Module – I : **Basic Introduction to Energy:**

Introduction

Energy is involved in all life cycles, and it is essential in agriculture as much as in all other productive activities. An elementary food chain already shows the need for energy: crops need energy From solar radiation to grow, harvesting needs energy from the human body in work, and cooking needs energy from biomass in a fire. The food, in its turn, provides the human body with energy.

Intensifying food production for higher output per hectare, and any other advancement in agricultural production, imply additional operations which all require energy. For instance: land preparation and cultivation, fertilizing, irrigation, transport, and processing of crops. In order to support these operations, tools and equipment are used, the production of which also requires energy (in sawmills, metallurgical processes, workshops and factories, etc.).

Major changes in agriculture, like mechanization and what is called the "green revolution", imply major changes with respect to energy. Mechanization means a change of energy sources, and often a net increase of the use of energy. The green revolution has provided us with high yield varieties. But these could also be called low residue varieties (i.e. per unit of crop). And it is exactly the residue which matters as an energy source for large groups of rural populations.

Other sectors of rural life require energy as well. The provision of shelter, space heating, water lifting, and the construction of roads, schools and hospitals, are examples. Furthermore, social life needs energy for lighting, entertainment, communication, etc. We observe that development often implies additional energy, and also different forms of energy, like electricity.

Energy is a scarce resource, at least for some groups of people in some places and, maybe, for the world as a whole. A rational use of energy is then necessary for economic and environmental reasons. This applies to agriculture as much as to any other sector of the economy. A key to the rational use of energy is the understanding of the role of energy. The following sections aim to help understand energy in agriculture and rural development. It should help communication between agricultural planners and energy specialists. Anyone familiar with energy concepts should skip this chapter and read immediately

What is Energy?

Energy is the ability to perform work. Energy can neither be created nor destroyed. It can only be transformed from one kind to another. The unit of Energy is same as of Work i.e. Joules. Energy is found in many things and thus there are different types of energy. **Energy** is also defined as the ability to produce change or do work,

All forms of energy are either kinetic or potential. The energy in motion is known as **Kinetic Energy** whereas **Potential Energy** is the energy stored in an object and is measured by the amount of work done. Some other types of energy are Mechanical, Mechanical wave, Chemical, Electric, Magnetic, Radiant, Nuclear, Ionization, Elastic, solar, Gravitational, Rest, Thermal, and Heat Energy.

What is Power?

Power is the rate of doing work. It is the amount of energy consumed per unit time.

P=W/ t

Where,
P = Power
W = Work done
T = Time taken

As powers don't have any direction, it is a scalar quantity. The SI unit of power is **Joules per Second (J/s)**, which is termed as **Watt**. The unit Watt is dedicated in honour of So James Watt, the developer of the steam engine.

Difference between Energy and Power

Sl.no	Energy	Power
1.	Energy is defined as the capacity to do some work. It is power which is integrated over time.	Power is defined as the rate at which a specific work is done, or which the energy is transmitted.
2.	The unit used to measure energy is joules or watt-seconds	The unit used to measure this is watt or joules per second
3.	'W' is the symbol which denotes energy	The symbol used to denote power is P.
4.	Energy changes from one form to another	Power cannot be transformed from one type to another
5.	Energy is a time quantity or component	It is an instantaneous quantity
6.	Various types of energy are kinetic, thermal, potential, gravitational, sound, electromagnetic, light, elastic, etc	Different kinds of power are electric power, optical power, human power, etc.
7.	Energy is known to be stored which can be used in future	Power quantity is not storable or cannot be stored
8.	energy is used in moving a car, heating home, lighting night, flying an aeroplane, etc	Power finds its uses in mechanical applications, electrical applications,heat applications, etc

Forms of Energy :

Energy exists in many different forms. Examples of these are : Mechanical Energy : kinetic energy and potential energy. Thermal Energy, Chemical Energy, Radiant Energy, Nuclear Energy, Electrical Energy.

✓ Mechanical Energy

Mechanical energy is energy stored in objects and is the sum of two other energy sources: kinetic energy and potential energy.

- **Kinetic energy** is motion. The faster an object moves, the higher its kinetic energy. The energy of rivers (hydraulic energy) and of the wind (wind energy) is a form of kinetic energy. This energy can be converted into mechanical energy by water mills, windmills or pumps connected to turbines or into electricity when it drives a generator.

- . **Potential Energy** is stored energy. This energy of because of its position. Examples of potential energy are oil sitting in a barrel, or water in a lake in the mountains. This energy is referred to as potential energy, because if it were released, it would do a lot of work.

✓ Thermal Energy

Thermal energy is simply heat. It is caused by the movement of molecules and atoms within substances. Thermal energy therefore represents an object's internal kinetic energy. In a steam engine or turbine, it is converted into mechanical energy; in a thermal power plant, it is converted into electricity. Thermal energy contained in the subsurface (geothermal energy) can be used for heating or to generate power.

✓ Chemical Energy

Chemical energy is energy stored in the bonds of atoms and molecules. Some chemical reactions, known as exothermic reactions, can break these bonds to release their energy. During combustion, which is an exothermic reaction, oil, gas, coal and biomass convert their chemical energy into heat — and often light. In batteries, the electrochemical reactions that occur produce electricity.

✓ Radiant Energy

Radiant energy is energy carried by radiation. Both visible light and infrared radiation are forms of radiant energy. Both are emitted by the Sun and the filaments in electric light bulbs. The energy of the Sun’s rays can be recovered and converted into electricity (photovoltaic solar energy) or heat (solar thermal power).

- ✓ **Nuclear Energy**

Nuclear energy is energy stored in the center of atoms, more specifically in the bonds between the particles (protons and neutrons) that make up the nucleus of an atom. When atomic nuclei are converted by nuclear reaction, heat is released. In nuclear power plants, the uranium nuclei are split in a process known as fission and some of the heat released is converted into electricity. In stars like the Sun, atomic energy is released when the nuclei combine in a process known as fusion.

- ✓ Electrical Energy

Electrical energy is the energy transferred from one system to another (or stored, in the case of electrostatic energy) using electricity, which is the movement of charged particles. To be precise, electricity is an energy carrier rather than a type of energy in itself, but the term "electrical energy" is commonly used in everyday speech. Alternators and batteries are examples of systems that can provide electricity, while resistors, light bulbs and electric motors are examples of systems that receive electricity.

Sources of Energy

People have always used energy to do work for them. Thousands of years ago, early humans burned wood to provide light, heat their living spaces, and cook their food. Later, people used the wind to move their boats from place to place. A hundred years ago, people began using falling water to make electricity. Today, people use more energy than ever from a variety of sources for a multitude of tasks and our lives are undoubtedly better for it. Our homes are comfortable and full of useful and entertaining electrical devices. We communicate instantaneously in many ways. We live longer, healthier lives. We travel the world, or at least see it on television and the internet. Energy is one of the major inputs for the economic development of any country. In the case of the developing countries, the energy sector assumes a critical importance in view of the ever-increasing energy needs requiring huge investments to meet them.

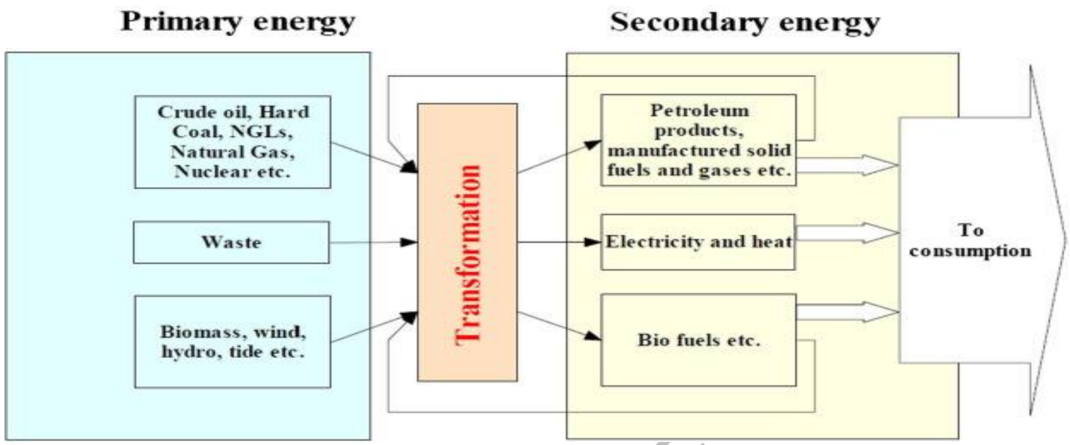
Energy can be classified into several types based on the following criteria:

1. Primary and Secondary energy
2. Commercial and Non commercial energy
3. Renewable and Non-Renewable energy

1. Primary and Secondary Energy

Primary energy sources are those that are either found or stored in nature. 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 earth's gravity.

Primary energy sources are mostly converted in industrial utilities into **secondary energy sources**; for example coal, oil or gas converted into steam and electricity. Primary energy can also be used directly. Some energy sources have non-energy uses, for example coal or natural gas can be used as a feedstock in fertilizer plants.



2. Commercial Energy and Non Commercial Energy

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. Commercial energy forms the basis of industrial, agricultural, transport and commercial development in the modern world. In the industrialized countries, commercialized fuels are predominant source not only for economic production, but also for many household tasks of general population.
Examples: Electricity, lignite, coal, oil, natural gas etc.

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 used especially in rural households. These are also called traditional fuels. Non-commercial energy is often ignored in energy accounting.

Example: Firewood, agro waste in rural areas; solar energy for water heating, electricity generation, for drying grain, fish and fruits; animal power for transport, threshing, lifting water for irrigation, crushing sugarcane; wind energy for lifting water and electricity generation.

3. Renewable and Non-Renewable Energy

Renewable Energy

Renewable energy is energy obtained from sources that are essentially inexhaustible. Examples of renewable resources include wind power, solar power, geothermal energy, tidal power and hydroelectric power. The most important feature of renewable energy is that it can be harnessed without the release of harmful pollutants.

Renewable energy sources include biomass, geothermal, hydropower, solar, and wind. They are called renewable energy sources because their supplies are replenished in a short time. Day after day, the sun shines, the wind blows, and the rivers flow. We use renewable energy sources mainly to make electricity.

Is electricity a renewable or nonrenewable source of energy? The answer is neither. Electricity is different from the other energy sources because it is a **secondary source of energy**. That means we have to use another energy source to make it. In the United States, coal is the number one fuel for generating electricity.

Non-Renewable Energy

Non-renewable energy is the conventional fossil fuels such as coal, oil and gas, which are likely to deplete with time. **Nonrenewable** energy sources include coal, petroleum, natural gas, propane, and uranium. They are used to generate electricity, to heat our homes, to move our cars, and to manufacture products from candy bars to cell phones. These energy sources are called nonrenewable because they cannot be replenished in a short period of time. Petroleum, a fossil fuel, for example, was formed hundreds of millions of years ago, before dinosaurs existed. It was formed from the remains of ancient sea life, so it cannot be made quickly. We could run out of economically recoverable nonrenewable resources some day.

Energy flow

As we have seen, generating and utilizing energy means converting energy from one form into another. Often, intermediate steps are implied. The energy flows through a number of forms, as well as conversion steps, between the source and the end-use. The costs increase accordingly. We distinguish between primary, secondary, final and useful energy.

An example is an energy flow which is related to charcoal. Here, the primary energy form is wood. The wood is converted into charcoal in a charcoal kiln. Charcoal is the secondary form of energy, and it is transported to the consumer. What the consumer buys at the market place is charcoal, and this is called final energy. The consumer eventually converts the charcoal into heat for cooking. The heat is the useful energy.

Another example of an energy flow is: primary energy in the form of a hydro resource, secondary energy in the form of electricity at the hydro power station, final energy in the form of electricity at a saw mill, and useful energy in the form of shaft power for sawing.

ENERGY	TECHNOLOGY	EXAMPLES
primary		coal, wood, hydro, dung, oil, etc.
	conversion	power plant, kiln, refinery, digester
secondary		refined oil, electricity, biogas
	transport/transmission	trucks, pipes, wires
final		diesel oil, charcoal, electricity, biogas
	conversion	motors, heaters, stoves
useful		shaft power, heat

Energy flow is represented In the above diagram.

Primary energy is the energy as it is available in the natural environment, i.e. the primary source of energy.

Secondary energy is the energy ready for transport or transmission.

Final energy is the energy which the consumer buys or receives.

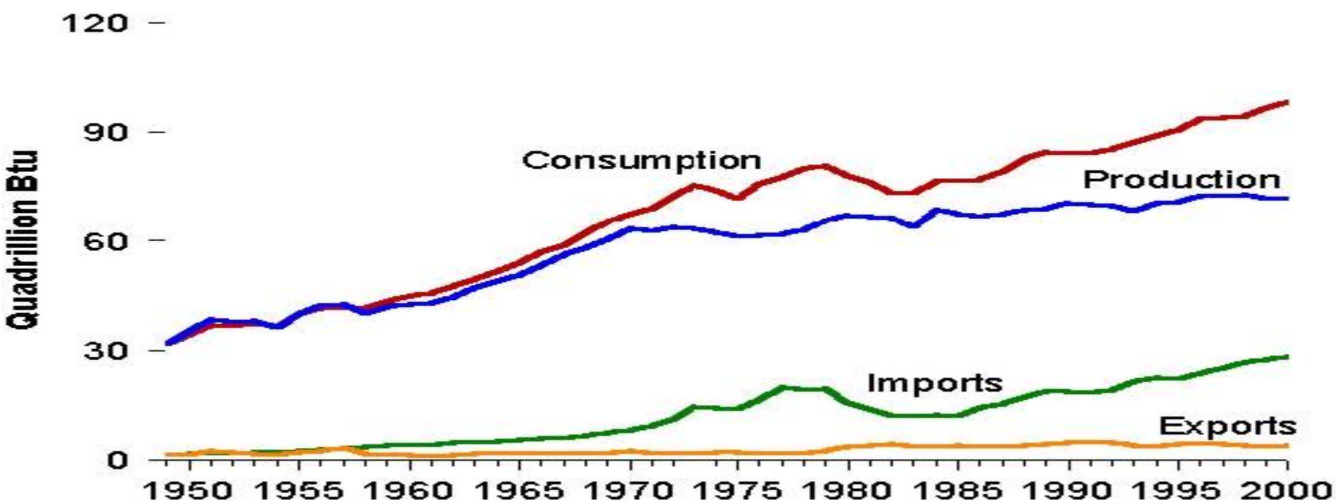
Useful energy is the energy which is an input in an end-use application.

Note that useful energy is almost invariably either in the form of heat or in the form of shaft power. For a few end-uses (e.g. communication equipment), electricity is the form of useful energy. in some cases the primary energy is at the same time the secondary, and even the final energy (c.f. wood gathered for cooking purposes, or animate power for pulling).

The breakdown of primary to useful energy is relevant, because with each conversion step some energy is lost. In order to reduce costs and avoid unnecessary losses, we will always aim at eliminating unnecessary steps in the flow of energy. Furthermore, the breakdown of energy flows is relevant for surveys and statistics. We may not simply add primary energy with, say, and final energy

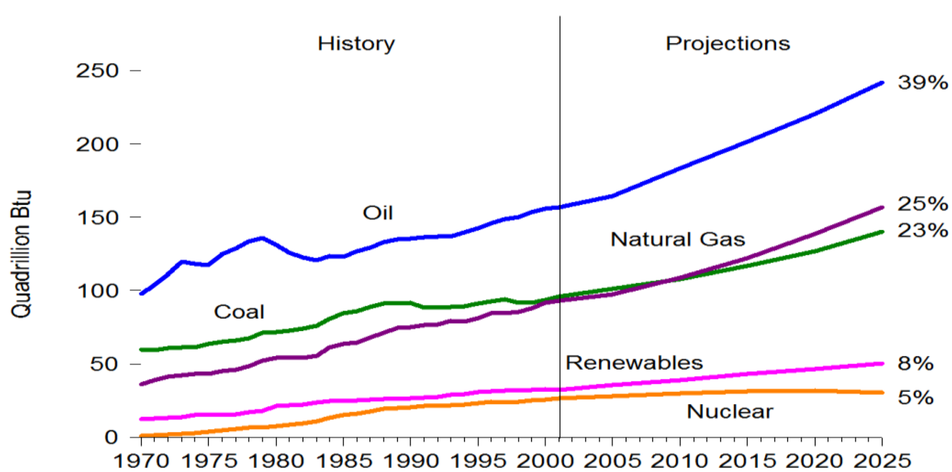
World-wide Energy production and Consumption

The success of an industrial society i.e., the growth of its economy, the quality of the life-style of the population and the society's impact on the environment, is a function of the quantities and types of energy resources it exploits and the efficiency with which it converts potential energy into work and heat. Increasing energy consumption closely matches societal modernization.



Until about 1958, the U.S. was largely self-sufficient in terms of energy, producing almost all the energy needed for consumption. However since that time, the gap between domestic production and consumption has continually widened as shown in Figure.

World Primary Energy Consumption by Fuel Type, 1970-2025



Oil continues to be the dominant energy source. Oil's share of world energy remains unchanged at 39% over the forecast period. Natural gas grows most rapidly over the projection period, capturing 25% of the world's energy use by 2025, up from 23% in 2001.

- In the industrialized world, increases in oil use are projected primarily in the transportation sector, where there are currently no available fuels to compete significantly with oil. In the developing world, demand for oil increases for all end uses, as countries replace non-marketed fuels used for home heating and cooking, with diesel generators and for industrial petroleum feedstock's.
- Natural gas is projected to maintain average annual growth of 2.2 percent over the forecast period, capturing 25 percent of the world's energy use by 2025. Gas is seen as a desirable option for electricity, given its efficiency relative to other energy sources and the fact that it burns more cleanly than either coal or oil, making it a more attractive choice for countries intent upon reducing greenhouse gas emissions.
- Coal remains an important fuel in the world's electricity markets and is expected to continue to dominate fuel markets in developing Asia. Coal's share of world energy consumption declines slightly in the *IEO2004* reference case, from 24 percent in 2001 to 23 percent in 2025. Coal use is projected to increase in all regions of the world except for Western Europe and the EE/FSU (excluding Russia), where coal is projected to be displaced by natural gas and, in the case of France, nuclear power for electric power generation.
- The highest growth in nuclear generation is expected for the developing world, where consumption of electricity from nuclear power is projected to increase by 4.1 percent per year between 2001 and 2025. Developing Asia, in particular, is expected to see the largest increment in installed nuclear generating capacity over the forecast, accounting for 95 percent of the total increase in nuclear power capacity for the developing world as a whole. In the industrialized world and the EE/FSU, extensions of operating licenses (or the equivalent) slow the decline in nuclear generation.
- Consumption of electricity from hydropower and other renewable energy sources is expected to grow by 1.9 percent per year over the projection period. Much of the growth in renewable energy use is expected to result from large-scale hydroelectric power projects in the developing world, particularly among the nations of developing Asia. China, India, Malaysia, and Vietnam are already constructing or have plans to construct ambitious hydroelectric projects in the coming decades.

- **<u>Energy Distribution between Developed and Developing Countries</u>**

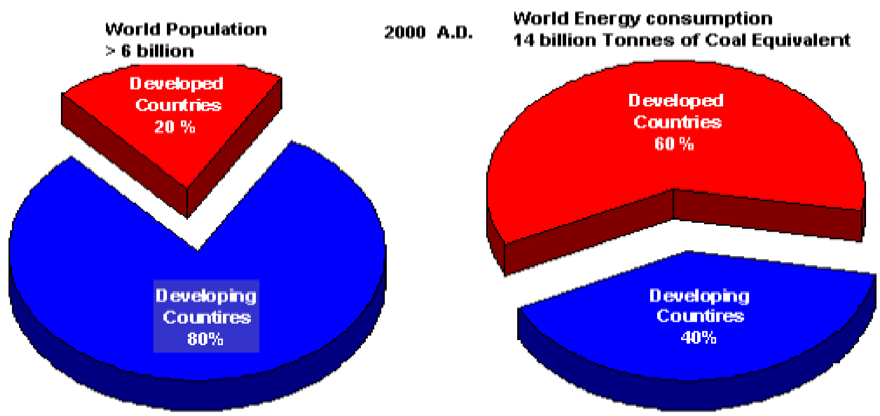


Figure: Energy Distribution Between Developed and Developing Countries

- Although 80 percent of the world's population lies in the developing countries (a fourfold population increase in the past 25 years), their energy consumption amounts to only 40 percent of the world total energy consumption. The high standards of living in the developed countries are attributable to high-energy consumption levels. Also, the rapid population growth in the developing countries has kept the per capita energy consumption low compared with that of highly industrialized developed countries.

- The world average energy consumption per person is equivalent to 2.2 tonnes of coal. In industrialized countries, people use four to five times more than the world average, and nine times more than the average for the developing countries. An American uses 32 times more commercial energy than an Indian.

<u>ENERGY IN INDIA TODAY</u>

India is in the midst of a profound transformation that is moving the country to centre stage in many areas of global interaction. A vibrant democracy that is home to over one-sixth of the world's population and its third-largest economy, India's modernisation has been gathering speed and new policies have been introduced to unleash further growth. Theopportunities are huge, but so is the size of the remaining challenges: although incomes and corresponding standards of living are on the rise, India is still home to a third of the world's poor and gross domestic product (GDP) per capita is well below the international average.

India's energy sector has grown tremendously in recent years. Further economic and population growth, allied to structural trends such as urbanisation and the nature of the envisioned industrialisation, point unmistakeably to a trend of continued rapid expansion in demand for energy. Recognising this challenge, Indian policy-makers are making strenuous efforts to remove obstacles to investment in energy supply, while moving ahead with complementary policies on efficiency and energy pricing that can constrain growth in consumption. The analysis and findings in this special focus on India disclose these multiple pressures and show how policies can affect the evolution of the Indian energy sector so as to realise the huge benefits that a well-managed expansion of energy provision will bring. No effort is made here to prescribe a path for India; our intention is, rather, to provide a coherent framework to contribute to the policy choices that India itself will make, drawing out the possible implications of these choices for India's development, energy security and environment, as well as for the global energy system.

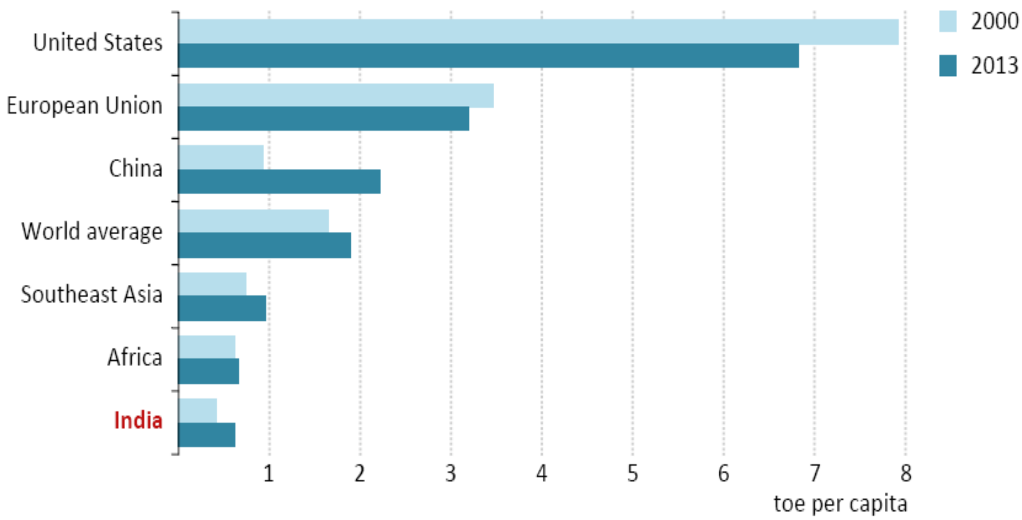
KEY ENERGY TRENDS IN INDIA

Energy is an essential building block of economic development. In an effort to meet the demands of a developing nation, the Indian energy sector has witnessed a rapid growth. Areas like the resource exploration and exploitation, capacity additions, and energy sector reforms have been revolutionized.

However, resource augmentation and growth in energy supply have failed to meet the ever increasing demands exerted by the multiplying population, rapid urbanization and progressing economy. Hence, serious energy shortages continue to plague India, forcing it to rely heavily on imports.

Demand

India has been responsible for almost 10% of the increase in global energy demand since 2000. Its energy demand in this period has almost doubled, pushing the country's share in global demand up to 5.7% in 2013 from 4.4% at the beginning of the century. Expressed on a per-capita basis, energy demand in India has grown by a more modest 46% since 2000 and remains only around one-third of the world average as shown below.



Note: toe = tonnes of oil equivalent.

Figure: Per-capita energy consumption in India and selected regions

Almost three-quarters of Indian energy demand is met by fossil fuels, a share that has increased since 2000 because of a rapid rise in coal consumption. Coal now accounts for 44% of the primary energy mix. The availability and affordability of coal relative to other fossil fuels has contributed to its rise, especially in the power sector.

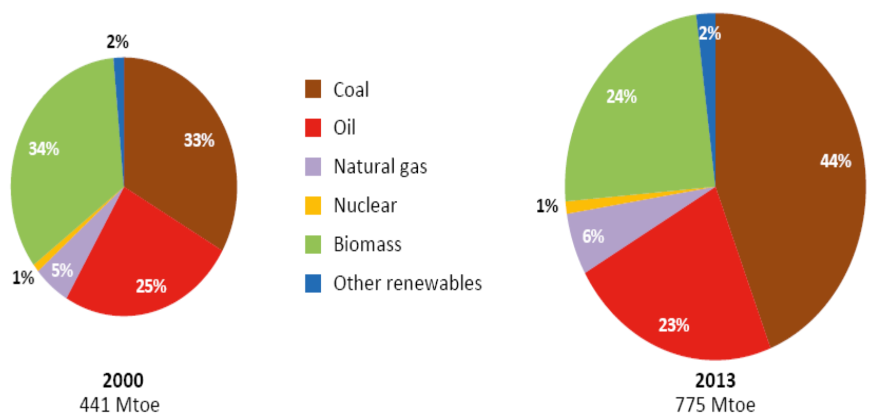
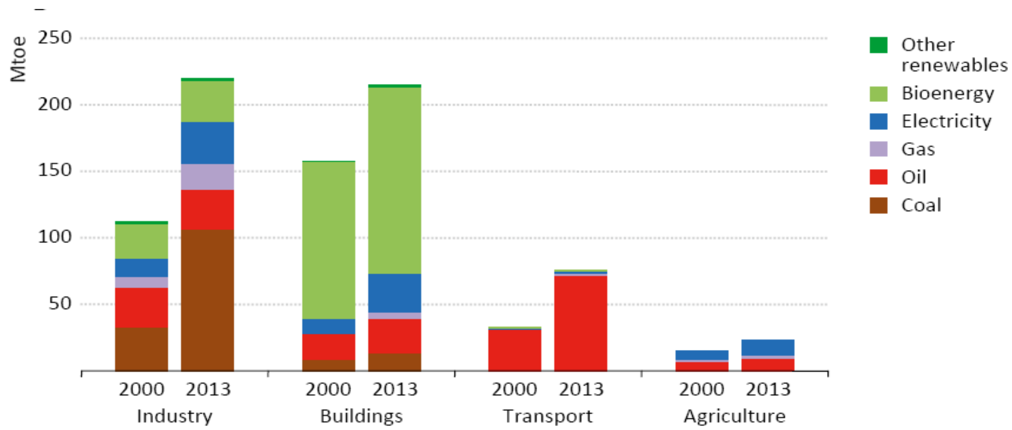


Figure : Primary energy demand in India by fuel

Oil consumption in 2014 stood at 3.8 million barrels per day (mb/d), 40% of which is used in the transportation sector. Natural gas makes up a relatively small share of the energy mix (6% in 2013 compared with 21% globally). Hydropower, nuclear and modern renewables (solar, wind and geothermal) are used predominantly in the power sector but play a relatively small role in the total energy mix.



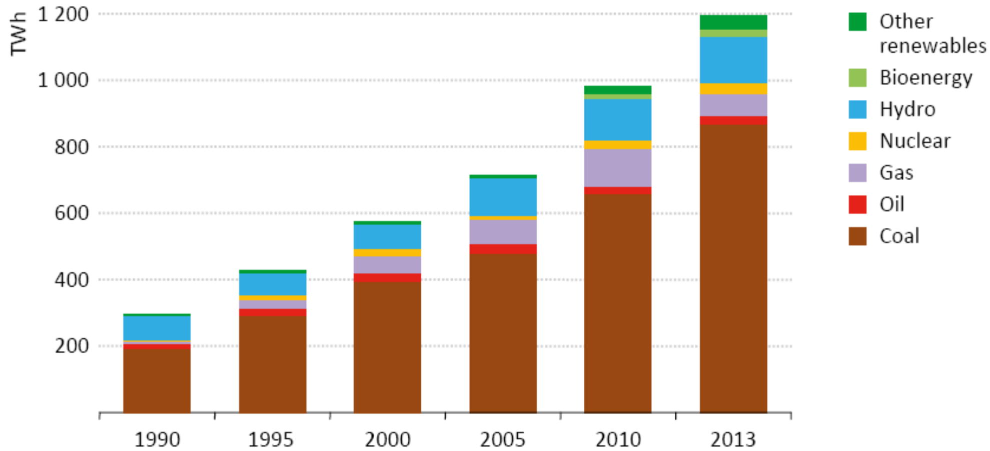
Notes: Other renewables includes solar photovoltaics (PV) and wind. Industry includes energy demand from blast furnaces, coke ovens and petrochemical feedstocks.

Figure: Energy demand by fuel in selected end-use sectors in India

Energy demand had traditionally been dominated by the buildings sector (which includes residential and services). In the buildings sector, a key driver of consumption in both rural and urban areas has been raising levels of use of appliances. As a result, electricity demand in the buildings sector grew at an average rate of 8% per year over 2000-2013 as shown.

Electricity

The country's electricity demand in 2013 was 897 terawatt-hours (TWh), up from 376 TWh in 2000, having risen over this period at an average annual rate of 6.9%. Electricity now constitutes some 15% of final energy consumption since 2000. The situation varies from state to state, but higher tariffs paid by commercial and industrial consumers are typically not enough to offset the losses arising from subsidies to residential and agricultural consumers, despite efforts to raise retail rates in recent years. On the supply side, India has some 290 gigawatt (GW) of power generation capacity, of which coal (60%) makes up by far the largest share, followed by hydropower (15%) and natural gas (8%). The mix has become gradually morediverse: since 2000, almost 40% of the change in installed capacity was non-coal. This is reflected also in the figures for generation, which show how renewables are playing an increasingly important role.



Note: Other renewables includes solar PV and wind.

Figure: Total electricity generation in India by fuel

Access to modern energy

India has made great strides in improving access to modern energy in recent years. Since 2000, India has more than halved the number of people without access to electricity and doubled rural electrification rates. Nonetheless, around 240 million people, or 20% of the population, remain without access to electricity. The electrification rates are already well above 90%. Of the total without access, the large majority live in rural areas where extending access is a greater technical and economic challenge. In urban areas, electrification rates are much higher, but the quality of service remains very uneven.

India's rural electrification programme, the Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY), was launched in 2005 and aimed to provide electricity to villages of 100 inhabitants or more and free electricity to people below the poverty line. The effective implementation of RGGVY has faced several challenges and there are strong variations in outcomes between states.

In July 2015, RGGVY was subsumed within a new scheme, the Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY). The main components of this scheme are the separation of distribution networks between agricultural and non-agricultural consumers to reduce load shedding, strengthening local transmission and distribution infrastructure, and metering. Aside from those without electricity, India also has the largest population in the world relying on the traditional use of solid biomass for cooking. The government has made a major effort to address its pollution issues, primarily through the subsidised availability of LPG as an alternative cooking fuel.

Energy production and trade

Fossil fuels supply around three-quarters of India's primary energy demand and, in the absence of a very strong policy push in favor of alternative fuels, this share will tend to increase over time as households move away from the traditional use of biomass. This high – and potentially growing – reliance on fossil fuels comes with two major drawbacks. India's domestic production of fossil fuels, considered on a per-capita basis, is by far the lowest among the major emerging economies meaning that India has a structural dependence on imported supply. In addition, combustion of coal and oil products contributes to pressing air quality problems in many areas, as well as to global greenhouse gas (GHG) emissions.

Coal

India has the third-largest hard coal reserves in the world (roughly 12% of the world total), as well as significant deposits of lignite. Yet the deposits are generally of low quality and India faces major obstacles to the development of its coal resources. In 2013, India produced almost 340 million tonnes of coal equivalent (Mtce), but it also imported some 140 Mtce. Around 7% of national production comes from captive mining, i.e. large coal-consuming companies that mine for their own use. At present, more than 90%of coal in India is produced by open cast mining.

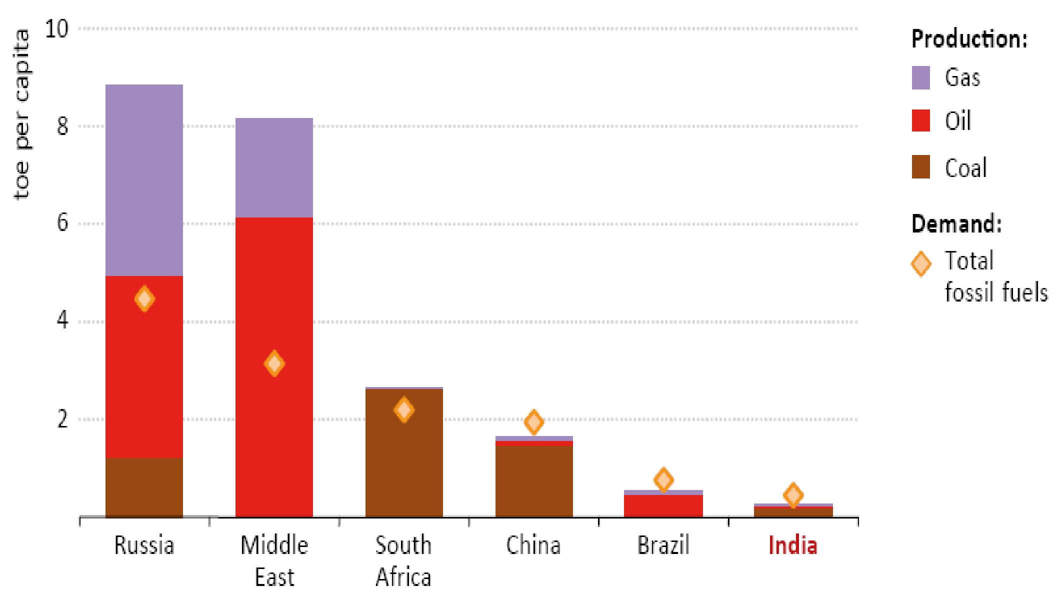
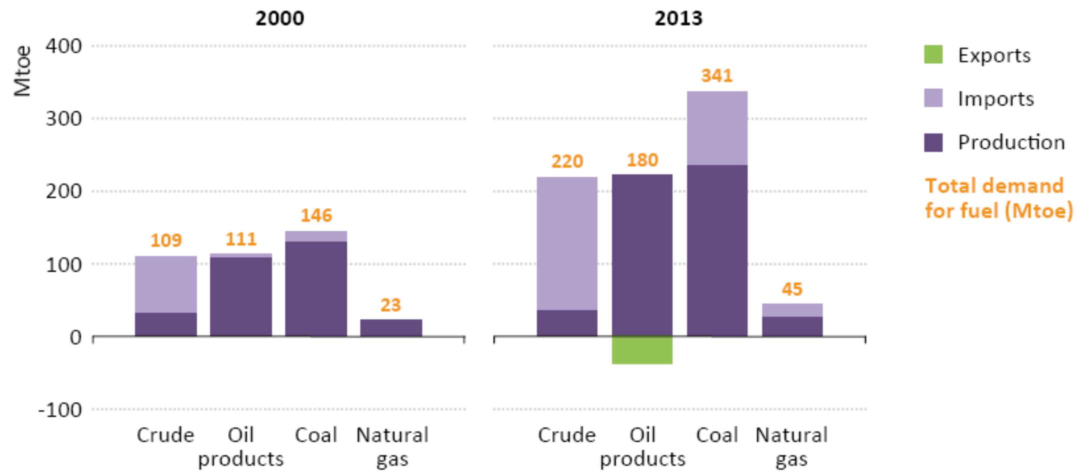


Figure Fossil-fuel production and demand per capita by selected countries, 2013



Note: Demand for crude oil shows refinery intake.

Fig. Fossil-fuel balance in India

oil and Oil Products

India is one of the few countries in the world that rely on imports of crude oil while also being significant net exporters of refined products. India has relatively modest oil resources and most of the proven reserves (around 5.7 billion barrels) are located in the western part of the country, notably in Rajasthan and in offshore areas near Gujarat and Maharashtra. Most of the remaining production comes from joint ventures with the national oil and gas companies and from blocks awarded under successive licensing. India has almost doubled its refining capacity in the last ten years and has added more than 2 mb/d of new capacity since 2005, with strong private sector participation. With refinery output exceeding total demand by roughly 1 mb/d, India is a net exporter of all refined products except LPG.

Natural gas has a relatively small share (6%) of the domestic energy mix.Production of conventional gas reached 34 bcm in 2013 and was supplemented by LNG imports. The majority state-owned gas company,GAIL, is the largest player in the midstream and downstream gas market. In addition to conventional gas resources, India also has large unconventional potential, both from coalbed methane (CBM) and shale gas. Commercial production at scale is still some way off, although CBM activity is starting to gain momentum, with a number of private companies, including Reliance and Essar, stepping up their involvement. In the case of shale gas, the government approved in 2013 an exploration policy that allows the two national companies – ONGC and OIL – to drill for shale resources in their existing blocks

Hydropower India has significant scope to expand its use of hydropower: its current 45 GW of installed capacity (of which over 90% is large hydro) represents a little under a third of the assessed resource. A further 14 GW are under construction, although some of these plants have been delayed by technical or environmental problems and public opposition. If developed prudently, hydropower can bring multiple benefits as a flexible source of clean electricity, and also as a means of water management for flood control, irrigation and domestic uses. It can also enable variable renewables to make a greater contribution to the grid. However, its development has lagged well behind thermal generation capacity, leading to a consistent decline in its share of total electricity output.

Bioenergy

Bioenergy accounts for roughly a quarter of India's energy consumption, by far the largest share of which is the traditional use of biomass for cooking in households. This reliance gives rise to a number of problems, notably the adverse health effects of indoor air pollution. India is also deploying a range of more modern bioenergy applications, relying mainly on residues from its large agricultural sector. There was around 7 GW of power generation capacity fuelled by biomass in 2014, the largest share is based on bagasse (a by-product of sugarcane processing) and a smaller share is cogeneration based on other agricultural residues. The remainder produce electricity via a range of gasification technologies that use biomass to produce syngas, including small-scale thermal gasifiers that often support rural small businesses.

WIND AND SOLAR

India's energy mix as the government has put increasing emphasis on renewable energy, including grid-connected and off-grid systems. Wind power has made the fastest progress and provides the largest share of modern non-hydro renewable energy in power generation to date. India has the fifth-largest amount of installed wind power capacity in the world, with 23 GW in 2014, although investment has fluctuated with changes in subsidy policies at national and state level. Key supporting measures have included a generation-based financial incentive (a payment per unit of output, up to certain limits) and an accelerated depreciation provision

Solar power has played only a limited role in power generation thus far, with installed capacity reaching 3.7 GW in 2014, much of this added in the last five years. However, India began to put a much stronger emphasis on solar development with the launch in 2010 of the Jawaharlal Nehru National Solar Mission, the target of which was dramatically upgraded in 2014 to 100 GW of solar installations by 2022, 40 GW of rooftop solar photovoltaics (PV) and 60 GW of large- and medium-scale grid-connected PV projects (as part of a broader 175 GW target of installed renewable power capacity by 2022, excluding large hydropower).

Nuclear power

India has twenty-one operating nuclear reactors at seven sites, with a total installed capacity close to 6 GW. Another six nuclear power plants are under construction, which will add around 4 GW to the total. NPCIL supplied 35 TWh of India's electricity in 2013-14 from 5.3 GWe nuclear capacity, with overall capacity factor of 83% and availability of 88%. Some 410 reactor-years of operation had been achieved to December 2014. India's fuel situation, with shortage of fossil fuels, is driving the nuclear investment for electricity, and 25% nuclear contribution is the ambition for 2050, when 1094 GWe of base-load capacity is expected to be required. Almost as much investment in the grid system as in power plants is necessary.

Factors affecting India's energy development

The various factors that affect our country's energy development are

- Energy and Demographics
- Policy and Institutional Framework
- Energy Process and affordability
- Social and environmental aspects
- Investment

Economy and demographics

India's economy has grown at an average rate of 6.5% a year, second only to China among the large emerging economies, and two-and-a-half-times the global average. India alone has accounted for over 9% of the increase in global economic output since 1990. Despite this progress, income per capita is still low and a gap has emerged between India and its counterparts. Services sector has been the major driver of growth in India's economy, accounting for around 60% of the increase in GDP between 1990 and 2013. The services sector employs only around one-quarter of the labourforce. The agricultural sector, with less than 20% of GDP (compared withjust over 35% in 1990), continues to account for around half of totalemployment as shown below.

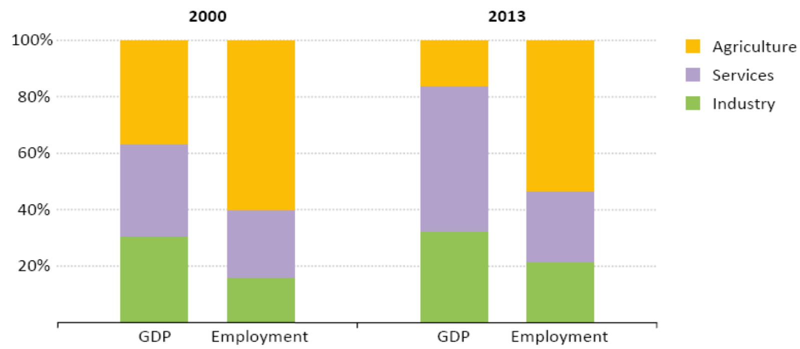


Figure : Composition of GDP and employment structure in India

The government has expressed its intention to re-balance the economy and announced the "Make in India" initiative, with an intention of increasing the share of manufacturing in GDP to 25% by 2022 and creating 100 million jobs in the process.

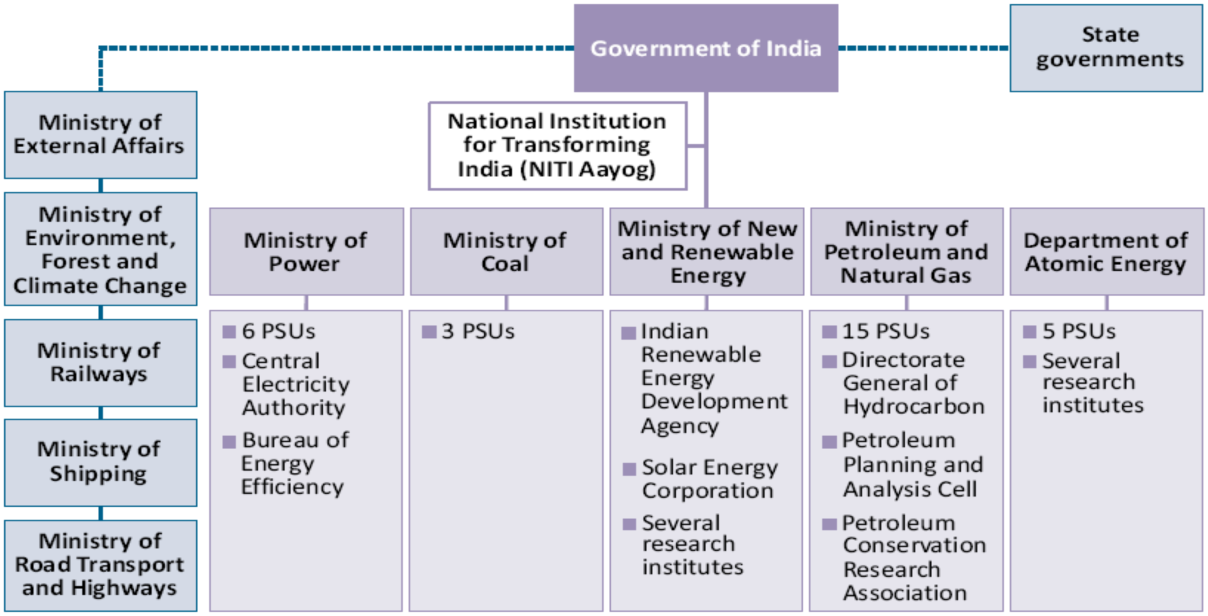
Policy and institutional framework

The direction that national and state policies take, and the rigour and effectiveness with which they are implemented, will naturally play a critical role in India's energy outlook and has few policies listed such as Integrated Energy Policy 2008, National Action Plan on Climate Change , Planning Commission (now the National Institution for Transforming India, [NITI Aayog])

Some key aspects of the emerging energy vision are

- A commitment to the efficient use of all types of energy in order to meet rapidly growing demand
- Increase the target for renewables to 175 GW by 2022
- A sharpened focus on achieving universal access to modern energy, including the objective of supplying round-the-clock electricity to all of India's population Reorientation of energy subsidy programmes.
- A drive for market-oriented solutions and increased privat einvestment (including foreign investment) in energy, both through some energy-specific reforms.
- Drive to simplify and deregulate the business environment.
- A pledge to pursue a more climate-friendly and cleaner path than the one followed thus far by others at corresponding levels of economic development.
- Twin energy-related commitments to increase the share of non-fossil fuel power generation capacity to 40% by 2030 and to reduce the emissions intensity of the economy by 33-35% by the same date, measured against a baseline of 2005.

Figure 1.12 ⊳ Main institutions in India with influence on energy policy



Notes: PSU = Public sector undertaking (state-owned enterprise). Other ministries with responsibilities relevant to the energy sector include the Ministry of Urban Development, Ministry of Water Resources, Ministry of Agriculture, Ministry of Finance and the Department of Science and Technology.

Source: Adapted from (IEA, 2012).

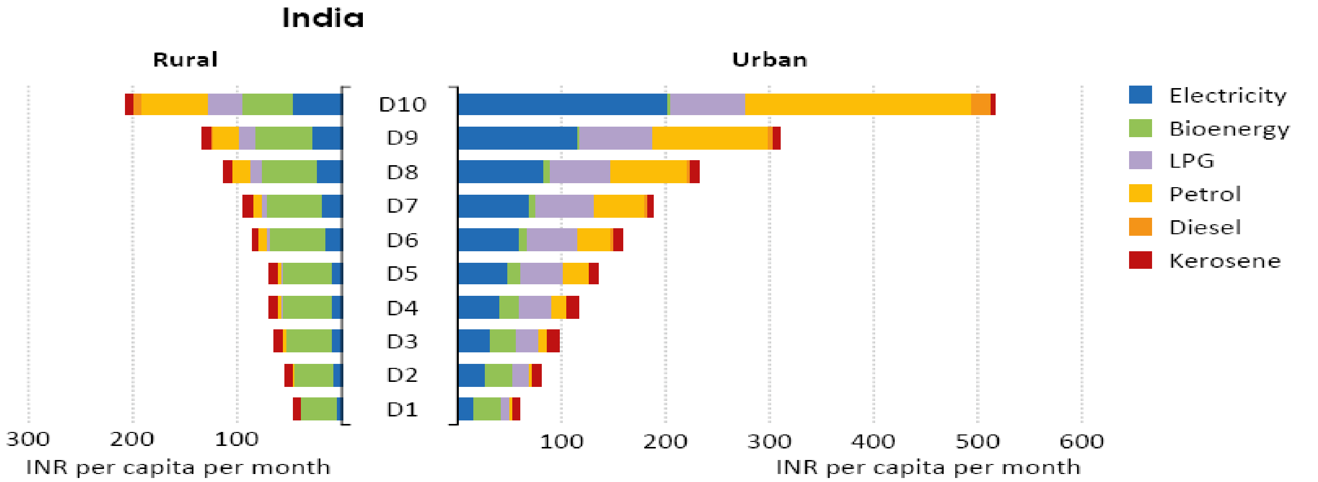
The risk of fragmented decision-making also applies at the national level itself, as there is no single body charged with formulating and implementing a unified energy policy. India has several ministries and other bodies, each with partial responsibility for aspects of energy policy and the related infrastructure (Figure 1.12). Effective co-ordination has been improved by the appointment of a single Minister for Power, Coal, New and Renewable Energy, although the individual ministries themselves continue to exist as separate entities. The institutional structure requires constant effort – not always successful – to achieve co-ordination and resolve disputes.

Energy Prices and Affordability

The relationship between income levels, energy prices and energy expenditure is fundamental to the evolution of India's energy system. Energy consumption increases with income. Level of consumption and the fuel choice are also affected by location. Household expenditure on energy is, on average, almost two-and-a-half-times higher in urban centres than in rural areas. India has made significant moves towards market-based pricing for energy in recent years. Gasoline (in 2010) and diesel (2014) prices have both been deregulated.

Subsidies to oil product consumption remain

Ex: LPG, the government is committed to make them more efficient through the use of "AADHAAR"



Notes: INR = Indian rupees. The income ranges are by decile (i.e. 10% slices) of the rural and urban population, with D10 being the most affluent 10% and D1 the poorest.

Source: Ministry of Statistics and Programme Implementation (2012).

Figure : Per-capita energy expenditure by location and income in India

Social and environmental aspects

Pollution

India is burning more fossil fuels and biomass than it has at any other time in the past, releasing more pollutants, including fine particulate matter and sulphur and nitrogen oxides, into the air. Deteriorating air quality in growing urban centres is becoming an alarming issue for India. Estimated that life expectancy, as a result, is reduced by 3.2 years for each person living in these areas:

Land : Welfare of India’s rural population is closely linked to the amount of land they have available for productive use. Land acquisition for public or private enterprises wishing to build infrastructure, from roads and railways to power plants and steel mills, is therefore an issue. Legislative changes introduced in 2013 introduced stringent procedural requirements for land acquisition. Someof the measures include

- Defining compensation payments and
- Rehabilitation and resettlement benefits
- Need to secure the consent of 80% of affected families in the case of land acquisition (70% for acquisitions by public-private partnerships)

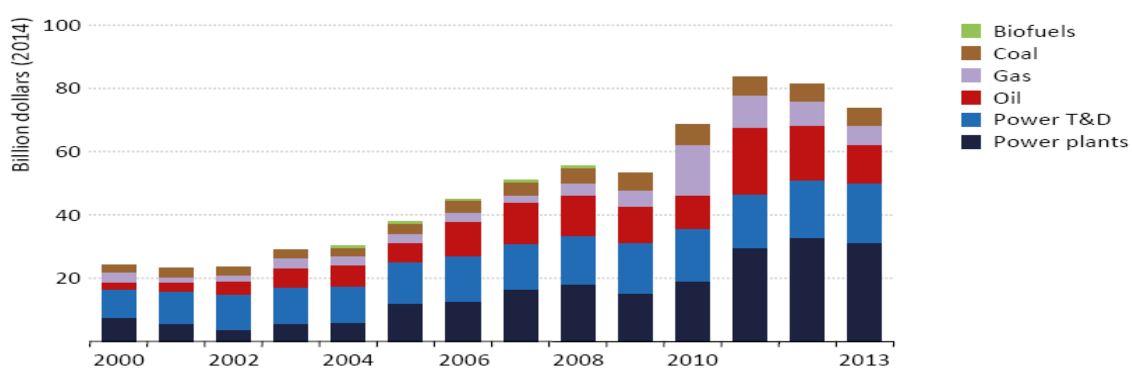
Water: High rates of population and economic growth, along with highly inefficient patterns of water use in the agricultural sector, are putting severe strain on India’s water resources. Around 90% of India’s water withdrawal is for use in agriculture and livestock, often extracted by tube wells powered from the grid and drawing from groundwater reserves. Subsidised electricity tariffs for agricultural users and a lack of metering have led to hugely inefficient consumption of both electricity and water.

Carbon-dioxide emissions : India's CO_2 emissions can be seen through two lenses. Calculated on a per-capita basis, emissions are extremely low, standing at just one-quarter of China's and the European Union's and one-tenth the level in the United States (Figure 1.17), while India also accounts for only a small share of cumulative historical GHG emissions. On the other hand, India is the third-largest country in volume terms of CO_2 emissions in the world, behind only China and the United States. Heavy dependence on coal for power generation and the use of inefficient subcritical plants to burn it push up the carbon intensity of India's power sector to 791 grammes of carbon dioxide per kilowatt-hour (g CO_2/kWh), compared to a world average of 522 g CO_2/kWh

Investment :

Since 2000, investment in energy supply in India has increased substantially, reaching almost $77 billion on average since 2010 with power sector absorbing the largest share. India's government aims to increase investment in infrastructure (broadly defined, including communications, road, rail and energy networks, as well as social areas such as schools and hospitals) to 8.2% of GDP, from roughly 7.2% in 2007-2011. 2014 saw a significant increase in FDI inflows, which rose by 22% compared to the previous year. The power sector absorbs the largest share, spurred by the rapid increase in demand as encouraged by the liberalisation agenda launched by the landmark Electricity Act in 2003. Maintaining a rising trend in infrastructure spending, especially energy sector spending, is a major government policy priority.. More than a third of this $1 trillion in infrastructure spending is to go to electricity, renewable energy, and oil and gas pipeline projects, with around half from private investment

Figure : Energy supply investment by type, 2000-2013



Note: T&D = transmission and distribution.

As the Indian government has recognised, public funds sufficient to support the necessary investment projects in the energy sector cannot be taken for granted, in the face of increasing competition from other areas of public spending (including healthcare, pensions, education, etc.). So meeting the country's investment needs will require the mobilisation of increasing amounts of private capital, including foreign direct investment (FDI). Access to such investment opportunities by the private sector though is uneven across the Indian energy economy and a number of broader impediments to attracting investment persist, such as the complex regulatory environment, in relation to which the World Bank has ranked India 142 out of 189 countries in terms of ease of doing business. Despite these impediments, India's vast potential puts it high on the list of prospective destinations for foreign investment, ranking third behind China and the United States. Furthermore, 2014 saw a significant increase in FDI inflows, which rose by 22% compared to the previous year, to a total of over $34 billion (UNCTAD, 2015). Preliminary numbers for FDI in 2015 show a further substantial increase.