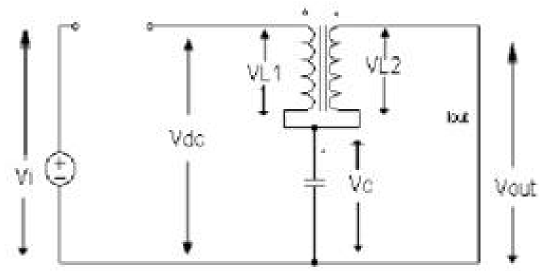



Figure3.2 illustrates the equivalent circuit of TSI in Non – shoot through mode of operation. In this mode capacitor is charged, the inverter bridge operate in one of traditional active states, thus acting as a current source when viewed from T – source circuit. During active state current is zero because of open circuit. The open circuit voltage appears across Inverter Bridge. The diodes conduct and carrycurrent difference, between the inductor current and input DC Current. Note that both the inductors have an identical current because of coupled inductors.




3.2. Non – Shoot through Mode of TSI
Assume: Drop across diode is negligible. For symmetrical T network L1=L2; VL1=VL2=VL, Total switching period (Tt) = T1+T0 T1-Non shoots through time period (active state) T0-Shoot through time period (zero state) From non-

shoot through mode for the time period of T1 Vi= Vdc(3.1) Vi= VL1+Vc Vc=Vi-VL(3.2) VL=Vi-Vc Vout=Vc-VL2 V0ut=Vc-VL Vout=2Vc-Vdc; Vi=Vdc (3.3)

2.4.2. B) SHOOT THROUGH MODE: This shoot through zero state prohibited in traditional voltage source inverter. It can be obtained in three different ways such as shoot through via any one phase leg or combination of two phase leg or combination of three phase leg. During shoot through mode as shown in figure3.3, Diode is reverse biased capacitor charges the inductor L2 separating DClink from the AC line.

Table3.2. Single phase TSI switching inverter

| SWITCHING STATE | S1 | S2 | S3 | S4 |
|---|---|---|---|---|
| Active[1 0] | 1 | 0 | 0 | 1 |
| Active[0 1] | 0 | 1 | 1 | 0 |
| Null[0 0] | 0 | 1 | 0 | 1 |
| Null[1 1] | 1 | 0 | 1 | 0 |
| Shoot through-1 | 1 | 1 | 0 | 1 |
| Shoot through-2 | 1 | 1 | 1 | 0 |
| Shoot through-3 | 0 | 1 | 1 | 1 |
| Shoot through-4 | 1 | 0 | 1 | 1 |
| Shoot through-5 | 1 | 1 | 1 | 1 |

Inverter in shoot through mode for the time period of T0 Vc=VL2 (3.4) Vc=VL Vout=0 (3.5) At steady state the average voltage of the inductor for one switching period (Tt) is zero.

## Conclusion

In this project T-source inverter with simple boost control technique has been introduced for photovoltaic applications. The mathematical model of T-source inverter is derived and it is simulated in MATLAB software. Its performance under change in temperature and irradiation conditions was analyzed. The results showsproposed T-source inverter gives high voltage gain, improved transient response and reduction inTotal harmonic distortion when compared to conventional z-source inverter.

**Project**

## 5. Simulation of PV array fed source inverter

1. Introduction: Micro-inverter topologies for PV power generation are classified into three major groups the single-stage, the two-stage and the multi-stage types. The multi-stage micro-inverters are usually comprised of a step-up DC-DC converter front stage, under Maximum Power Point Tracking (MPPT) control, an intermediate high frequency DC-DC converter stage, used to attain a rectified-sine waveform, and a low frequency unfolding stage to interconnect to the grid , However, the multi-stage power train and the associated high component count results in a costly product . The two-stage micro-inverter can be designed cascading a MPPT controlled step-up DC-DC converter and a grid tied high frequency inverter. Whereas the single-stage topology has to perform the voltage step-up, the MPP tracking, and the DC-AC inversion functions all in one stage. In order to convert and connect the solar energy to the grid the low voltage of the PV panel first has to be stepped-up significantly to match the utility level. This poses a challenge to the designer of photovoltaic inverters as the traditional boost converter cannot provide the required gain at high efficiency. Therefore, an extensive research effort is dedicated to developing various topologies of high step up DC-DC converters that can be used in tandem with a half or full bridge inverter to implement a solar power generation system. Another concern, typical to single phase DC-AC power systems, is AC-DC power decoupling problem. A traditional solution is application of a decoupling capacitor on the DC link between the input and output stages. The value of the decoupling capacitor depends on the rated power, Pdc, the line frequency, f, and the average voltage across the capacitor, Vdc, and the allowed peak-to-peak ripple, v, [9]:

The two-stage or the multi-stage micro-inverters can have their decoupling capacitor on the high voltage DC link, and, according to (1), attain lower value of the decoupling capacitor .

2. SSBI ANALYSIS AND SIMULATION

To facilitate the analysis approach the following assumptions are adopted: (a) all semiconductors are ideal with zero on resistance and voltage drop; (b) the decoupling capacitor and the output filter capacitor are sufficiently large and their voltage ripple is negligible; (c) continuous current operation of both the tapped inductor and the output filter inductor is assumed. 2.1. Derivation of Voltage Conversion Ratio Inspection of the converter's equivalent circuits in Fig. 4 reveals that the power stage operates as a boost-derived tapped inductor DC-DC converter merged with a buck-derived full-bridge DC-AC inverter. Define ta, tb, and tcthe duration of states A, B and C respectively and Ts=ta+tb+tcthe switching period. Boost charging state, that is the time interval dedicated to charging the primary winding of the tapped inductor, takes place during the states A and B, see Fig. 4 (a) and Fig. 4 (b), whereas, boost discharge takes place in state C. The total duration of the boost charging is, therefore:

Accordingly, the resulting boost duty cycle, Dbst, is

Hence, SSBI performs the DC-DC step-up conversion function identically to the tapped inductor boost converter. Adopting the approach of [20] and [21], the DC-DC voltage conversion ratio of SSBI is

The voltage conversion ratio (5) is plotted in Fig. 4.1. Clearly, by adjusting the turn ratio, n, the proposed SSBI can achieve higher conversion ratio than a traditional boost converter.

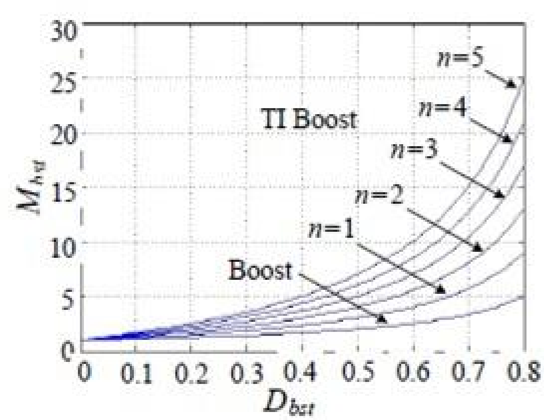


Fig. 4.1. Comparison of conversion ratio, Mbst, of the traditional boost and the tapped inductor (TI) boost converters. According to the state description above, the buck charging state, that is, the time interval dedicated to charging the output inductor, Lo, occurs in state A, whereas buck discharge takes place in states B and C while the terminals of the output filter are shorted. Thus, the duration of the buck charging is:

Accordingly, the resulting buck duty cycle, Dbk, is

Clearly, under CCM condition of the output filter inductor, the voltage gain of the output section is identical to that of a buck converter and is given by:

Hence, the overall DC-AC voltage conversion ratio, M, of the proposed SSBI under CCM conditions can be derived combining (5) and (8):

In stand-alone application the buck duty ratio, Dbk, is modulated to attain a sinusoidal output voltage, Vo, of required amplitude and frequency, whereas the boost duty ratio, Dbst, is adjusted to satisfy load power demand and so stabilize the DC link voltage, Vdc. However, an important constrain arising from SSBI principle of operation is that the buck duty ratio, Dbk, should be smaller than the boost duty ratio, Dbst, at all times: Dbk<Dbst.

2.2. Voltage and current Stress of semiconductor devices Peak voltage and peak current of the semiconductor devices during a switching cycle are summarized in Table II. The values of the RMS currents of the semiconductor devices throughout the line cycle are given in Table III. Here, the RMS value of buck duty cycle is defined as Dbkrms =Dbkm/2.

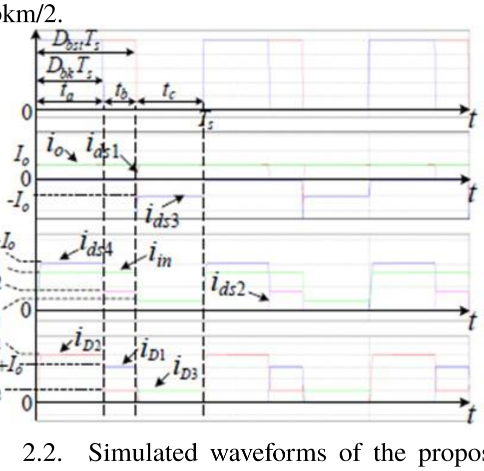



Fig. 2.2. Simulated waveforms of the proposed SSBI on the switching frequency scale during positive half cycle.

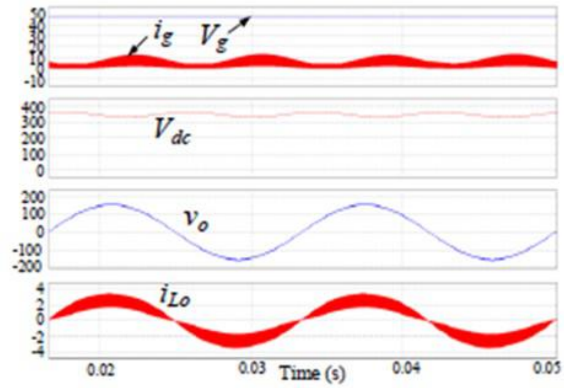



Fig. 2.3. Simulated waveforms of the proposed SSBI on the line frequency scale.

## Conclusion

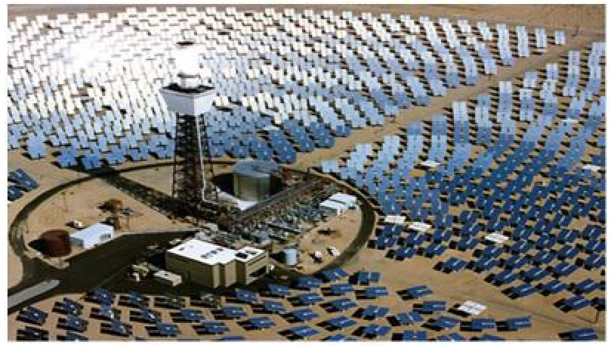
In this project a high gain single-stage boosting inverter, SSBI, for alternative energy generation applications is presented. The proposed topology employs a tapped inductor to attain high input voltage step-up and, consequently, allows operation from low DC input voltage. The project presented principles of operation, theoretical analysis of continuous and discontinuous modes including gain and voltage and current stresses.

The proposed SSBI topology has the advantage of high voltage step-up which can be further increased adjusting the tapped inductor turns ratio. The SSBI allows decoupled control functions. By adjusting the boost duty cycle Dbstthe SSBI can control the dc link voltage, whereas the output waveform can be shaped by varying the buck duty cycle, Dbk. The AC-DC power decoupling is attained on the high voltage DC link and therefore requires a relatively low capacitance value. OCC control method was applied to shape the output voltage. OCC's fast response and low sensitivity to DC bus voltage ripple allowed applying yet smaller decoupling capacitor value, and has demonstrated low THD output for different types of highly non-linear loads.

**Article**

## 6. Solar power generating technologies

**Introduction** The techniques that utilize working fluids or receiving devices to convert solarradiation into electricity eventually by some way are referred to as solar power generation techniques. Currently, there are two main kinds of solar energy generating technologies. The first kind is solar thermal power generation technologies, that is, they convert solar radiation into heat first, and this is followed by a particular power generation process to change thermal energy into electrical energy, such as thermoelectric power generation utilizing semiconductoror metallic materials, thermionic power generation in vacuumd evices, alkali metal thermal power generation, and MHD power generation, and so on. The characteristics of these technologies are power generation devices with no moving parts, a relative small electric generation capacity, and they are still in the primary experimental phase for many technologies. Currently, thermal power generation technologies are issues that are the most interested in, researched most deeply, and the most promising worldwide. Technologies, including solar central power tower technology, parabolic trough solar thermal technology, and dish solar thermal technology, use flowing work mediums to convert the solar radiation into thermal energy, and then drive the generator by heat engine to convert the heat energy of the medium into electricity. The basic equipment compositions of these technologies are similar to conventional power generation equipment. Other solar power generating technologies converting solar energy into electrical energy directly are light induction power generation, photochemical power generation, and biological power generation. The photovoltaic power generation technology, which transforms the solar radiant energy into electrical energy through the solar battery, is successfully commercialized. A brief introduction of solar central power tower system follows. The solar central power tower system generates electric power from sunlight by concentrating solar radiation on a tower-mounted heat exchanger (receiver).The system uses hundreds to thousands of sun-tracking mirrors called heliostatsto reflect the incident solar radiation onto the receiver. These kinds of solar powerplants are best suited for utility-scale applications in the 30- to 400-MWe ranges.In a molten-salt solar power tower, liquid salt at 290C is pumped from a "cold"storage tank through the receiver where it is heated to 565C and then on to a"hot" tank for storage. When power is needed from the plant, hot salt is pumped to a steam generating system that produces superheated steam for a conventional Rankine-cycle turbine/generator system. From the steam generator, the salt is returned to the cold tank where it is stored and eventually reheated in the receiver. In 1981, the United States successfully built a pilot solar-thermal project,that is, the Solar One solar central power tower plant, in the Mojave Desert just east of Barstow, California with 10 MW installed capacity. It was the world's first test prototype of a large-scale thermal solar power tower plant. Solar One was designed by the DOE, Southern California Edison, LA Department of Water and Power, and California Energy Commission. The energy collection method of Solar One was based on concentrating the solar energy onto a common focalpoint to produce heat to drive a steam turbine generator. It had hundreds of large mirror assemblies (heliostats) which tracked the sun, reflecting the solar energyonto the tower erecting in the center of the mirror area where a black receiverabsorbed the heat. High-temperature heat transfer fluid was used to carry theenergy to a boiler on the ground where the steam was used to spin a series of turbines,much like a traditional power plant. The primary difference between the solar central power tower system and the coal-fired power plants is that the former uses solar receiver to collect energy which has the same function as the boiler. Solar One was converted into Solar Two (Fig. 1) in 1995 by adding a secondring of 108 larger 95-m2 heliostats around the existing Solar One. Solar Two wasput into test operation in January, 1996 and was decommissioned in 1999. The1926 heliostats occupied a total area of 82750 m2. As a result, Solar Two had the ability to produce 10 MW to power an estimated 7500 homes. In addition, Solar Two used molten salt, a combination of 60 percent sodium nitrate and 40 percent potassiumnitrate, as an energy storage medium instead of oil or water as with Solar One,which helped in energy storage during brief interruptions in sunlight due to clouds. The molten salt also allowed the energy to be stored in large tanks for future use such as at night time—Solar Two had sufficient capacity to continue running for up to 3 h after sunset.



Although the tower thermal power generation system starts earlier, it has highsystem cost, low installed capacity, and the industrialization of the system facesa lot of problems. The primary reason for all the problems is the design of heliostat-system. Nowadays, the typical heliostat of tower thermal power generationhas two characteristics. First, the typical heliostats almost adopt the ordinaryspherical or flat reflective surface. Second, tracking angles for the heliostats alluse the traditional azimuth elevation formula. These two features result in thefollowing problems in the tower solar concentrator receiver: (1) The faculafocusing on the receiver changes substantially, which causes the concentrated light intensity to fluctuate significantly. The ordinary spherical or plane reflector cannot overcome aberration caused by the motion of the sun, which leads tothe heat conversion efficiency of the tower system being only 60 percent. Although methods to design heliostats spherical surfaces with different curvature radii were developed to reduce the sunspot size, the optical design complexity issignificantly increased, which leads to the rise of the manufacturing costs. (2) Many heliostats are built around the center tower and occupy a lot of land. To concentrate the sun on the top of the center tower efficiently, each heliostatcannot share the light of others and then the distance between near heliostat rows will increase along with their positions in the center tower. Therefore, the area of the tower thermal power generation system will increase exponentially along with the increase of power generation capacity. (3) Each heliostat requires a separate two-dimensional control, and the control system is quite complex. In a tower system, each heliostat has a different position relative to the center of the column. Therefore, each heliostat tracking should be a separate two-dimensional control. The control of each heliostat is different, which makes the control system complicated and unreliable, in particular for the installation of optical alignments. (4) In order to alleviate the cosine effect of heliostats, the center tower should be built very high. The center tower of the Solar Two (10 MW)thermal power is up to over 100 m. This leads to not only the dramatically increasing cost of the thermal power generation system, but also the awful adaption ability of the system to the harsh windy weather.

1.1 ADVANTAGES OF SCPPS The SCPPS is a not new type of solar power generation system as it was verifiedseveral decades ago. However, when compared with the traditional power generating methods, it has the following advantages: easier to design, more convenient to draw materials, lower cost of power generation, higher operational reliability,fewer running components, more convenient maintenance and overhaul, lower maintenance expense, no environmental contamination, continuous stable running,and longer operational lifespan. In addition, it can partly meet the electricity demand in developing countries and regions where traditional power resources are limited. In more detail, its primary characteristics are manifested in the following aspects: Large scale renewable energy collection Energy storage with low cost Air as working fluid Technical feasibility Environmental remediation Competitive investment and operation costs 1.2 WEAKNESSES OF SCPPS However, an inevitable problem is that the overall efficiency of SCPPS is relatively small. The overall efficiency of the SCPPS is influenced by the greenhouse efficiency of the collector, the updraft efficiency of the chimney, the thermal to mechanical efficiency of the turbines, and the mechanical to electrical efficiency of the generators. The chimney plays an important role in increasing the overall efficiency of the SCPPS; the higher the chimney, the higher the overall efficiency.The collector is a colossal solar energy collection system; the larger the collector diameter, the larger the system output power and energy being stored. So this kind of power stations is not suitable for those areas near metro poles where the land is very expensive. Considering the commercial application of an SCPPS with an output power upto 100 MW, the collector diameter should be several kilometers, which will cause difficulty in cleaning the collector canopy; the chimney should be about 1000 m,which will be a challenge for construction as there are no buildings in the world this high presently.

**Article:**

## 7.Wide area monitoring systems-Mr. M.Ramesh

## Introduction

The complexity of modern electrical power systems is steadily increasing. This is inspiring researchers and developers to propose new solutions capable to address a number of challenges, particularly those related to power system operation. A massive penetration of asynchronously connected renewable energy generation, the generation connected over inverters, is significantly changing the dynamics of modern power systems. On the one hand, the power system response time is becoming shorter and at the same time, the fault level is becoming smaller. This is significantly affecting requirements of control loops, as well as power system protection. Utilization of modern sensor and communication technology looks to be the critical technological enabler for addressing the mentioned challenges. Wide area monitoring (WAM) offers many opportunities to improve the performance of power system protection. This paper presents some of these opportunities and the motivation for their development. This methods include monitoring the suitability of relay characteristics, supervisory control of backup protection, more adaptive and intelligent system protection and the creation of novel system integrity protection scheme. The speed of response required for primary protection means that the role WAM in enhancing protection is limited to backup and system protection. The opportunities offered by WAM for enhancing protection are attractive because of the emerging challenges faced by the modern power system protection. The increasingly variable operating conditions of power systems are making it ever more difficult to select relay characteristics that will be a suitable compromise for all loading conditions and contingencies. The mal-operation of relays has contributed to the inception and evolution of 70 With the increasing size and complexity of network, power system analysis to ensure the security and reliability is becoming herculean task. The model based analytics with SCADA data are time consuming and less accurate. Distributed and renewable energy sources along with the increasing power electronics devices like HVDC and FACTs are adding to the complexities. To take on emerging challenges, there is a strong need for the improved analysis with the very high resolution data, which is faster and fairly accurate for the large power systems. The 2003 blackout in the United State of America (USA) supported the immediate need for such systems and had been one of the major driving forces of implementing Wide Area Monitoring System (WAMS) as it is highly valuable for online and post disturbance analysis. WAMS is one such advanced monitoring system that captures high resolution data for the basic measurements like voltages and currents. Phasor Measurement Units (PMU) are the field devices that digitize the analog waveform with the time stamping and push the data to the Phasor Data Concentrators (PDC). Collected data along with the derived quantities at the PDC can be used for advanced analytics and reflect the power system dynamics in the form of visualization directly. This can improve the situational awareness and facilitate the operator with properly estimated state of the system. Continuous monitoring will also help the operators to predict the behavior of the system and can opt for necessary measures. The data from WAMS can be effectively used for the fast response power system control and protection applications and hence the system is called Wide Area Monitoring, Protection and Control (WAMPAC). The system captures voltage and current phasor data from the critical substations distributed throughout the geographic locations of the power networks. 2. State-of-the-Art in WAMPAC has been used by many utilities worldwide for a variety of purposes. It is found useful by most of the utilities in terms of enhancing real-time monitoring and situational awareness. Few relevant examples of implementation of WAMS/ WAMPAC are discussed below. The major aim of North American Synchro phasor Initiative (NASPI) is to carry out research to understand potential of phasor measurement devices, phasor data and applications for advanced power system analysis. In California, there have been case studies where PMU data is used for control of reactive power from SVC. In the western states of USA, PMU data is extensively used for planning studies as well. During hurricane Gustav, PMU data was used for system separation, islanding studies. For forensic analysis the PMU data is mostly used by many utilities. In India, Maharashtra State Electricity Transmission Company Ltd. (MSETCL) took lead in pilot implementation of WAMS in their network covering critical locations using 15 PMUs along with the visualization tool. POSOCO started its initiative through pilot deployment of 4 PMUs along with PDC in northern region. The pilot project was further extended to all regions with the aim of monitoring Indian network through 56 PMU's and other infrastructure. Based on various experiences through pilot projects, PGCIL took up the herculean task of covering India's backbone network using WAMS via deployment of 1200 nos. of PMUs with advanced network assessment capabilities known as the unified real time dynamic state measurement (URTDSM) project.

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