2.1 Introduction

Energy is an essential ingredient for human life on earth. It is used in all activities of society, for preparing meals, making cloth, building house and other activities. Human beings have needed and used energy at an increasing rate for their sustenance and well-being. One of the important requirements of energy for man is in the form of food. A brief description of the profile of energy is presented in this chapter.

2.2 Types of Energy Sources

Primary and Secondary Energy

Common primary energy sources are coal, oil, natural gas, and biomass (such as wood). Other primary energy sources available include nuclear energy from radioactive substances, thermal energy stored in earth's interior, and potential energy due to earths' gravity.

Commercial Energy and Non Commercial Energy

The energy sources that are available in the market for a definite price are known as commercial energy. By far the most important forms of commercial energy are electricity, coal and refined petroleum products.

Non-Commercial Energy

The energy sources that are not available in the commercial market for a price are classified as non-commercial energy. Non-commercial energy sources include fuels such as firewood, cattle dung and agricultural wastes, which are traditionally gathered, and not bought at a price and used especially in rural households. These are also called traditional fuels. Non-commercial energy is often ignored in energy accounting.

Renewable and Non-Renewable Energy

Renewable energy (inexhaustible) are mostly biomass based and are available in unlimited amount in nature. Since these can be renewed over a relatively short period of time, energy sources that are replenished more rapidly are termed as renewable. These include firewood or fuel wood from forest, petro plants, plant biomass ie. agricultural waste like animal dung, solar energy, wing energy, water energy in the form of hydro-electricity and tidal energy and geothermal energy etc.

Non-renewable energy (exhaustible) are available in limited amount and develop over a longer period of time. As a result of unlimited use, they are likely to be exhausted one day. These include coal, mineral, natural gas and nuclear power. Coal, petroleum and natural gases are common sources of energy being organic (biotic) in this origin. They are also called fossil fuels.

2.3 Sources of Energy for Cooking in India

It is evident from Table 2.1 that around two-third of Indian households still use firewood and other bio mass for cooking purpose. It is noted that this source is the most harmful in terms of the emission of green house gases. Combustion of biomass (firewood, dung cake, etc.) emits not only carbon dioxide, but also nitrous (nitric) oxides and methane. The environment friendly fuel of LPG is being used by only about one-fifth of the population. Government attempts to provide kerosene and LPG have not touched around three-fourth of the households in the country.

Table: 2.1 - Primary Source of Energy Used for Cooking

Source	Percent
Firewood and chips	61.4
LPG	17.1
Dung cake	9.5
Kerosene	5.0
Others	5.0
No cooking arrangement	2.0
Total	**100**

Source: Compiled from National Sample Survey 57th round (2001-02)

2.3.1 Regional Variation in the Dependence on Sources of Cooking Energy

Table 2.2 shows that the dependence on firewood is more intense in states such as Uttaranchal, Chattisgarh, Rajastan, Orissa, MP, Jharkhand, and in most of the hilly states located in the North and Northeastern parts of the country. On the other hand, only a small percentage of households use firewood, and the majority use LPG in urbanized areas such as Delhi, Chandigarh, Goa, Pondichery, etc. Kerosene is also widely used in urbanized areas and localities such as Sikkim and Lakhshadeep where probably the availability of biomass is limited.

Table: 2.2 - State-wise Distribution of Primary Source of Cooking Energy

	Fire wood and chips	LPG	Dung cake	Kerosene	Others	No cooking arrangement
Jammu & Kashmir	47.2	44.5	4.2	3.3	0.5	0.3
Himachal Pradesh	70.9	21.9	0	4.6	0.4	2.1
Punjab	29.7	37.6	13.9	15.1	1.7	2
Chandigarh	2.1	81.1	0	8.6	0	8.2
Uttaranchal	76.3	19.3	0.3	3.7	0.1	0.3
Haryana	40.1	37.6	17.8	3.9	0	0.6
Delhi	1.8	60	0.3	32	0.1	5.7
Rajastan	81.4	13.1	0.9	3.6	0.4	0.6
Uttar Pradesh	51.8	10.3	33.7	1.8	0.9	1.5
Bihar	47.3	3.2	20.7	2.2	26.3	0.2
Sikkim	46.7	24.4	0	18.1	0.6	10.2
Arunachal Pradesh	73.1	23.7	0	0.8	2.3	0
Nagaland	85	12.4	0.5	1.3	0	0.7
Manipur	70.1	25.4	0.3	1.4	1.8	1
Mizoram	54.5	42	0.1	1.8	1.6	0
Tripura	82.9	14.6	0	2.2	0.3	0
Meghalaya	89.8	7.2	0	0.8	0.9	1.3
Assam	83.6	14.3	0.1	1.6	0	0.4
West Bengal	53.8	14.5	3.4	6.6	19.4	2.2
Jharkhand	73.6	5.5	2.1	0.7	17	1.1
Orissa	88	3	3.8	1.1	3.6	0.6
Chattisgarh	77.5	4.4	9.3	0.3	8.3	0.2
Madhya Pradesh	77	16.2	1.5	3.9	0.6	0.9
Gujarat	57.2	24.3	2	11.4	2.4	2.7
Daman & Diu	14.1	39.6	0	27	0	19.3
Dadra & N. Haveli	52	27.6	0	12.2	0	8.2
Maharastra	47.7	31.3	0	9.2	7.2	4.5
Andra Pradesh	69.5	21.6	0.2	5.1	0.7	2.9
Karnataka	64.4	25.1	0.2	4.7	0.1	5.6
Goa	25.3	56.3	0	9.8	0	8.6
Lakshadweep	54	27.2	0	10.9	0	8
Kerala	69.6	26	0	1.8	0.3	2.3
Tamil Nadu	**57.4**	**25.4**	**0.1**	**13.4**	**0.9**	**2.7**
Pondicherry	35	45.5	1.5	12.2	0	5.8
A & N Islands	63.2	17.3	0	16	0	3.6
All India	61.4	17.1	9.5	5	4.9	2

Source: Compiled from National Sample Survey 57^{th} round (2001-02)

2.3.2 Long Term Energy Scenario for India

Coal

Coal is the predominant energy source for power production in India, generating approximately 70 percent of the total domestic electricity. Energy demand in India is expected to increase over the next 10-15 years. Although new oil and gas plants are planned, coal is expected to remain the dominant fuel for power generation. Despite significant increases in total installed capacity during the last decade, the gap between electricity supply and demand continues to increase. The resulting shortfall has had a negative impact on industrial output and economic growth. However, to meet the expected future demand, indigenous coal production will have to be greatly expanded. Production currently stands at around 290 million tonnes per year, but coal demand is expected to more than double by 2010. Indian coal is typically of poor quality and as such requires to be beneficiated to improve the quality; Coal imports will also need to increase dramatically to satisfy industrial and power generation requirements.

Oil

India's demand for petroleum products is likely to rise from 97.7 million tonnes in 2001-02 to around 139.95 million tonnes in 2006-07, according to projections of the Tenth Five-Year Plan.

Natural Gas

India's natural gas production is likely to rise from 86.56 million cmpd in 2002-03 to 103.08 million cmpd in 2006-07. It is mainly based on the strength of a more than doubling of production by private operators to 38.25 mm cmpd.

Electricity

India currently has a peak demand shortage of around 14 percent and an energy deficit of 8.4 percent. Keeping this in view and to maintain a GDP (gross domestic product) growth of 8 percent to 10 percent, the Government of India has very prudently set a target of 215,804 MW power generation capacity by March 2012 from the level of 100,010 MW as on March 2001, that is a capacity addition of 115,794 MW in the next 11 years.

Nuclear Energy

Nuclei of atoms can be broken down into two or more parts through artificial methods. In the same way two or more nuclei of light weight can be combined to form a big nucleus. The above two types or reactions are called "Nuclear Reactions". During these reactions some of the atomic mass is converted into energy. This energy is called Nuclear Energy. The amount of the nuclear energy can be estimated by the following formula (By Einstein)

E = Energy

M = Mass

C = Velocity of light (3 x 10^8 m/sec.)

Even a very small quantity of matter can produce a greater amount of nuclear energy (because C2 = 9 x 10^{16}) for example, the energy produced by 3.5 millions tonnes of coal or 12 million tonnes of oil is equivalent to the nuclear energy produced by one tonne of Uranium. Uranium, Thorium and Radium are some important radio active elements, which give off specific rays like α (Alpha), β (Beta) and ϒ (Gamma) due to spontaneous disintegration of their nuclei.

Atomic Reactors are furnaces used to release energy during nuclear reactions. The energy is generated in the form of heat, which is converted into steam. The steam can be used in running steam - turbines to produce electric energy. When a nucleus is broken down into two or more parts, the process is called "nuclear fission". The combination of two or more lighter nuclei of low mass is called "Nuclear Fusion".

Solar Energy

The energy of sun called solar energy can be used effectively. The earth receives energy continuously from the sun at the rate of about 75,000 x 10 KWH of energy every day Green Plants have the capacity to trap the solar energy and they convert to solar energy into chemical form by a process called photo synthesis. Most part of solar energy is left unused. Just 0.1% of this could meet the total world energy requirements. Scientists have developed ways and means to trap solar energy artificially and convert into various forms like electrical, chemical and mechanical.

The solar radiation coming to the earth is called INSOLATION and it is in the form of electro magnetic waves. One square centimetre area on earth receives two calories of solar energy in one minute. It can be increased through artificial means to meet the energy requirement. Photo - chemical change involves changes due to heating effects of sun rays. eg. during our child hood days we might have played with leaves to burn papers by sun rays.

Some chemical changes also can occur in objects that absorb solar energy. eg. bright colour clothes fade away when put into strong sunlight continuously. Black surfaces absorb sunlight and thus get heated. Sun light also causes the synthesis of starch in green plants (Photosynthesis).

$6Co_2 + 12\ H_2O$ Sunlight $C_6H_{12}O_6 + 6H_2O_6 + 6O_2$

When sunlight falls on some specific metals like sodium, potassium and lithium it activates the electrons inside it. The excited electrons after some time return to their original level after releasing the energy, It is called 'Photo Electric Effect'.

All the above principles are used to convert solar energy into heat, chemical and electrical energy.

Solar cooker, solar oven (developed by Jodhpur's Central Arid Zone Reseach Institute (CAZRI) space heating buildings during cold weather in USA signals at RS are examples of how solar energy can be used effectively.

Advantages

1. Can be used in remote and rural areas, ships and military camps where there are no power lines.
2. Solar energy is available free of cost.
3. Cost of maintenance is very low.
4. The greatest and foremost advantage is that it does not produce wastes or pollutants.

Disadvantages

1. Depends upon total hours of sunshine in a day affected by cloudy weather and short winter days.
2. Solar cells, solar panels and solar energy conversion equipments are costly.

Progress in India

Solar cookers, solar heaters, solar desalination plants, solar photovoltaic electric power, generators and solar pump sets are being used even in remote villages. The following organisations develop solar energy system.

1. Department of Non - conventional energy sources (DNES)
2. Rural Electrification Corporation
3. Indian Institutes of Technology
4. Department of Metallurgy of Pune Engineering College.

Wind Power

The wind is air in motion. It is caused by differential heating of land, water, hills and mountain slopes by sun rays. There is kinetic energy in wind. Even in ancient times the great sailors utilized kinetic energy of the wind in sailing their ships around the globe.

The kinetic energy of wind is caused by its motion, the higher the velocity of wind the greater the kinetic energy in it. This velocity of wind is affected by solar radiation, which varies from season to season and from place to place. Strong winds blow in coastal plains and hill. The kinetic energy of the wind can be utilized by converting it into mechanical form. With this wind mills are operated. Large blades of wind mills can convert much of the wind energy into mechanical form.

The installation of wind power generation system depends upon extensive survey, site selection, construction and machinery plantation. The continuous supply of electricity generated from wind power needs installation of electronically operated black - boxes (Synchronus Generator) which are very costly. At times there may be no wind and the power generation may stand still.

Progress in India

Wind energy is pollution free and a renewable source of energy. California with 17,000 turbines generating 1500MW is the world's largest producer of wind energy. India started utilization of the wind power during the period of the VIIth five year plan. It was found that on 80 per cent days winds in Karnataka, Tamil Nadu, Andhra Pradesh, Maharashtra and Gujarat below 10Km / hour for morethan 10 hours and 20 hours on 40 per cent days. Large scale research in this direction started in 1983. As a result wind power farms were established in different parts of Indian states and union territories. In 1995, the total wind energy potential was estimated, around 20,000 MW.

In Tamil Nadu, Muppandal in Kanyakumari district and Kayathar in Thoothukudi District are the major wind energy producing places. Many villages in and around Muppandal developed economically because of this wind power. Lot of employment opportunities were created. As the village Muppandal is situated in the mountain pass area of Western Ghat naturally it is well suited for the wind energy production.

Bio Mass Power

Bio mass means dry weight of organic matter produced by plants, their derivatives and wastes. It includes plant parts, animals and animal wastes. As biomass is the product of Photosynthesis by plants, bio mass energy is regarded as another form of indirect use of solar energy. It is very cheap, renewable and almost pollution free. Bio-mass energy has from the following three ways.

1. By incineration or controlled burning of fuel wood and agricultural left over.

2. By converting bio - mass into alcohol through thermo chemical process and using it in engines.
3. By making bio-gas (or Gobar gas) through bio-chemical conversion ie, anaerobic (without air fermentation (digestion) of moist cattle.

The energy from bio-mass is very high. One cubic metre of bio-gas contains about 6000 calories which is equivalent to 0.8 litres of petrol, or 0.6 litres of crude oil or 1.5m^3 of natural gas, or 1.4kg of charcoal or 2.2 KWH of electrical energy.

Most of bio-gas is Methane (CH_4) at normal temperature and pressure. It is highly combustible and gives non - luminous flame. Estimates show that it can produce 22,500 million cubic metres of methane (Gobar gas) and 206 million metric tonnes of organic manual every year. Scientists have identified several species of plants (Petro - plants) that can be used as bio-mass sources. Green leaves, animal urine, animal fodder left over or waste and perishable food wastes are other bio - mass resources besides the animal dung. (Gobar)

The only limitation of this energy source is its availability. Population explosion or urbanization has already put excessive pressure on available cultivable land. So where is the land for the creation of more bio - mass?

Progress in India

The department of Non - conventional energy sources launched a National Bio - gas Development Programme. The installation of these plants is going on all over the country at the block and panchayat level in rural areas. During the year 1984 - 1985 alone 1,50,000 Bio - gas plants were installed. Now it is estimated that about 3,30,000 bio-gas plants are working in India.

2.3.3 Power Generation in India

The total power consumption in the State during the last twenty five years has shown about six-fold increase. In Tamil Nadu, energy use has been increasing at a faster rate in respect of domestic and agricultural purpose as compared to commercial and industrial uses. However, in view of inadequate and intermittent supply of power, a large number of industrial establishments have captive power generation capabilities, which apparently explain the relatively low growth of commercial and industrial use of energy. During the last three decades Tamil Nadu's total installed capacity has increased more than three and a half times. Yet, the demand for electricity continues to increase at an accelerated rate with the result energy and peaking shortages hamper the growth of industrial and other sectors. Apparently, to meet the increasing demand for energy supply, the public sector investment will necessarily have to be supplemented by capacity addition in the private sector. The Government of India have initiated a number of measures to further the pace of reforming the power sector in the country and make the State Electricity Boards more vibrant. (Policy Initiatives: Government of India).

1. The energy Conservation Bill 2000, which envisages the efficient use of energy and its conservation was introduced. Efforts are being made to

create awareness about energy conservation potential by better housekeeping, proper maintenance and better control of instruments;

2. To ensure efficiency of the thermal plants, special schemes have been devised to renovate / modernize and refurbish old plants. Plants at the verge of senescence are to be modernized by inducting latest technologies;
3. Scheme for securitisation of dues of Central Sector Power and coal utilities to assist the State Electricity Board to clear these dues was initiated;
4. Policy on Hydro Power Development lays stress on exploitation of hydel potential available at a faster rate by providing of incentives viz., rationalizing the tariff for hydro projects and simplifying the procedure of obtaining clearances. Projects with less than 25 MW are to be given to the Ministry of non - conventional energy sources;
5. The Government of India has formulated the revised Mega Power Policy to generate power at the lowest possible tariff by setting up such plants at the pit heads;
6. Assistance is given to the State's Power Sector to reform and for investments on renovation and modernization of old and inefficient plants and strengthening of the distribution system.

2.3.4 Energy and Environment

The interaction between energy and environment has been dealt with extensively by ecologists and environmental economists. A given abiotic physicochemical environment and its particular biotic assemblage of plants, animals and microbes constitute an ecological system or ecosystem; a pond, a field, a forest, an ocean, or even an aquarium'. Human use of energy has an effect on the eco system in which the energy is used and the changes caused contribute, probably negatively to the environment leading to ecological imbalance. The toxic effects of chemical and physical agents affect not only the living organisms but also the environment as a whole.

The pattern of generation and use of energy indiscriminately, over a period of time create the global concern on environmental protection. The greenhouse effect, acid rain, the ozone hole, and the immediate health hazards necessitate environmental awareness, at all levels of human activities.

Oil, natural gas, and coal being the major energy resources, their depletion poses the need for identifying alternate energy resources. Huge amount of money is invested on identifying alternative energy resources besides exploring oil and gas in different areas in the globe. While it is certain that the globe will not sustain the energy requirements from conventional sources the need for identifying renewable energy resources is acute.

The actions to protect the global environment cannot be an event that may last for just a few decades; it has to be a long drawn process. As such the effort has to be all pervasive. Conceptually in a broader sense the energy and environmental education has to be at the first instance to for the policy makers at the national and Global level. Economists and politicians may not go for short term profits at the cost of long term welfare. Also, they should assume, while taking any decision that their primary responsibility is to leave their country as a better place for the next generation. Environmental education should result in a firm belief that the present generation may have to sacrifice a lot in the interest of the future generations.

The other end from which the environmental education can start is in the minds of the children. The desired end points of interest at different levels of biological organization should be taught to the children and they must be made aware of the environmental values that are to be protected. Special teaching methods may be deployed wherein the children's learning is activity-based and experiential. Children must be exposed to various fields of study on ecology and environment, disasters and managing disasters and so on. Ready made teaching and training kits may be designed and used.

2.4 Energy Development in Tamil Nadu

The most important single factor, which can act as a constraint on the economic growth of a country, is the availability of energy. There is a direct correlation between the degree of economic growth, the size of per capita income and per capita consumption of energy. Since energy is an essential input of all productive economic activity, the process of economic development inevitably demands increasing higher levels of energy consumption. So the energy development is very important in all the countries.

Energy development has been given high priority by the State and Centre over the plan periods. In Tamil Nadu, the State Sector investment for power development has been very high. Cumulatively upto the IX plan, over 22 percent of plan expenditure had been devoted for the development of this vital infrastructure. The power sector attracted the highest allocation during the first three plan periods (37.7%, 42.2% and 37.6% respectively). It may be noted that a sum of Rs.8,030 crores accounting for 20.07 percent of X plan outlay has been earmarked for energy development.

Energy Sector Policies and Financial Support Measures

Among the factors that have led to distortion in the supply and demand of cleaner petroleum-derived cooking fuels (Kerosene, LPG) at national level have been government price controls, particularly subsidies on domestic kerosene and LPG, and protection of state oil monopolies, for example through import restrictions and discrimination against the private sector.

Although the measures may have been introduced with a view to making cleaner fuels more accessible to the poor, universal fuel subsidies have often tended to be counter-productive, with wealthier people, who have better access to these fuels, gaining most advantage.

To reduce the adverse fiscal impact of such policies, some governments have supplemented a heavy kerosene subsidy with a ration system that made subsidised kerosene available in small amounts, but not sufficient for cooking. In addition, a price differential between domestic kerosene and LPG on one hand and other petroleum products that are close substitutes (e.g. commercial kerosene and LPG, and diesel) have led to illegal diversion of domestic fuels to the commercial and transport sector; thus further reducing their availability for the poor.

Lack of incentives and enabling environments for the private sector may also slow growth in supply, removal of infrastructure bottlenecks and development of effective marketing strategies. Although in some countries, the recent removal of subsidies on kerosene is believed to have pushed poor families back to reliance on biofuels, "across-the board" subsidies are neither a sustainable nor an efficient tool for addressing the needs of the poor.

Subsidy schemes should always be carefully assessed and designed to target households in greatest need. In particular, carefully targeted financial support for technical development and production of appliances, and for infrastructure for marketing and transport may be reasonable.

Biogas: In another successful programme, financial incentives were used in a biogas project in India where meeting of quality standards and durability of the biogas system were rewarded in the form of an additional bonus. A mechanism that is receiving growing attention is the provision of affordable micro-credit to households: if used to support the purchase of efficient appliances that reduce fuel (and health) costs in the long term, this could be a powerful instrument for change.

The generation of power and the consumption of power in Tamil Nadu are given in Table 2.3.

Table: 2.3 – Electricity in 2000 - 2001

A. Generation of Electricity (Gross) - (in m.u.)		**Percentage**
a. Hydro	5,450	13.05
b. Wind Mill Generation	18	0.04
c. Thermal	19,464	46.60
d. Power Purchased	16,617	39.80
e. Gas Turbine	215	0.51
Total	**41,764**	**100.00**
B. Consumption of Electricity (in m.u.)		
a. Agriculture	9,095	27.22
b. Industry	11,751	35.16
c. Commercial	3,148	9.42
d. Domestic	7,176	21.47
e. Public Lighting and Water works	902	2.70
f. Sales to other States	211	0.63
g. Miscellaneous (including Traction and Railways)	1,135	3.40
Total	**33,418**	**100.00**

Source: Tamilnadu hand book 2001.htm

There was a moderate gain during 2002 – 03 both in building installed power generation capacities (4.3 %) and also on the gross power availability (5.7%), despite a setback in the hydel generation. To meet the increasing demand, the Tamil Nadu Electricity Board resorted to a higher level of purchase during the year and ensured unrestricted supply to all the categories of consumers. The per capita consumption of power increased from 567 units in 2001 – 02 to 586 units in 2002 – 03. This information is given in Table 2.4.

The total installed capacity of Tamil Nadu Electricity Board as on 31.12.2004 was 9394 Mega Watts (MW). This comprises 5381 MW of TNEB's own projects, 1066 MW of Private Sector Projects, 2587 MW as share from Central Sector Projects and external assistance of 360 MW. Apart from this, a total capacity of 1664 MW is available from wind mills in the Private Sector and 19 MW of power from the wind mills of TNEB. Besides this a total capacity of 275 MW is available from Co-generation plants and 31 MW from Bio-mass plants.

The maximum peak demand so far reached is 7,468 MW (on 23.02.2005). The growth of energy consumption is expected to be of the order of 6% per annum. Energy consumption during 2004 - 05 upto December 2004 was 38,462 Million Units (MU) with a maximum daily consumption of 154.942 MU on 23.02.2005.

Table: 2.4 – Power Sector – Profile

Details	2000 - 01	2001 - 02	2002 - 03
1. Installed Capacity (MW)	7,513.4	7,924.7	8,268.8
i. State's Own	5,213.1	5,213.1	5,308.1
ii. Central Sector	1,905.0	1,913.0	1,903.0
iii. IPPs	301.7	729.1	988.2
iv. Captive Power	93.6	69.5	69.5
2. Power Generation (mu)	25,147	25,562	24,929
3. Power Purchase (mu)	16,617	18,358	21,263
4. Gross Power Availability (mu)	41,764	43,920	46,414
5. Total consumption within the state (mu)	33,418	35,202	36,347
6. Per capita consumption (units)	510	567	586
7. Number of consumers (lakhs)	145.73	153.43	160.16
8. Peak Demand (lakhs)	6,290	6,687	6,957
9. Line loss (%)	16.50	16.25	18.0
10. Auxiliary Consumption (mu)	1,672	1,791	1,878

Source: Economic Appraisal 2002 – 03, Evolution and Applied Research Department, Government of Tamil Nadu, Kuralagam, Chennai, P.86.

As on 31.12.2004 there were 1069 substations, 1.46 lakh kms. of Extra High Tension / High Tension (EHT/HT) lines, 4.75 lakh kms. of Low Tension (LT) lines, 1.59 lakh distribution transformers and 169.10 lakh service connections.

To meet the increase in demand, the TNEB has planned to augment its generating capacity to 2,408.8 MW and to correspondingly expand the transmission and distribution system during the X Plan period (2002 - 07).

2.4.1 Performance of Power Generation in Tamil Nadu

In Tamil Nadu, energy use has been increasing at a faster rate in respect of domestic and agricultural purpose as compared to commercial and industrial uses. However, in view of inadequate and intermittent supply of power, a large number of industrial establishments have captive power generation capabilities, which apparently explains the relatively low growth of commercial and industrial use of energy. During the last three decades Tamil Nadu’s total installed capacity has increased more than three and a half times. Yet, the demand for electricity continues to increase at an accelerated rate with the result energy and peaking shortages hamper the growth of industrial and other sectors. The profile of the power sector in Tamil Nadu is presented in Table 2.5.

The table 2.5 reveals that, the year 1999 - 2000 witnessed an accelerated growth in power generation by 6.4 percent and the total power consumption by 9.3 percent as compared to (-) 4.0 percent and 3.8 percent respectively during 1998 - 99. Power purchases which increased by 18.5 percent in 1998 - 99 decreased to 13.3 percent in 1999 - 2000. The per capita consumption steadily increased from 430 units in 1997 - 98 to 452 units in 1998 - 99 and further to 480 units in 1999 - 2000.

Table: 2.5 - Power Sector: A Profile in Tamil Nadu

Items	1997- 98	% Change	1998 - 99	% Change	1999 - 00	% Change
1. Installed Capacity (MW)	6,916.105	0.1	7,119.605	2.9	7,203.555	1.2
2. Generation (mu)	23,066	0.5	22,141	-4.0	23,549	6.4
3. Power Purchases (mu)	10,999	12.8	13,031	18.5	14,764	13.3
4. Gross Power Availability (mu)	34065	4.2	35,172	3.2	38,313	8.9
5. Total Power Consumption (Million units)	26,740	4.5	27,657	3.8	30,238	9.3
6. Per Capita (Consumption units)	430	2.4	452	5.1	480	6.2
7. Number of Agricultural Pumpsets Energized (lakhs)	16.10	2.5	16.44	2.1	16.79	2.1

Source: www.govt.tn.in.
Note: % percentage change over previous year

The table concludes that the power generation increases year by year, and at the same time the power purchase also increases. So there is a negative relationship between the power generation and power purchase. It is not appreciated. So the government should take necessary action to increase the power generation.

2.4.2 Capacity of State's Own Projects

The installed power generating capacity at the command of Tamil Nadu Electricity Board gained visible improvements during 1998 - 99 and 1999 - 2000. The source-wise number of powerhouses and installed capacities are depicted in Table 2.6.

Table: 2.6 – Tamil Nadu State Owned Projects

Source	No. of Power Houses			Installed Capacity (MW)		
	1997 - 98	**1998 - 99**	**1999 - 00**	**1997 - 98**	**1998 - 99**	**1999 - 00**
Hydro	27	28	30	1955.75 (38.5)	1963.25 (38.6)	1995.20 (39.0)
Thermal	4	4	4	2970 (58.5)	2970 (58.4)	2970 (58.1)
Gas	2	2	2	130 (2.6)	130 (2.6)	130 (2.5)
Wind	10	10	10	19.355 (0.40)	19.355 (0.4)	19.355 (0.4)
Total	**43**	**44**	**46**	**5,075.105 (100.0)**	**5,082.605 (100.0)**	**5,114.555 (100.0)**

Source: www.govt.tn.in.
Note: Figure in brackets indicates share to total

Table 2.6 explains that, the total installed capacity of the State's own projects rose from 5075.105 MW in 1997 - 98 to 5114.555 MW in 1999 - 2000. All the additions (39 MW) came from the three-hydel stations – Sathanur (7.5 MW), Parsons Valley (30MW) and Tirumurthi Mini (1.95 MW). It is significant to note that the State has been taking efforts for exploiting even the mini and micro hydel sources to augment the capacity. With no additions possible in respect of other sources, the share of hydel capacity marginally improved from 38.5 percent in 1997 - 98 to 39.0 percent during 1999 - 2000. In Tamil Nadu thermal and hydropower houses are the important sources of energy.

2.4.3 Shared Capacity from Central Sector Projects

Substantial quality of the power has been added to the State grid by means of purchases made from Central Sector Projects such as Neyveli I and II, National Thermal Power Corporation (NTPC), Ramagundam and Madras Atomic Power Project (MAPP), Kalpakkam. One notable addition to this category is the Kaiga Atomic Power station in Karnataka, the purchases from which were linked with the State grid in 1998 - 99. The installed capacities of the three sectors are presented in Table 2.7.

Table: 2.7 - Installed Capacity: Central Sector Projects (MW)

Project	1997 - 98	1998 - 99	1999 - 00
1. Neyveli I & II	1,041	1,041	1,041
2. NTPC	470	470	470
3. MAPP & Kaiga	330	330	382
Total	**1,841**	**1,841**	**1,893**

Source: www.govt.tn.in.

Table 2.7 reveals that, the share of installed capacities from the Central Sector Projects, a modest addition of 52 MW was possible with the commissioning of the Kaiga Nuclear Power Project in Karnataka during 1999 - 2000. This addition came as a much needed relief after several years of stagnancy and helped improve the capacity due from Central Sector Projects from 1,841 MW to 1893 MW.

2.4.4 Capacity Creation by Private Sector in Tamil Nadu

The Tamil Nadu government encourages the private power sectors - both thermal power and windmill power. The capacity creation of private sector is explained in Table 2.8.

Private sector came into play in power development for the first time in 1997 - 98. In 1998 - 99, a quantum of 196 MW (4 units each of 49 MW) Diesel

Electric Power Project (DEPP) was commissioned. Encouraged by the private sector participation, a total capacity of 7,390.06 MW has been awarded to private sector. Even if a portion of it could be brought to fruition every year with favourable pricing agreements, the power needs of the State could be adequately met. It is also noteworthy, that the State has made great strides in exploiting non-conventional sources of energy, especially, wind energy with the help of private sector.

Table: 2.8 - Capacity Creation: Private Sector (MW)

<table>
<tr><th>Category</th><th>1997 - 98</th><th>1998 - 99</th><th>1999 - 00</th></tr>
<tr><td>1. Thermal Power Project (GMR Vasavi)</td><td>-</td><td>196.0</td><td>196.0</td></tr>
<tr><td>2.Wind Mills</td><td></td><td></td><td></td></tr>
<tr><td>i. Muppandal</td><td rowspan="2">166.1</td><td>117.0</td><td>117.7</td></tr>
<tr><td>ii. Perungudy</td><td>261.3</td><td>283.5</td></tr>
<tr><td>iii. Kayathar and Devi Kulam</td><td>46.2</td><td>48.7</td><td>63.1</td></tr>
<tr><td>iv. Poolavadi</td><td rowspan="3">275.6</td><td>143.9</td><td>143.9</td></tr>
<tr><td>v. Sultanpet</td><td>46.5</td><td>51.4</td></tr>
<tr><td>vi. Kethanur</td><td>88.4</td><td>91.8</td></tr>
<tr><td>Total (Wind Mills)</td><td>487.9</td><td>705.8</td><td>751.4</td></tr>
<tr><td>Grand Total</td><td>487.9</td><td>901.8</td><td>947.4</td></tr>
</table>

Source: www.govt.tn.in.

2.4.5 Power Generation

Remarkable recovery in the thermal generation and sustained improvement in the generation of performance of the gas turbines and windmills helped compensate the set back in the hydel generation during 1999 - 2000. It is displayed in Table 2.9.

Table: 2.9 - Power Generation - Source-wise

Source	Electricity Generated (mu)		
	1997 - 98	**1998 - 99**	**1999 –00**
Hydel	5,287 (24.3)	4,918 (-7.0)	4,444 (-9.6)
Thermal	17,682 (-4.9)	17,076 (-3.4)	19,861 (10.5)
Wind & Gas	97 (-5.8)	147 (51.5)	244 (66.0)
Total	**23,066 (0.5)**	**22,141 (-4.0)**	**24,549 (6.4)**

Source: www.govt.tn.in
Note: Figure in bracket indicates percentage change over the previous year

Table 2.9 indicates the electricity generated through hydel capacity has been declining in the recent years from 5,287 mu in 1997-98 to 4,918 mu in 1998 - 99 and further to 4,444 mu in 1999 - 2000. The thermal power generation is displayed in Table 2.10.

Table: 2.10 - Thermal Power Generation

Source	Generation (mu)			PLF (%)		
	1997 - 98	1998 - 99	1999 – 00	1997 - 98	1998 - 99	1999 – 00
Ennore	1,924	1,799	1,295	49	46	33
Thoothukudi	6,906	6,596	7,449	75	72	81
Mettur	5,440	5,004	5,786	74	68	78
North Chennai	3,412	3,677	4,331	62	67	78
Total	**17,682**	**17,076**	**18,861**	**68**	**66**	**72**

Source: www.govt.tn.in

Table 2.10 shows the details of the total thermal power generation during 1999 - 2000 that increased by 10.5 percent to reach 18,861 mu. The performance of all the thermal stations was quite impressive save that of the Ennore Thermal Plant. The overall Plant Load Factor (PLF) which indicates the operational efficiency of the plants and defined as the ratio of average load carried by a power station to the maximum load, increased from 66 percent in 1998 - 99 to 72 percent in 1999 - 2000. This table discloses that the total thermal power generation increased at a considerable rate.

2.4.6 Non-conventional Sources of Energy

Wind energy, solar energy, biomass and other forms of bio energy, tidal energy, fuel cell, ocean-thermal and geo-thermal energy are important among renewable energy sources. Among these sources, though the first three renewable energy sources, namely, wind, solar and bio energy are being harnessed in a big way in India and in Tamil Nadu, the other sources have not yet reached a stage of commercial exploitation. The following table is given to show the energy generation from non-conventional source.

Table: 2.11 - Energy Generation from Non-conventional Source (mu)

Source	**1999- 00**	**2000 - 01**	**2001 - 02**	**2002 - 03**
1. Government				
Wind	27.2	19.5	17.8	19.5
Solar	0.05	0.13	0.12	0.15
Co-generation Plants	60.0	54.0	54.0	54.0
Total	**87.25**	**73.63**	**71.92**	**73.65**
2. Private				
Wind	1,129.4	1,070.7	1,239.3	1,286.2
Solar	--	339	0.031	0.018
Co-generation Plants	312	-	340.0	546.0
Total	**1,441.4**	**1,409.7**	**1,579.331**	**1,832.218**

Source: Economic Appraisal 2002 – 03, Evolution and Applied Research Department, Government of Tamil Nadu, Chennai, p.95.

The major share of this comes from wind energy followed by biogas based co-generation plants in sugar industry. It may be noted that investments in these projects have mainly come from private sector.

2.5 Energy Consumption in Households

The household sector, the most important one, consumes 70 percent of the energy even now which is absolutely necessary for survival. Of the various facts of energy problems confronting the developing countries, the problem of energy, affecting the household sector is important. As Elizabeth Cecelski observes, "In most of the developing countries, the household sector is still the largest single energy consuming sector".[1]

A household requires a minimum amount of energy for sheer survival. But, the actual amount of energy consumed by a household depends on several factors such as education, income, family size, price of energy occupation, cost of stove, fuel types, plinth area of the house in sq. feet, hours of cooking and nature of stove and location of kitchen that also influence household energy consumption.

Households require both commercial and non-commercial source of energy for various uses. Commercial sources include electricity, kerosene, petrol, diesel and L.P. Gas. Non-commercial sources consist of firewood, dung cake, and agricultural wastes. Among the fuels consumed by the households, firewood forms a major share. In the face of global energy crisis with the fast depleting situation of primary sources of energy like coal, oil and gas and depleting forest resources in the country, it is essential not only to use these fuels more efficiently and sensibly but also to look for better and improved heating and cooking ovens.

[1] Elizabeth Cecelski, "Energy and Rural Women's Work: Crisis. Response and Policy Alternatives", **International Labour View**, 126 (1): 1987, p.41.