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Chapter-I

Introduction and Concept of Energy Conservation

1.1 Introduction:

In the earliest days of civilization human beings used their own strength/muscles etc., in moving and carrying loads, trapping or in hunting animals for their food. In stone age, man discovered the magic 'Shakti' of fire by rubbing together two pieces of stones. This revolutionary discovery was reported to be the first attempt of man to use energy from a source outside his own body. Since then, he has continuously striven to minimize labour through the use of tools and machines which need energy source.

In the initial ancient period, energy resources were in natural form for instance, the power of falling water and the use of wind for ships.

In India the concept of 'energy' as 'Shakti' has been almost a focal point of philosophical, scientific and metaphysical thought from time immemorial. India's ancient literature is rich with the references on the so-called Shakti. The interpretation of the concept of 'Shakti' is made some times as synonymous with the supreme being (Adi-Shakti).

The term 'energy' (from the Greek word energia) is recorded to have been coined by Thomas Young (1723-1829) who applied it later to what is now called kinetic energy.¹

We are all intuitively conscious of the concept of 'energy' from early childhood. In school and colleges, we talk about the energy to run several kilometers or to climb mountains or to do other physical
work. This physical energy can be easily defined as the capacity to do work. In the human body, this energy comes from muscles of the human system, which in turn, get its energy from food and nutrition.

In industry the primary source of energy is fire originating from the burning of wood. Wind-mills were also widely used for grinding, water flow and other purposes in many parts of the world. In the 18th century, steam power was developed followed by refinement and innovations therein which affected the 19th century to a large extent. Oil as a lamp fuel is supposed to have been used on the island of Sante in the Loniam sea in the year 400 B.C.²

Today, we are quite conversant with the wide uses and applications of energy. By burning petrol or diesel, we get energy for vehicular traffic, viz., to run scooters, cars, trucks, rails etc. Many sources like, coal, kerosene and gas etc. are in use for cooking food and other domestic activities. Similarly, we also need electrical energy for illumination. In short, we live in a world of energy all around us.

1.2 Energy and Economic Development:

Energy is the basic natural resource without which existence of mankind is almost impossible. It plays a vital role in human welfare as all important economic activities of present development are dependent on the use of energy. The ready availability of cheap energy may serve to stimulate industrial agriculture, service and other sectoral development in the country. But inadequate energy supplies can result in lower industrial and agricultural production and slow
rate of economic growth. In other words energy is an important parameter of overall economic development activity of any country.

To the common man energy is a commodity he buys, e.g. kerosene and electricity, to an engineer it is an important thing required for industrial furnaces that power machinery, to an economist it is the key ingredient in the national prosperity.

There is a close correlation between the per capita Gross National Product (GNP) of a country and the per capita energy it consumes. It is a well established fact that energy and economic growth go hand in hand. In fact some economists regard energy as the fourth factor of production, in addition to the traditional list of land, labour and capital.³

In a very broad sense our present standard of living as measured and denoted by Gross National Product, largely depends on the measure of effective and massive use of energy. In other words, there is a direct correlation between the level of economic growth of the country and the 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. This can be proved with the help of per capita income and per capita energy consumption in India and in other five countries as displayed in table No.1.1.
Table No.1.1

Per capita income and per capita consumption of energy in India and other five countries.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Country</th>
<th>Per capita Income (in U.S. $)</th>
<th>Per capita consumption of energy (Kgs of oil equivalent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>India</td>
<td>2880</td>
<td>515</td>
</tr>
<tr>
<td>2</td>
<td>Indonesia</td>
<td>3210</td>
<td>729</td>
</tr>
<tr>
<td>3</td>
<td>Egypt</td>
<td>3940</td>
<td>737</td>
</tr>
<tr>
<td>4</td>
<td>U.K.</td>
<td>27650</td>
<td>3982</td>
</tr>
<tr>
<td>5</td>
<td>Japan</td>
<td>28620</td>
<td>4099</td>
</tr>
<tr>
<td>6</td>
<td>U.S.A.</td>
<td>37500</td>
<td>7996</td>
</tr>
</tbody>
</table>


The table No. 1.1 reveals that the first three countries are developing ones with low per capita income while the next three are developed countries with high per capita income. The per capita consumption of energy in India was 515 kgs. Of oil equivalent (kgos) as compared to 729 kgs in Indonesia 737 kgs in Egypt, 3982 kgs in U.K., 4099 kgs in Japan and 7996 kgs. In U.S.A.

Per capita consumption of energy in India is only 12.56 per cent as compared to Japan and only 6.44 per cent to that of United State of America (USA). Due to the lower consumption of energy per
capita income in India is only 10 per cent as compared to Japan and only 7.68 per cent to that of U.S.A.

As a result of this abundant energy consumption, Gross National Product per capita in developed countries i.e. Japan and U.S.A. is 10 times and 13 times more than India.4

Meson's (1955) study pertaining to per capital income and per capita energy consumption in 52 countries for the year 1952 is worth studying. In his words "no country can enjoy high per capita income without becoming an extensive consumer of energy"5. Energy consumption and Gross National Product (GNP) in United States were correlated during 1880 to 1915 as observed by Schurr et.al.6 Fremont Ferix (1964) also showed that national income (per capita) and energy consumption are closely related7.

Another study by Dramstadar et.al. (1971) related the correlation between energy consumption and national income using both time series and cross sectional data. The conclusion of the study is as follows:

'A prominent characteristic of per capita consumption of commercial energy forms is its systematic and quantitatively close association with indicators of general economic development measured hereby per capital GNP. This relationship between GNP and energy holds both cross sectionally and historically. The higher the nations income or output on the current international scale, the higher in general its level of energy consumption as its GNP rise over time, so
does its energy consumption in close, even if not proportionate conformity.  

In the Indian context, a few studies have been made by Tyner\textsuperscript{9} and K. Balu et.al.\textsuperscript{10} Using the data on GNP and commercial energy consumption during the period of 1953-54 to 1970-71. Both the studies have concluded that there was a close correspondence between national income and energy consumption in India.

Moreover, uncertainty regarding future adequate availability of energy supplies may act as a stumbling-block to both private and public sector investment in future. Ostensibly, adequate energy supplies at reasonable costs could provide an incentive to investments. In short, both current production and investment level which reflect future production potential are dependent on reliable and adequate energy supplies.

1.3 **Sources of energy:**

The ultimate source of almost all forms of energy is the energy that comes from the sun. All our chemical fuels like coal, wood, oil and natural gas are derived from plants and animals. It would be whole some to know briefly the various energy sources.

Energy sources, may broadly be classified into two groups, viz. conventional and non-conventional or alternative sources of energy. The conventional sources of energy consists of coal hydropower, oil and natural gas and nuclear energy. Non-conventional sources of energy include solar energy bio-gas energy, wind energy and animal power.
In a developing country like India, energy sources may be classified into two categories viz. commercial and non-commercial sources of energy. The former consists of coal, oil and natural gas, hydroelectric power and nuclear power while the latter encompasses firewood/fuel wood, charcoal, vegetable waste/agricultural waste (crop residue) and dried animal dung.

**Commercial Energy:**

Commercial energy is more correctly commercial source of energy. It consists of coal, petroleum, oil and natural gas, hydroelectric power and nuclear power and electricity etc. These sources are commercial in the sense that they command a price and the users have to pay for them. Commercial energy accounts for over 50 per cent of all energy consumption in India.\(^{11}\)

**Power / Electricity:**

Electricity is one of the major source of commercial energy. Power (electricity) constitutes an important part of the infrastructure. The rate of growth of any economy is directly linked with the availability and consumption of power. It is ostensibly clear that, all sector viz. Industry, agriculture, commerce trade and business are vitally dependent upon power sector.

**Hydro-Electric Power/Hydel Power**

There are five major sources of power viz. Water, coal, oil, gas and radio active element like uranium thorium and plutonium.

Electricity generated from water is known as hydro electricity.
The development and distribution of hydro power depends on supply of water from river, lakes, reservoirs, dams etc. Rainfall and snow are the two major sources of water in the rivers of our country. Snowfed rivers of the North India have perennial water supply. While water in the rainfed rivers of the south is stored in dams or reservoirs and released regularly to generate electricity.

**Thermal Power:**

The development of thermal power plants which use coal, oil or natural gas to generate electricity is common where these fuels are available. In India, since oil resources are rather limited the main source of thermal power is coal.

**Coal:**

Coal is one of the primary major sources of energy in India. It is of multipurpose use, for a heating purposes, as a fuel for boilers and steam engines, It is also used for generation of electricity in thermal power plant and cooking purposes in household sector.

**Oil and Natural Gas:**

As referred earlier, the energy from petroleum is derived from plants and dead animals, that lived in the remote past. Natural gas is also produced in the earth's crust by similar processes. With the discovery of oil and its refined products, new engines and machines came into existence and their productivity went on increasing later. Oil and its derived products are very convenient for use and easy for transportation leading to rapid augmentation in the consumption of oil in the world.
Nuclear Energy / Atomic Energy:

India is now one of the few countries which has made considerable progress in the field of atomic energy. The country is self-reliant in this technology and thus it has established competence in carrying out activities over the entire nuclear fuel cycle. Atomic energy can be produced by using uranium or thorium. This energy can also be obtained both through fusion and fission processes.

Thorium is another potential fuel for nuclear fission reactors. It is not fissionable in itself, but can be converted into uranium which is fissionable.

1.4 Non-commercial energy resources in India -

Fuel wood:

Fuel wood is essential for cooking and it is extensively used in our villages and towns. According to an official estimate, 65 per cent of total rural energy consumption is met from fuel wood.

Animal Dung:

Dried dung of animal is extensively used as fuel in our rural areas and also in town.

Agricultural Wastes:

Agricultural wastes such as straw are presently used as feed and fodder, roofing materials, and as fuel for cooking purpose.
While the above source of energy both commercial and non-commercial are known as conventional sources of energy. There are other sources of energy which are commonly called as non-conventional sources of energy. They are solar energy, biogas, wind energy, animal power etc.

**Solar Energy**:

Solar radiant energy falling on the surface of the earth in the form of visible light, can be converted into thermal energy. Simple devices are required for this conversion. In future it is expected that solar energy may be utilized widely for community lighting, minor irrigation pumping of drinking water, radio and television sets for educational purpose and communication equipment.

**Biogas**:

This is methane fuel gas produced by anaerobic formation of organic matter like animal dung, human waste and vegetable wastes.

**Wind Energy**:

Wind energy is the kinetic energy associated with movement of large masses of air. The shaft power from the wind turbine can be utilized for a wide variety of purposes including electricity generation.

**Animate Energy**:

There is yet another sources of energy, viz. living energy, consisting human efforts and animal power. This source of energy has been predominantly used in the third world countries.
1.5 Concept of Energy Conservation:

Energy conservation means avoidance of waste; but more accurately it means optimal use of available energy resources to achieve high efficiency with low specific energy consumption. 'The cheapest form of alternative energy is energy saved.'

Energy conservation can be broadly defined as better and more efficient utilization of energy resources. It does not seek to unilaterally curtail economic growth on energy demands but also envisages the effective utilization of energy which in turn influences the large consumption of fuels. In a nutshell, energy conservation does not involve sacrifice of any sort. Rather, it implies a more rational, efficient and effective use of energy in conformity with the laws of thermodynamics. The utilization of energy involves processing and other activities. Processing consists of the following stages:

1. Production of primary forms of energy.
2. Conversion or upgradation of primary forms into usable forms whenever necessary.
3. Transportation of primary / secondary forms of energy to the point of conversion / ultimate use.
4. Utilization of energy at the final consuming end.

Energy conservation is possible at all the above cited stages.

1.6 Need of Energy Conservation in India:

The urgent need for energy conservation in India can well be illustrated from the following facts:
1. Proved coal reserve in India as on 1st Jan. 2005 was 92960 million tonnes only. Its estimated demand would be 620 million tonnes in 2011-12 the coal reserve will finish in 100 to 125 years.

Moreover, the quality of Indian coal is not so good therefore we have to import about 25 million tonnes of coal by spending valuable foreign exchange\(^\text{13}\).

2. In the case of petroleum, the country had 786 million tonnes of crude oil in India on 1st Jan. 2005. Considering the current rate of crude oil exploration 33981 Thousand tonnes the oil reserves will be available for 23 years only. Moreover, the import dependency is over 75 percent. If the same trend persists, the International Energy Agency has projected that India's import dependency may increase to as high as 94 percent by 2030. Further we are spending massive foreign exchange of about 1168.06 billion Rupees for the import of petroleums\(^\text{14}\).

3. Natural gas reserves have 1101 billion cubic meters and its present rate of production is 31777 million cubic meters. It means our natural gas reserves will finish within coming 34 years\(^\text{15}\).

4. On power (electricity) front it is observed that there has been always a shortage of 7 percent to 8 percent between demand and supply. Due to the high demand of electricity there has been shortage of 11 to 12 per cent during recent years.\(^\text{16}\)
In order to meet the energy requirement of the country Govt. of India has invested heavy amount for the development of energy sector. It is evident seen from the data of plan allocation in the 4th plan and onwards which has been brought out in the table No. 1.2.

Table No. 1.2

Plan-Wise Allocation for Energy Sector

<table>
<thead>
<tr>
<th>Plan</th>
<th>Total expenditure</th>
<th>Expenditure on Energy Sector</th>
<th>Percentage of Allotment to Energy Sector to Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fourth Plan</td>
<td>15779</td>
<td>2932</td>
<td>18.58</td>
</tr>
<tr>
<td>Fifth Plan</td>
<td>39426</td>
<td>7400</td>
<td>18.77</td>
</tr>
<tr>
<td>Sixth Plan</td>
<td>109292</td>
<td>30751</td>
<td>28.13</td>
</tr>
<tr>
<td>Seventh Plan</td>
<td>218730</td>
<td>61689</td>
<td>28.20</td>
</tr>
<tr>
<td>Eighth Plan</td>
<td>434100</td>
<td>115561</td>
<td>26.62</td>
</tr>
<tr>
<td>Ninth Plan</td>
<td>941041</td>
<td>219243</td>
<td>23.30</td>
</tr>
<tr>
<td>Tenth Plan (outlay)</td>
<td>1525639</td>
<td>403927</td>
<td>26.48</td>
</tr>
</tbody>
</table>


The table reveals that more and more amount has been spent for the development of energy sector which was always more than 25 percent of total plan expenditure.17

1.7 National Energy Policy and Energy Conservation:

The first step towards the formulation of national energy policy was taken by government of India in 1963. The 'Energy Survey Committee of India' was appointed to study the present and prospective demand and supplies of energy and to provide the
government of India the basic material for development and planning in the field of energy till 1981.

The second attempt for energy policy formulation was made by government of India, twelve year later, by setting up a 'fuel policy committee in 1970, the report was submitted in May 1972 and resubmitted in a revised form (in the wake of crude oil price hike 1973) on August 22, 1974. The committee had recommended that energy conservation efforts should be encouraged. It further recommended the establishment of 'National fuel efficiency service' which can ensure the choice of fuel to each industry with regard to technical and national interest.

In 1979, the position was reviewed by another expert group. 'The working Group on Energy Policy' followed by the 'Advisory Board on Energy' in 1985, which also stressed for energy conservation.

However, all these efforts could not result in any definite plan for energy conservation. With the establishment of the 'Petroleum Conservation Research Association (PCRA)' in 1976, the first organized efforts was made to bring about efficiency in use of petroleum products.

1.8 Energy Conservation Potential:

A comprehensive study of the potentialities of energy conservation was made in 1981 by the 'Inter-Ministerial Working Group on the Utilization and Conservation of Energy' headed by Shri. D.V. Kapoor. One of the important findings of the committee was that there shall be a scope for effecting savings in energy consumption of
the order of 20 per cent, 25 per cent, 30 per cent in Transport, Industrial and Agricultural Sectors respectively. The committees another important finding was that an investment of Rs. 5140 crores in energy conservation measures would obviate an investment of Rs. 7980 crores for creation of additional capacity for energy production / generation which would be required if energy conservation measures are not adopted. On the other hand, the value of energy saved through energy conservation measures would be around Rs. 3100 crores/per year.

1.9 Role of Consumers in Energy Conservation:

The grab of any energy conservation program can not be achieved without the co-operation of consumers. In order to achieve this a nation wide publicity campaign through mass media like news papers, radio, television is being launched by government and petroleum conservation research association.

Consumers response towards this seems to be very poor. Therefore, it is necessary to undertake a study to find out the causes of this low or dismal picture and find out reasons and suggest remedies for the conservation of energy as a resource of development.

1.10 Energy Conservation in Household Sector:

Potential for energy saving in domestic sector has not been worked out so far. A few studies have concluded that the bulk of energy is consumed in the domestic sector in our country through appliances of very low efficiency and there is considerable scope for
energy conservation by improving the efficiency of domestic appliances.\textsuperscript{19}

\textbf{1.11 Energy Conservation in Transport Sector:}

A wide variety of transport is used to move men and materials in India. This ranges from bullock carts to the air buses. The different modes of transport vary widely in their performance characteristics, energy consumption, investment need etc. The consumption of energy by transport sector is accounted as much as one third (22 Million tonnes of Oil Equivalent (MTOE)) of the country’s total commercial energy consumption and about 56 per cent of its oil consumption. According to the Inter-ministerial working group on the utilization and conservation of commercial energy, there is an energy conservation potential of 20 per cent in the transport sector which can be achieved by an investment of Rs. 890 crores. The conservation measures would yield an annual saving of Rs. 765 crores on one hand and avoid an investment of Rs. 432 crores for creating additional energy capacity on the other.\textsuperscript{20}

\textbf{1.12 Energy Conservation in Industrial Sector:}

Industrial sector plays a crucial role in the economic development of the state. The share of manufacturing sector in the Gross Domestic Product (GDP) of the state is about 20 per cent and the corresponding share at All India level is about 14 per cent, which reflects the high level of industrialization of the state.\textsuperscript{21}
In the industrial sector, Maharashtra is one of the advanced state in the country. Industrially Parbhani district is however an under developed district in the state.

Due to direct linkage with railways, the district is gradually contributing in the development of industries. Parbhani comprises a pre-dominance of agricultural population.

In case of industrial sector PCRA has conducted studies of 1460 industrial units with consumption of 3.2 million kilo-liters of fuel oil. A saving of 0.3 million kilo liters of fuel oil work than Rs. 100 crores annually has been achieved out of a total identified saving potential of 0.36 kilo litres of petroleum fuel consumption of industrial sector.22

1.13 Energy Conservation Act 2001:

The Energy Conservation Act, 2001, came into force with effect from March 2002. This act provides the necessary legal and institutional framework to enable the government to rapidly promote efficient use of energy and its conservation in different sectors of the economy. The Ministry of Power has also created under this Act, a central coordinating body called the Bureau of Energy Efficiency, which is responsible for promoting energy saving measures. The Ministry of Power and the Bureau of Energy Efficiency have adopted self regulation and market based mechanisms for promoting efficient use of energy instead of resorting to a command and control system.

The Bureau of Energy Efficiency has taken the initiative to coordinate the Indian Industry Programme for Energy Conservation to
assist the Indian Industry in improving competitiveness through improved energy efficiency as well as for enabling it to meet mandatory provisions of the Energy Conservation Act.

Further to the six sectoral task forces that were formed last year for sharing information and best practices (task forces have been formed under the Indian Industry Programme for Energy Conservation to support designated consumers in cement, pulp and paper, textile, fertilizer, chlor-alkali, and aluminium sectors), one or two meetings have also been held for each sector this year. The activity has been further extended and a combined Task Force for Petrochemicals and Refinery sector has been formed. Each task force is headed by a task force leader from the industry who provides the overall direction to the programme.

The Bureau of Energy Efficiency executes the National Energy Conservation Awards scheme of the Ministry of Power to motivate and reorganize the industrial units who have taken extra efforts to reduce energy intensities while maintaining the production levels. In Energy Conservation award, 2004, 297 participating units saved 7630 million rupees per year against an investment of 13640 million rupees on account of implementation of various energy conservation projects. Electricity savings achieved by the participating industrial units resulted in savings in avoided capacity equivalent to 155 MW. Savings of 615 MW of electric power, as equivalent avoided capacity, have been achieved cumulatively by the participating industrial units during 1999-2004 through the National Energy Conservation Award schemes.23
Petroleum Conservation Research Association:

The first organized effort on conservation was made with the establishment of the Petroleum Conservation Research Association (PCRA) in 1976 to bring about efficiency in use of petroleum products.

The services rendered by this organization is free of charge and include diagnostic surveys, training programmes, seminars, symposia, development and dissemination of publicity material, preparation of audio-visual aids etc; since 1982.

PCRA prepared a definite plan for energy conservation in various sectors. A high degree of awareness about the need and scope of energy conservation is created both among all categories of users of energy.

With the help of mass media, seminars, workshop, exhibitions and also through publication of studies based on the actual experience of those who have already been benefited by introducing energy conservation method.

PCRA has so far surveyed about 1400 industrial units consuming fuel oil and succeeded in effecting annual savings of about 3 lakh kiloliters of petroleum fuel costing around Rs. 100 crores.24

To offer in the initial stages, free energy auditing and energy counselling services to selected groups of users of power and coal, as is being done by the PCRA in the field of oil (Petroleum).
1.15 National Productivity Council:

The National Productivity Council established in 1958, is an autonomous organization registered as a society. It is tripartite in its constitution and representatives of government, employer and workers and various professional bodies participate in its working. National Productivity Council operates through nine regional directorates and two-regional offices.

The objective of National Productivity Council (NPC) is to stimulate productivity consciousness in the country and to provide productivity services with a view to maximize the utilization of available resources of men, machines, materials and power, to wage a war against waste, and to help the people of the country for a better and higher standard of living.

National Productivity Council (NPC) has established various other specialized services, such as fuel efficiency services, plant engineering and production engineering services; productivity service for public sector undertaking, public utilities, public administration, post-harvest operations in agriculture and small industries; applied productivity research for evolving trends and indices of productivity in the core sectors of economy.25

The National Productivity Council (NPC) has also been active in the field and has studied energy audit report of 200 industrial units. According to these studies the annual energy consumption in industries in 1983 was of the order of Rs. 7700 crores of which around
25 percent or over Rs. 1990 crores could be saved through a one time investment of Rs. 3600 crores.26

In 1985 National Productivity Council, carried out a study of 178 units in 12 sectors covered under Inter Ministerial Working Group (IMWG) studies reveal that 70 units (40 percent) have implemented energy conservation programmes successfully, while, 29 units (16 percent) are yet to start energy conservation programmes. The pace of implementation has generally been slow and the energy saving achieved are Rs. 10.2 crores per annum against a potential of Rs. 83 crores indicating that 12.3 percent of the saving potential has been achieved in these units.27

Certain private sector industries like Tata, Hindustan Liver and Nocil have also initiated energy conservation measures in their plants and achieved impressive results.

1.16 Government Initiatives for Energy Conservation:

1963 Fuel efficiency service of National Productivity Council setup to provide training and consultancy to Indian industries.


1974 Fuel policy committee report.

1976 Petroleum conservation efforts institutionalized by setting up petroleum conservation action group, later known as Petroleum Conservation Research Association.


1982 Setting up of the department of non-conventional energy sources (DNES).

1983 Setting up of Advisory Board of Energy (ABE)

1984 Department of Power Identified as Nodal Agency for Energy Conservation.

1987 Adviser (Energy conservation) Office setup.


**Fiscal Measures:**

1982 PCRA Boiler Modernization Scheme.

1983 100 per cent depreciation for notified energy conservation equipment

1985 Customs duty reduction for fuel efficient vehicles.

1988 Customs duty reduced for notified energy conservation equipment device.

1988 Energy audit subsidy scheme.

1988 Energy conservation equipment finance scheme.

1.17 **Importance and Need of the Study:**

As stated in the earlier pages the reserves of energy resources are limited in India and world. Hence, a judicious use of these resources becomes the need of hour. Planners at National Level and
researcher are stretching their hand for initiation of energy conservation efforts. Theoretically all the energy users recognize the need of energy conservation. But in practical it is broadly observed that there is negative response in this regard. It may be due to increasing income, technical problems, lack of guidance and consultations ignorance towards the seriousness of the problem with may be routines habits.

Therefore, an attempt is made to focus on the awareness and response to energy conservation attempts in the surrounding area i.e. in urban area of Parbhani District in coming chapter.
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15. Ibid, pp. 80, 83
16. Ibid, p. 114
26. Ibid, p.11