Energy Classifications

Introduction:

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 critical importance in view of the ever-increasing energy needs, requiring huge investments to meet them.

The consumption of energy is increasing at a fast pace while available resources remain limited. The global need for energy is increasing on an average by about 2.4% every year. Out of the total amount of primary energy, over 85% comes from fossil fuels. The current consumption of fossil fuels, particularly oil, is not sustainable in the long term.

Energy consumption also has a significant impact on our natural environment. There is clear evidence that climate change is caused by human activity, mostly related to the use of energy.

Energy, that we use, can be classified into several types based on the following criteria:

- Primary energy and secondary energy
- Commercial and non commercial energy
- Renewable and non-renewable energy

Energy Classifications

Primary and Secondary energy:

Primary energy refers to all types of energy extracted or captured directly from natural resources. Primary energy can be further divided into two distinctive groups:

- Renewable (solar, wind, geothermal, tidal, biomass, hydel etc.)
- Non-renewable (fossil fuels: crude oil and its products, coal, natural gas, nuclear, etc.)

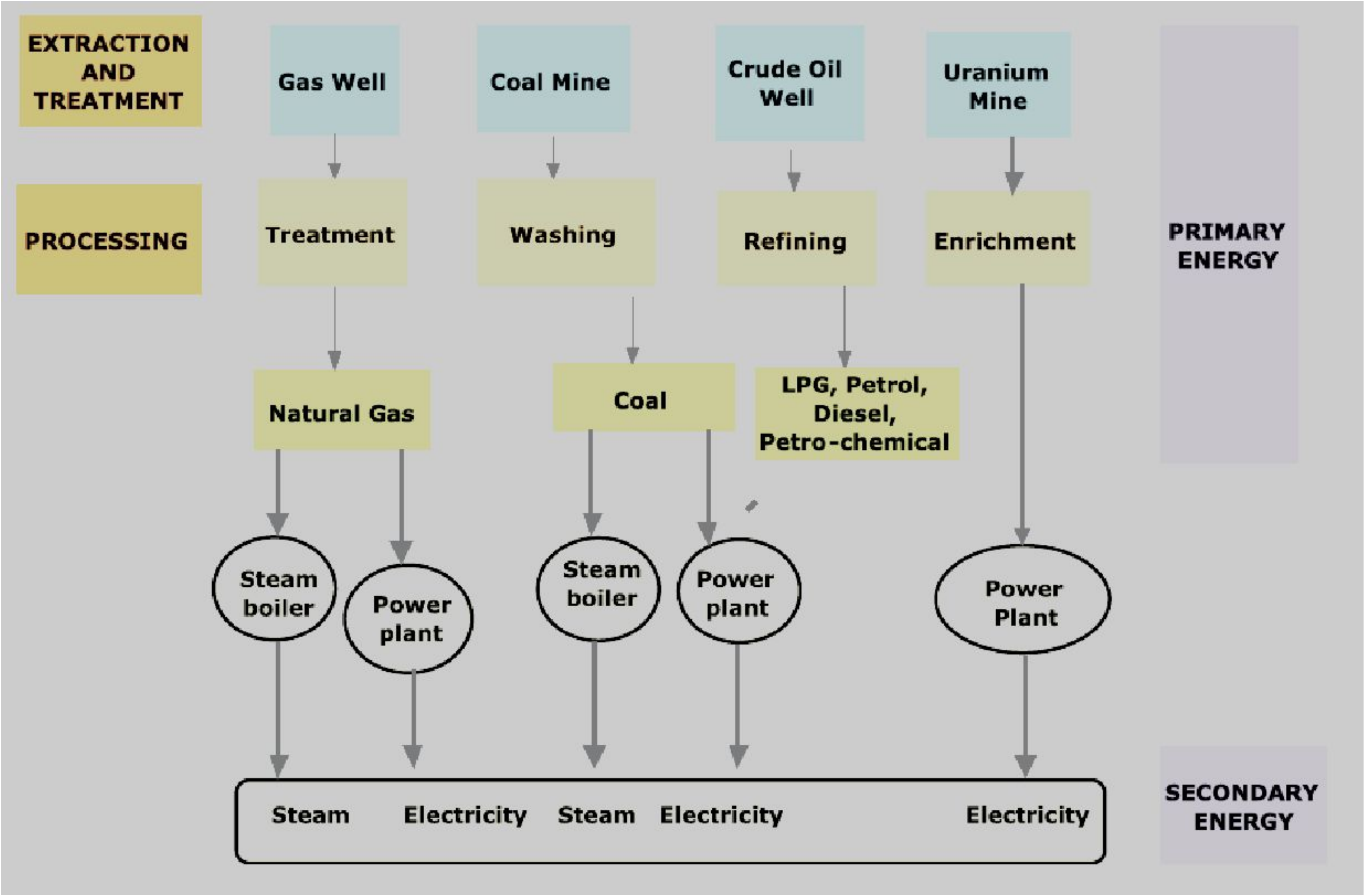
The primary energy content of all fuels is generally expressed in terms of toe (tonne of oil equivalent) and is based the following conversion factor.

One tonne of oil equivalent (toe) = 1 x 10^7 kcal = 11630 kWh = 41868 MJ

Primary energy sources are mostly converted in industrial utilities into secondary energy sources; for example coal, oil or gas converted into steam and electricity.

Energy Classifications

Major Primary and Secondary energy sources:



Energy Classifications

Commercial Energy

Energy that is available in the market for a definite price is known as commercial energy. No matter what the method of energy production is, whether it is from fossil fuels, nuclear or renewable sources, any form of energy used for commercial purposes constitutes commercial energy.

Examples: Electricity, lignite, coal, oil, natural gas etc.

Non-Commercial Energy

Any kind of energy which is sourced within a community and its surrounding area, and which is not normally traded in the commercial market is termed as non-commercial energy.

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

Energy Classifications

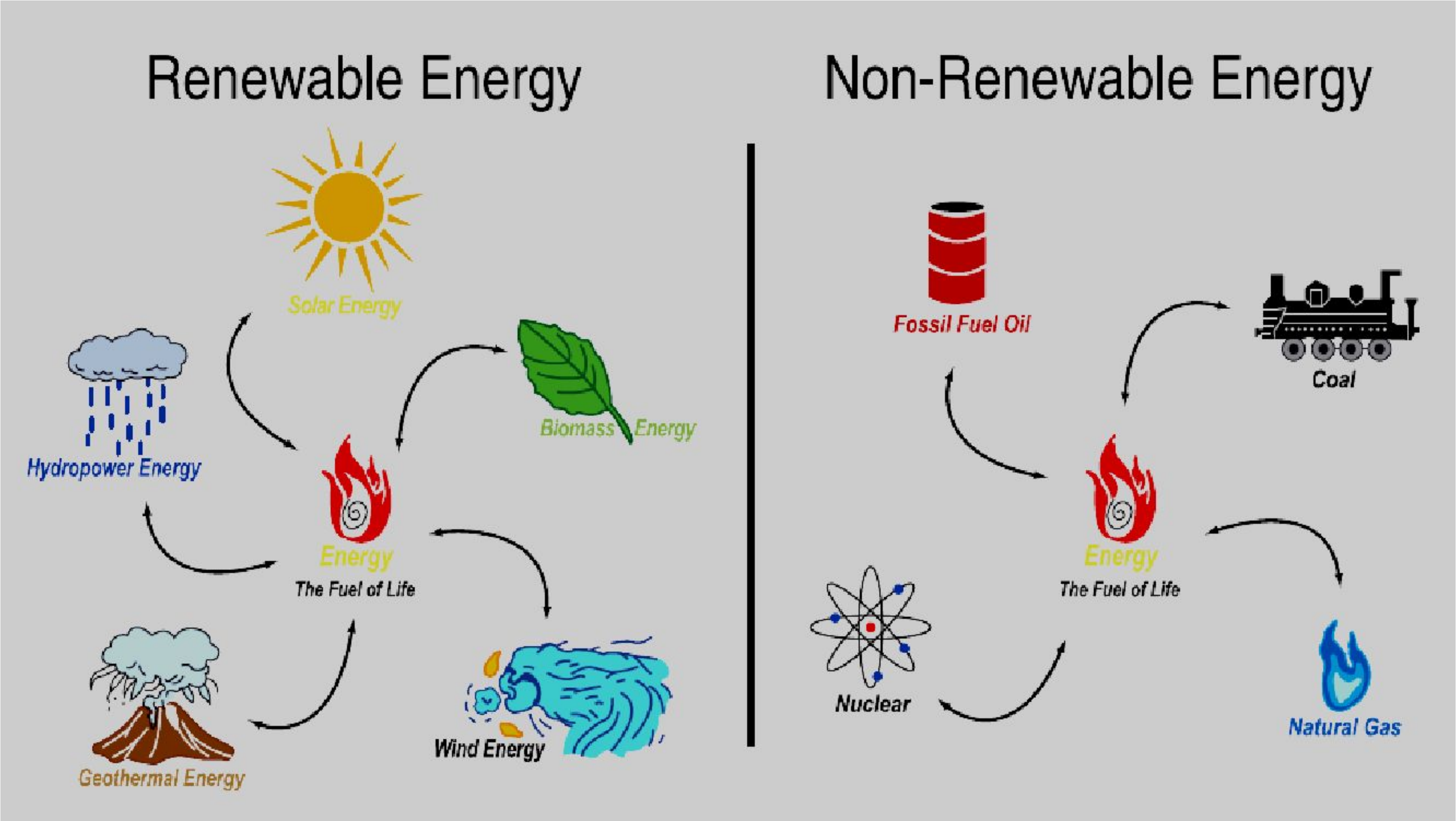
Renewable and Non-renewable energy

Renewable energy is the energy obtained from natural sources which 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 itcan be harnessed without the release of harmful pollutants.

A non-renewable resource is a natural resource which cannot be produced, grown, replenished, or used on a scale which can sustain its consumption rate. These resources often exist in a fixed amount, or are consumed much faster than nature can create them. Natural resources such as coal, oil and natural gas take millions of years to form and cannot be replaced as fast as they are being consumed now. These resources will deplete with time.

Energy Classifications

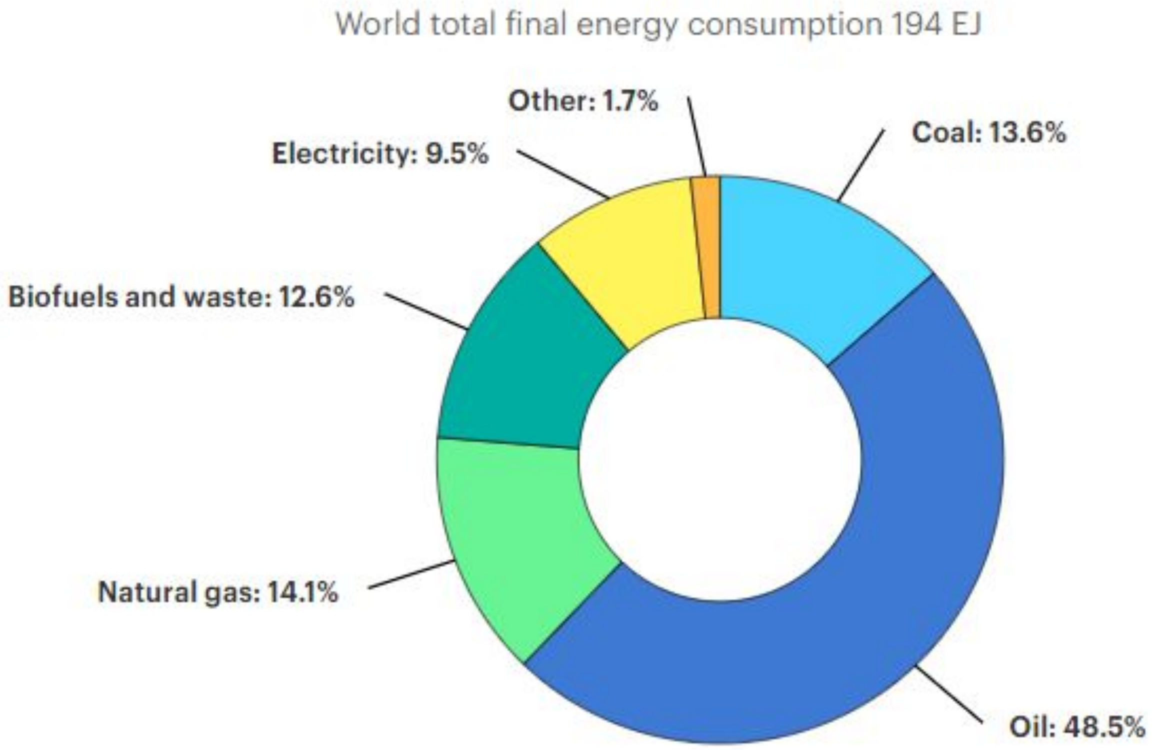
Renewable and Non-renewable energy



Sectorial Energy consumption:

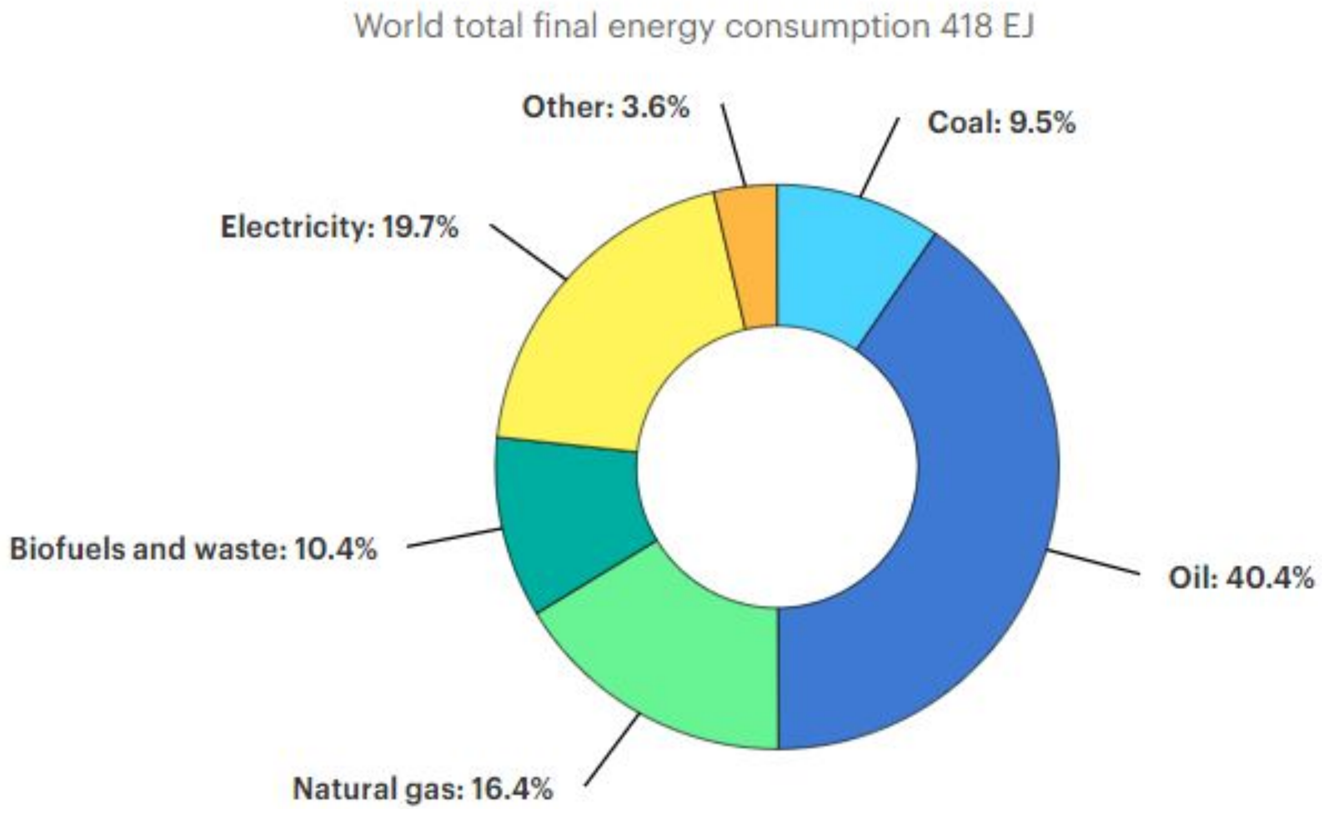
World total final consumption by source – 1973

Exajoule (EJ): 1 EJ = 10^{18} J



Sectorial Energy consumption:

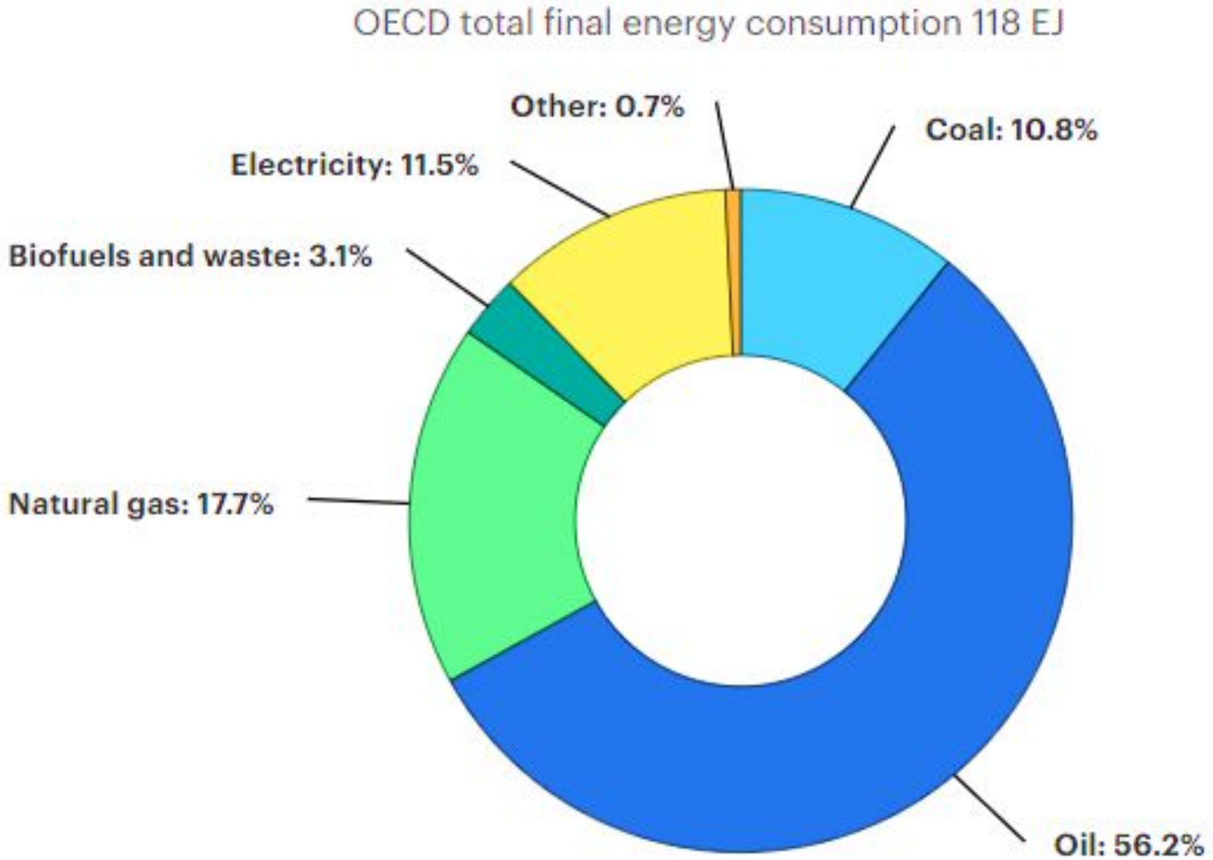
World total final consumption by source - 2019



Sectorial Energy consumption:

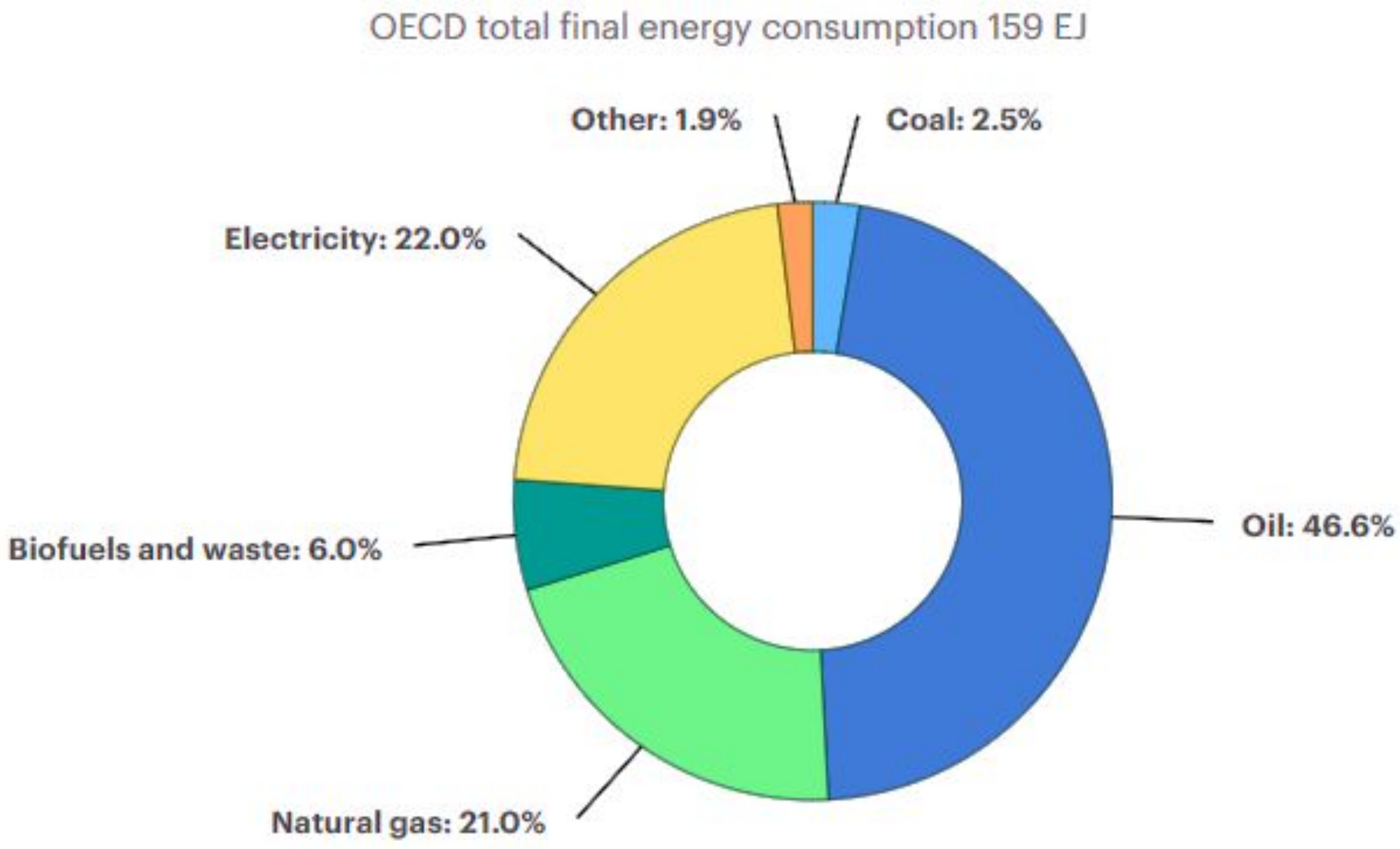
OECD total final consumption by source – 1973

OECD - Organization for Economic Cooperation and Development (OECD)



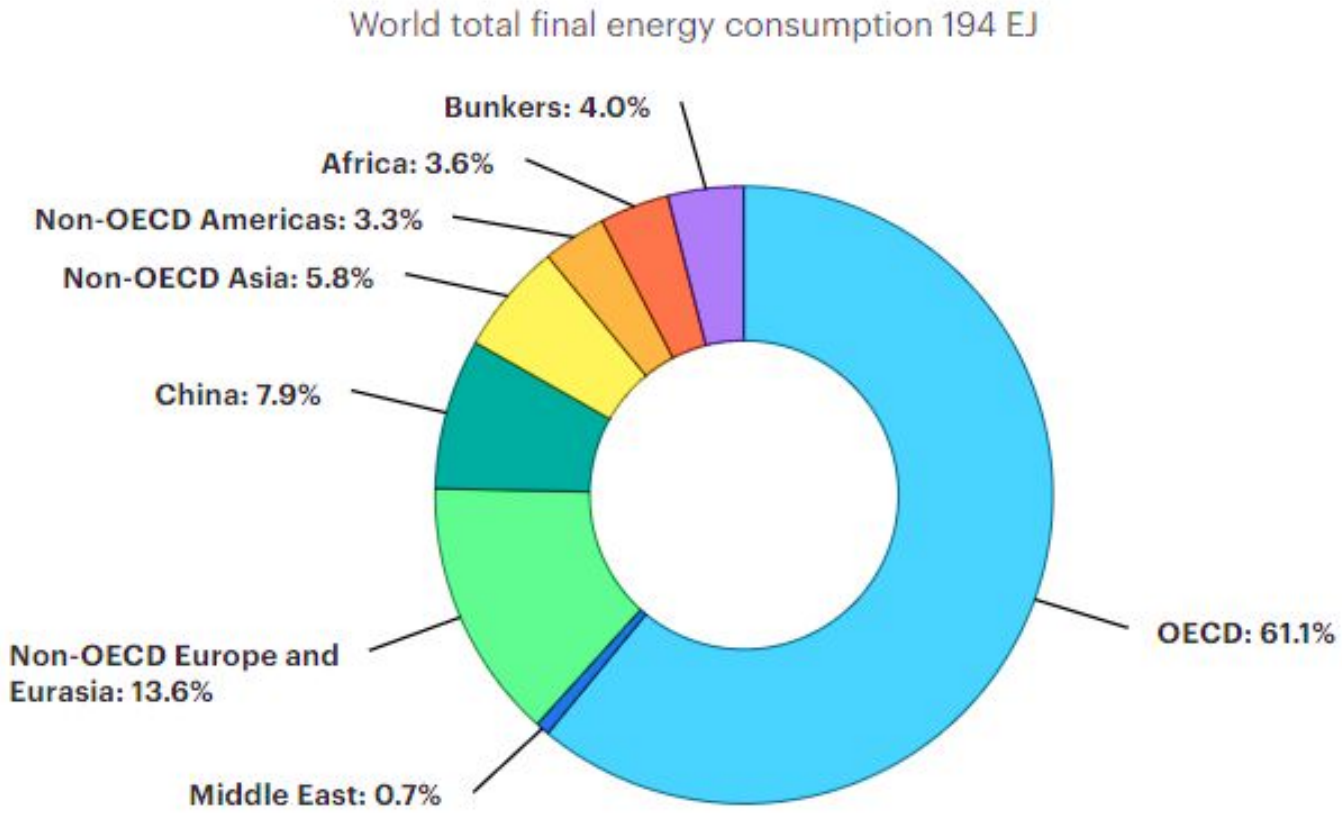
Sectorial Energy consumption:

OECD total final consumption by source - 2019



Sectorial Energy consumption:

World total final consumption by region - 1973



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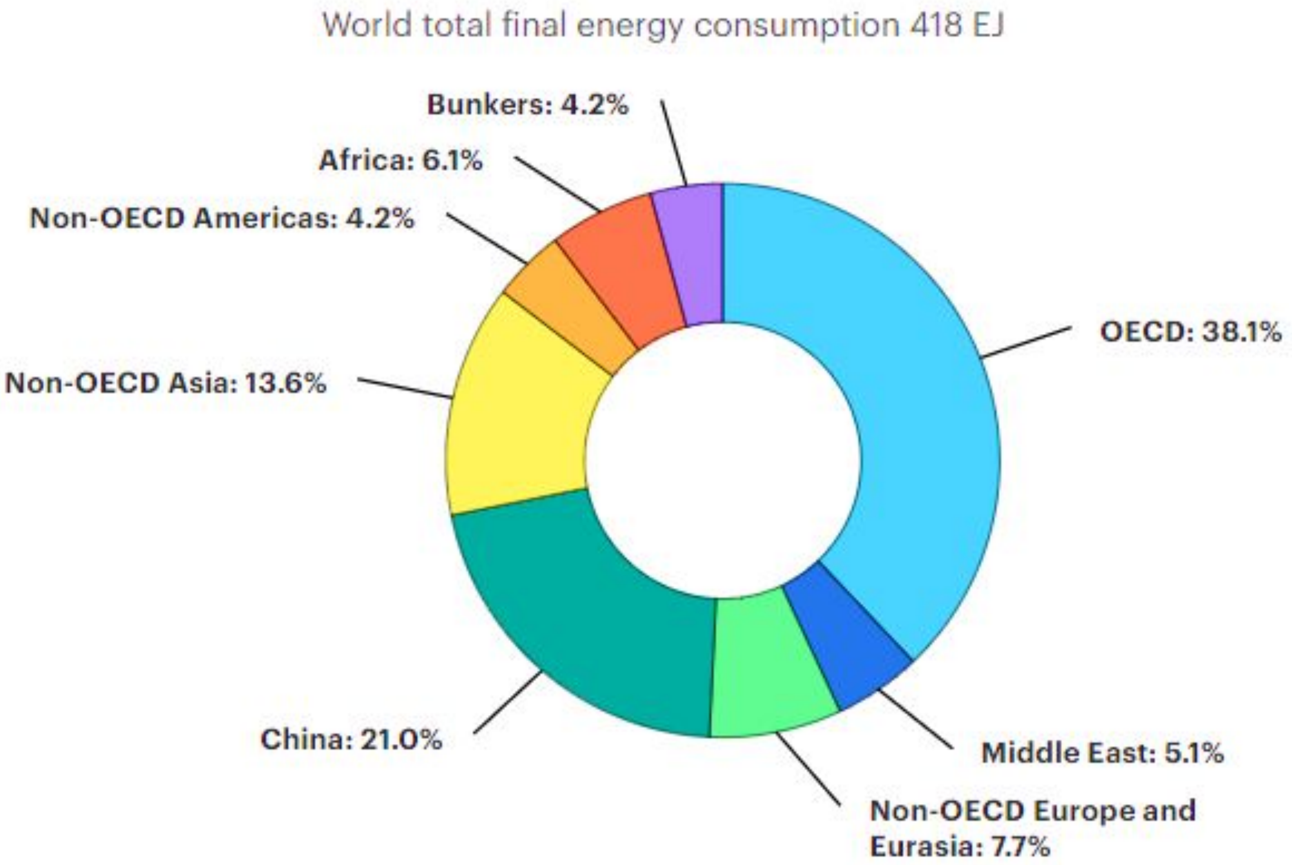

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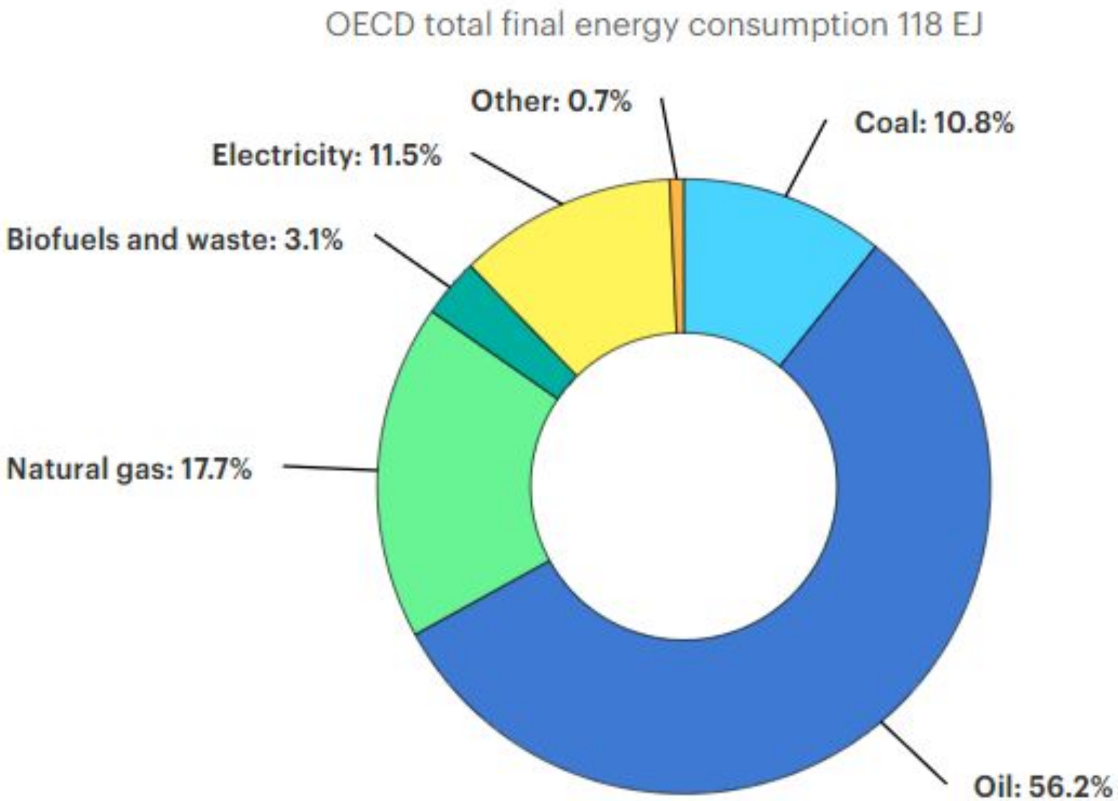

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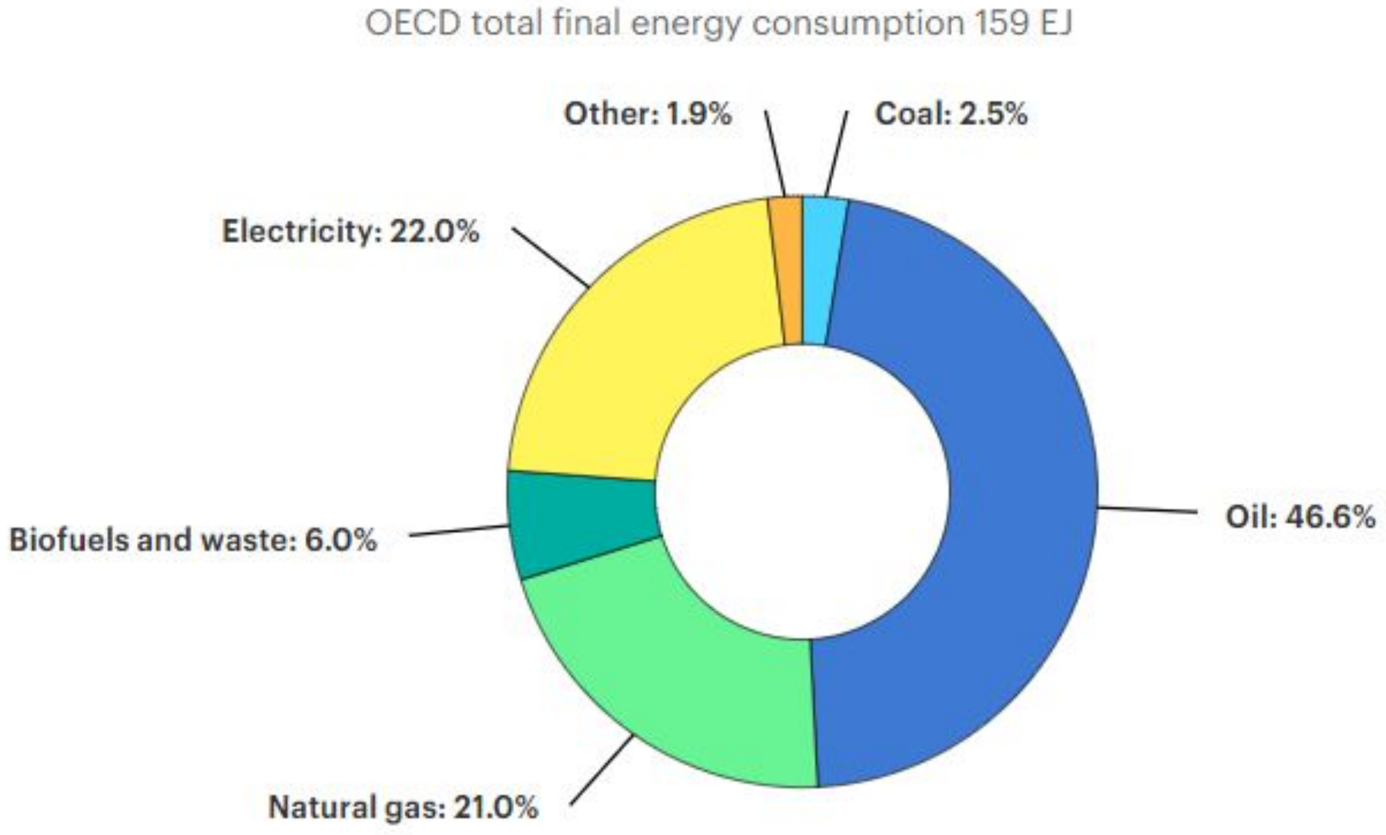
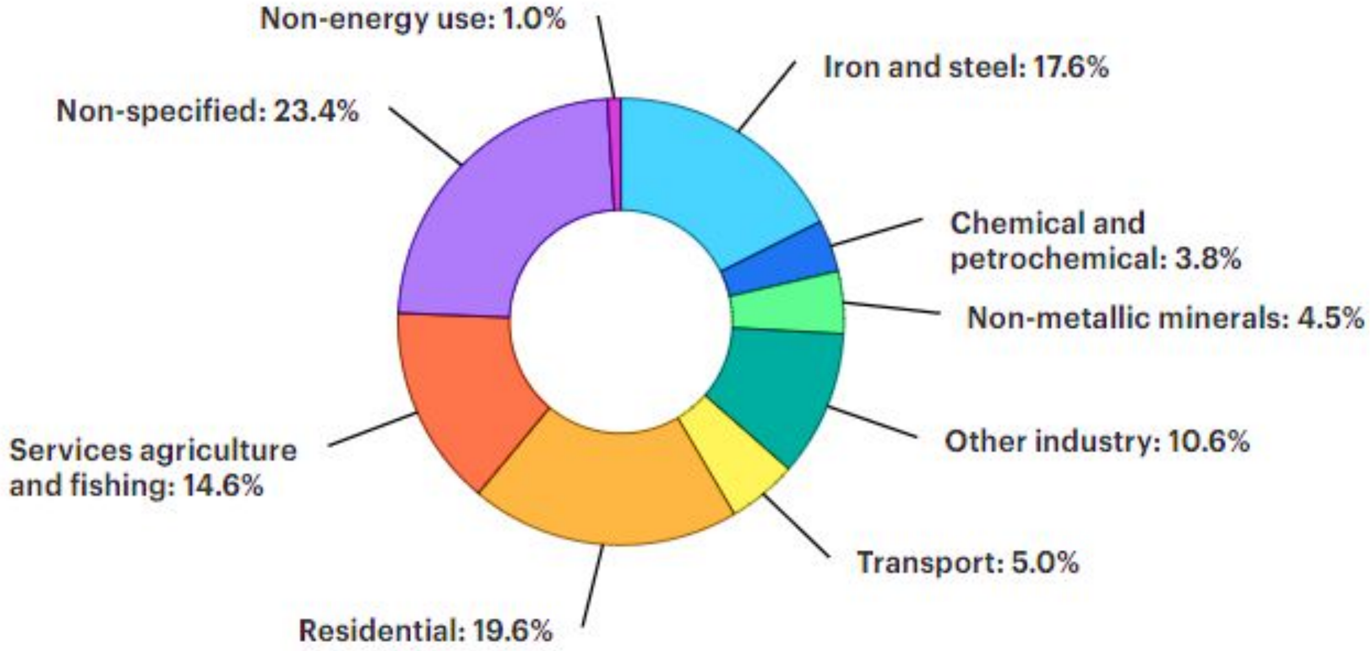


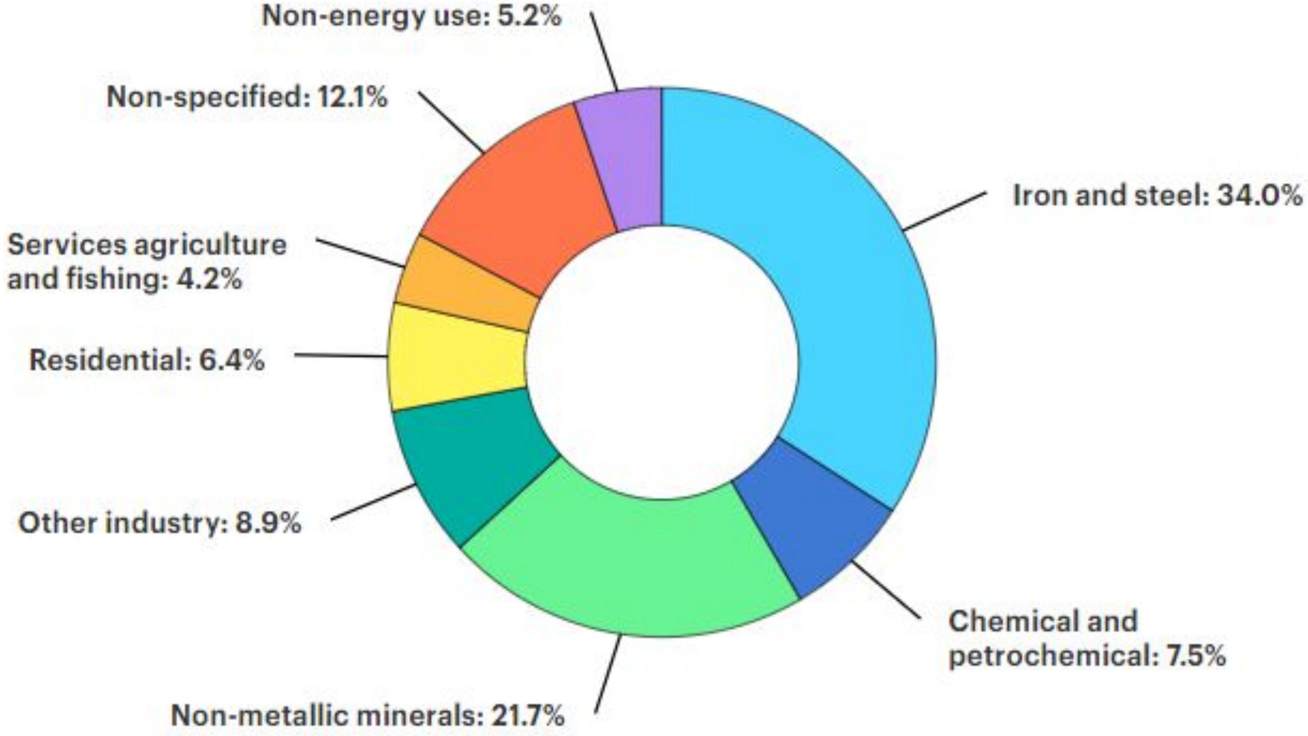
Sectorial Energy consumption:

Coal final consumption by sector - 1973



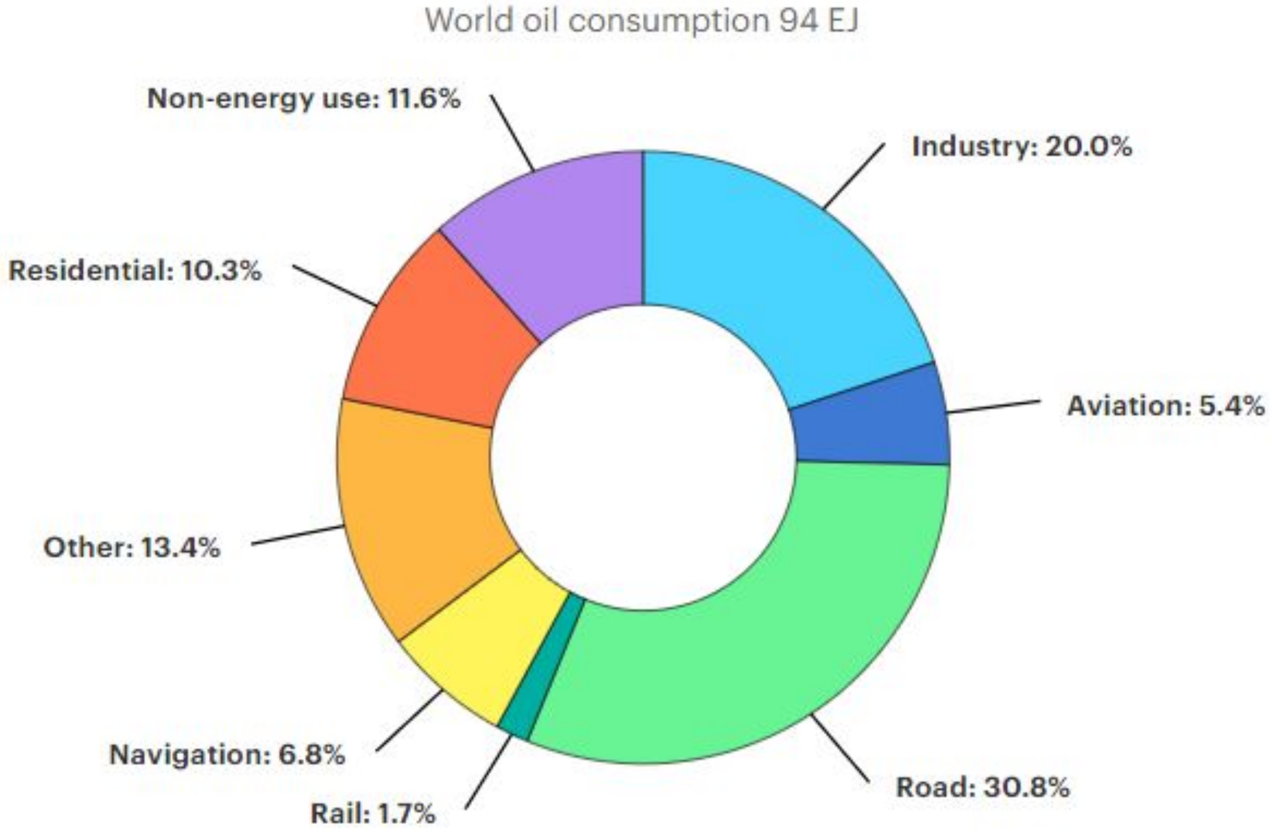
Sectorial Energy consumption:

Coal final consumption by sector - 2019



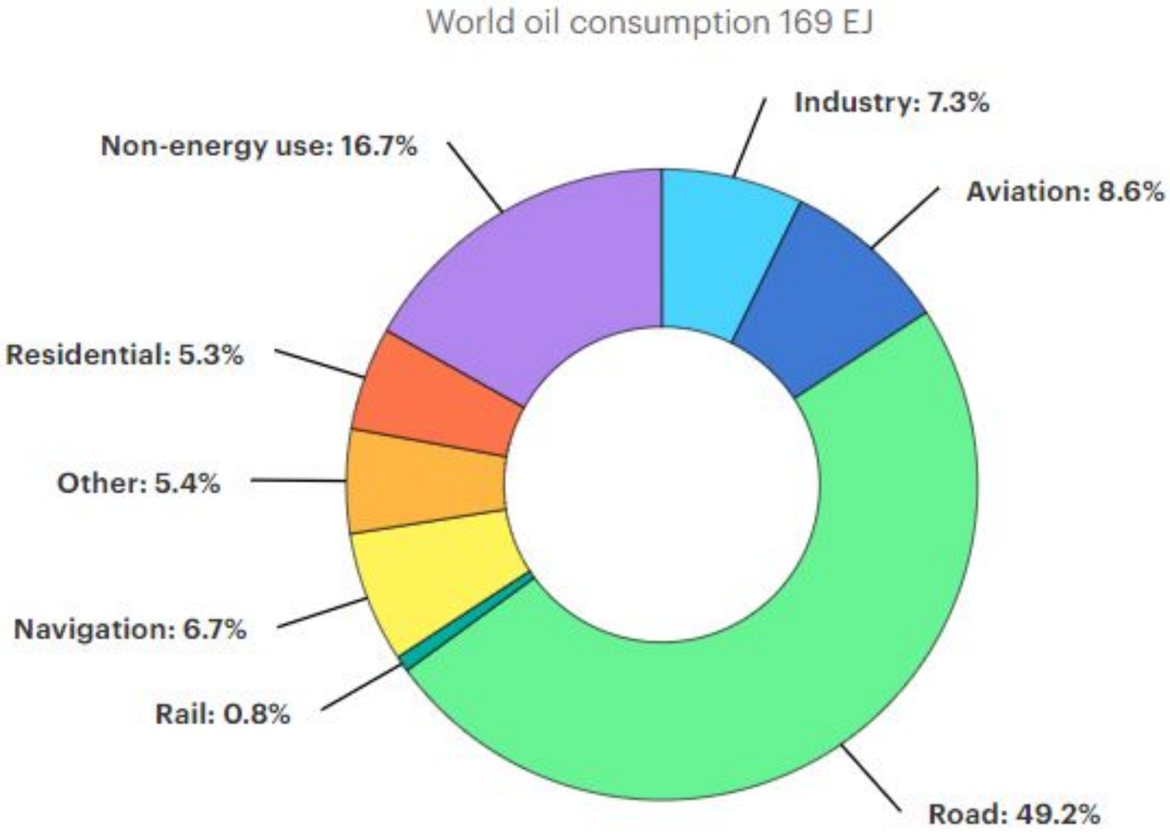
Sectorial Energy consumption:

Oil final consumption by sector - 1973



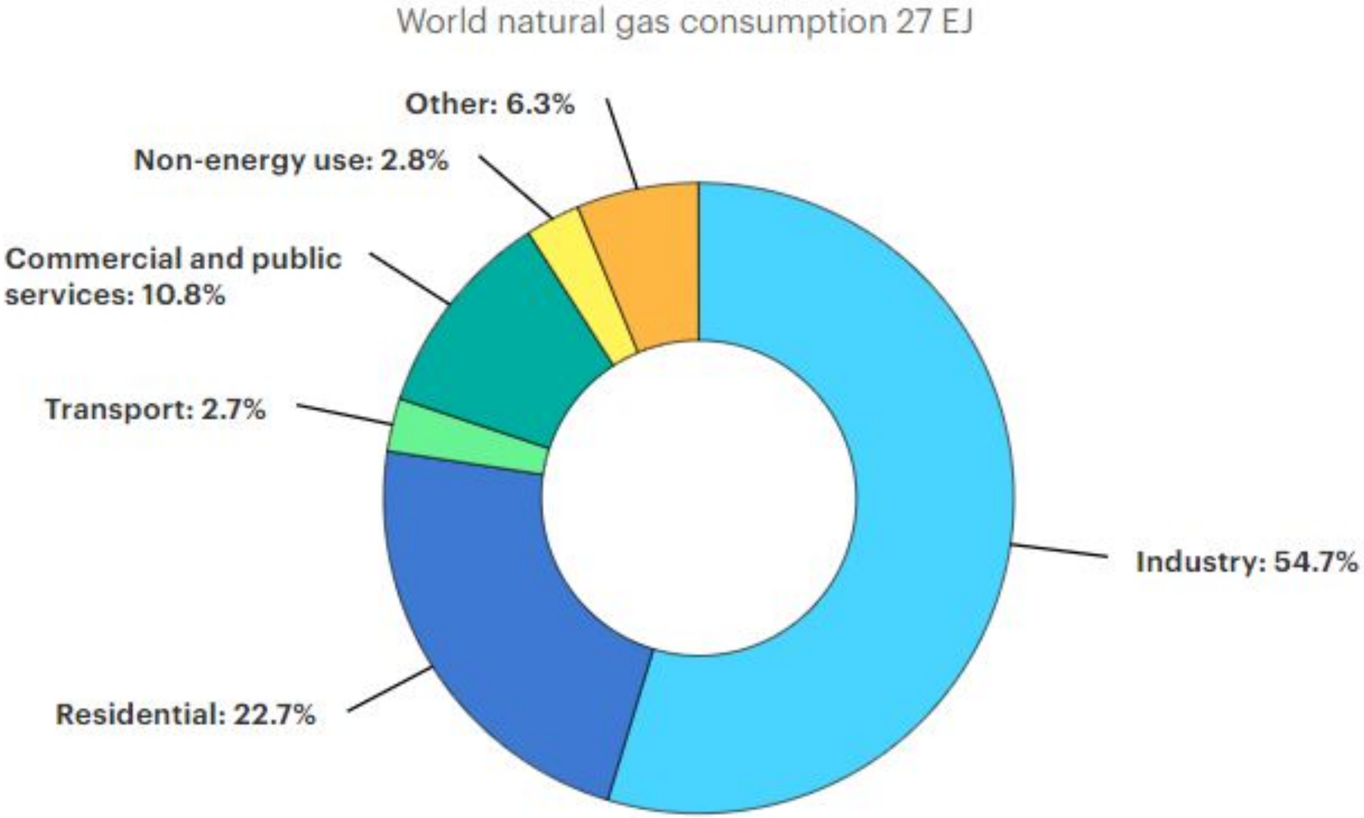
Sectorial Energy consumption:

Oil final consumption by sector - 2019



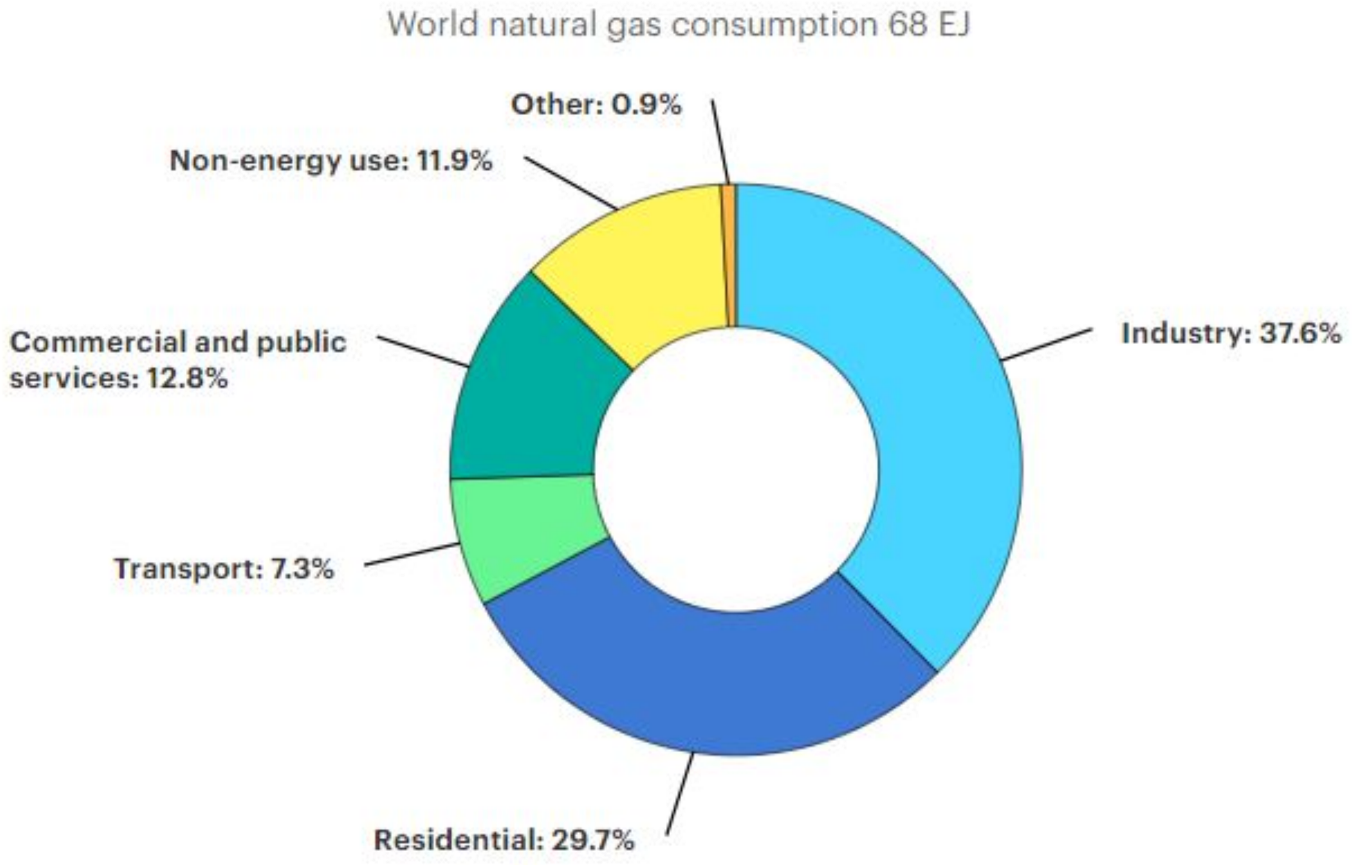
Sectorial Energy consumption:

Natural gas final consumption by sector - 1973



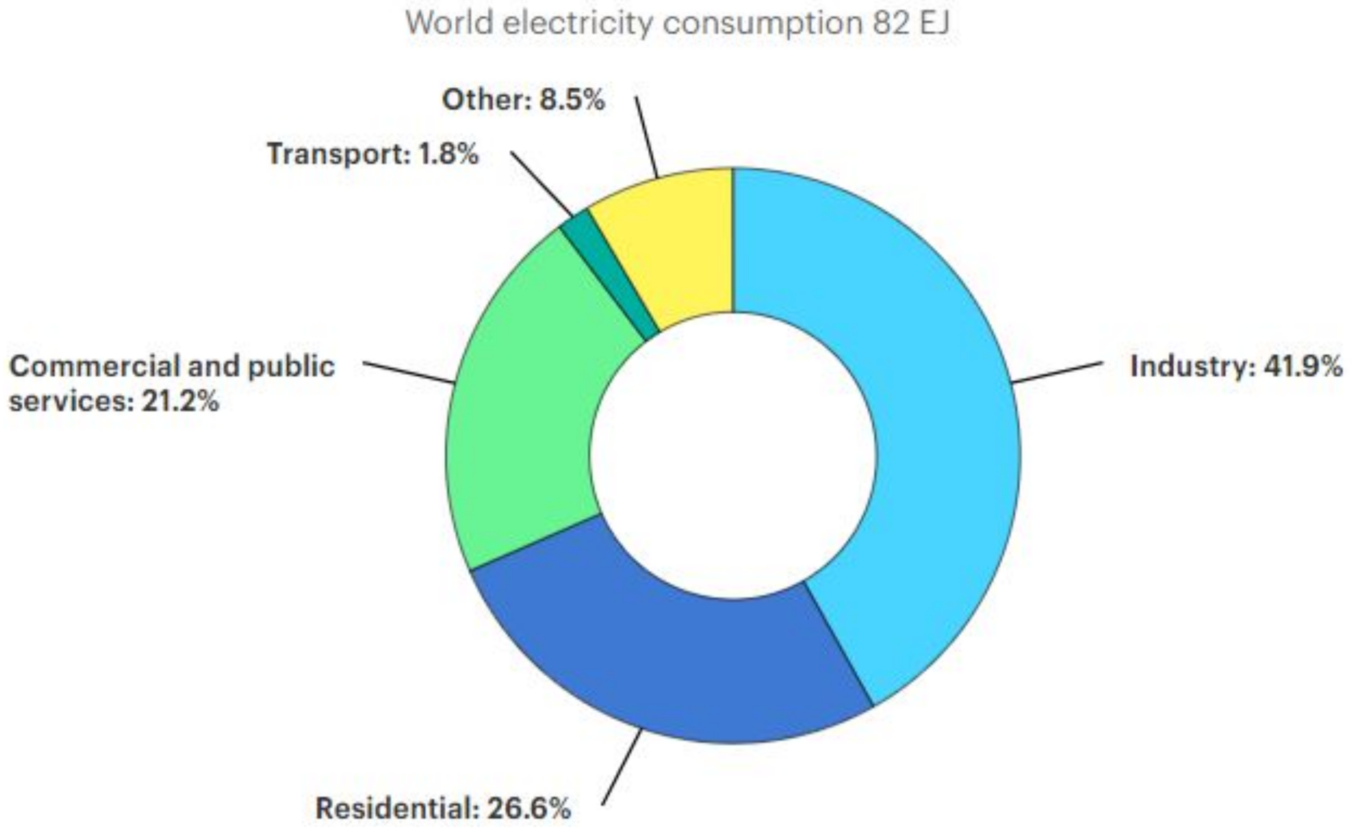
Sectorial Energy consumption:

Natural gas final consumption by sector - 2019



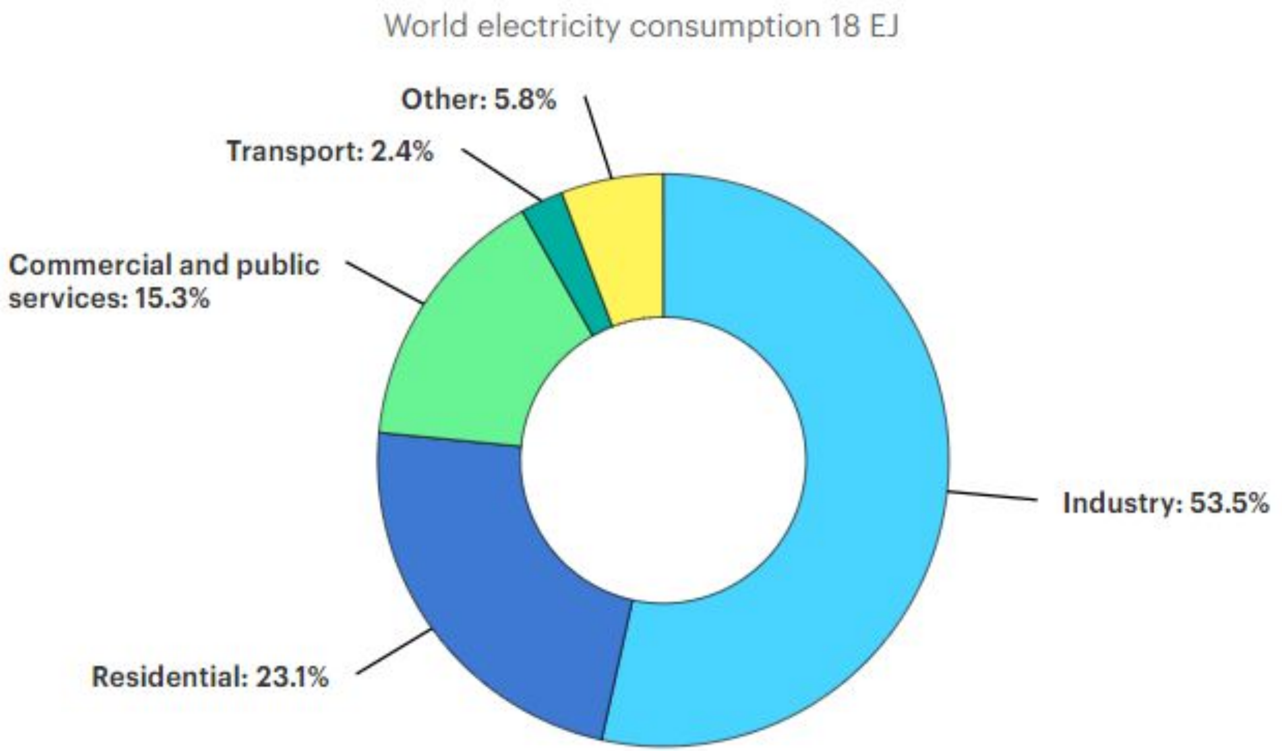
Sectorial Energy consumption:

Electricity final consumption by sector - 1973



Sectorial Energy consumption:

Electricity final consumption by sector - 2019



Energy Needs of Growing Economy

Economic growth is desirable for developing countries, and energy is essential for economic growth. However, the relationship between economic growth and increased energy demand is not always a straightforward linear one.

Massive investment in energy sector is required to deliver a sustained GDP growth rate of 8.0% till the year 2031- 2032. The requirements of energy sector are:

- Growth in primary energy supply by 3-4 times over current consumption
- Increase in electricity installed capacity by 6-7 times
- Increase in annual coal requirement by nearly 3 times over the current demand

Where, GDP - Gross domestic product

Particulars	2010-11	2011-12	2012-13
Per Capita Consumption (kWh)	819	884	917

Source: Growth of Electricity in India from 1947-2013: CEA Document

Energy Needs of Growing Economy

Requirement of coal, the dominant fuel in India's energy mix will need to expand to over 2 billion tonnes/annum based on domestic quality of coal given India's targeted GDP growth.

India's oil requirements also will increase at a significant rate. India already imports about 75% of its crude oil requirements which are likely to go up more than 90% in the near future as production in existing oil and gas fields are declining as a result of years of use.

The share of natural gas in the energy mix is expected to go upto 20-25% by the year 2030-32.

Nuclear power plant capacity targets as envisaged by the Department of Atomic Energy (DAE) are 20,000 MWe by 2020, 50,000 MWe by 2030 and 250,000 MWe of nuclear power by 2050.

Energy Intensity

Energy intensity on PPP:

Energy intensity is the ratio between the gross inland consumption of energy and the gross domestic product (GDP) for a given calendar year. It measures the energy consumption of an economy and its overall energy efficiency.

$$EI = \frac{FC}{GDP}$$

Where:

EI = Energy intensity, national level, toe per million US \$
FC = Total final consumption, national level, toe
GDP= Gross domestic product, million US \$

Energy Intensity

What is Purchase Power Parity (PPP)?

An egg in India costs Rs.3/- whereas it costs 30 Yens/- (equivalent to Rs.15) in Japan. The PPP for an egg between Japan and India is 30 Yens to Rs.3 or 10 Yens to a rupee. In other words, for every rupee spent on egg in India, 10 Yens would have to be spent in Japan to obtain the same quality of egg.

Applying actual exchange rates of Yen to Rupee in this process would overestimate the GDP of Japan with high price levels relative to India with low price levels. The use of PPPs ensures that the GDP of all countries is valued at a uniform price level and thus reflects only differences in the actual volume of the economy. Adjustments are required to give a better picture than comparing gross domestic products (GDP) using market exchange rates.

Long term energy scenario for India

Coal

Apart from meeting the energy needs of the industry, coal is the predominant energy source for power production in India accounting for about 60% of the installed capacity. Energy demand in India is expected to increase heavily over the next 10-15 years. Coal will continue to remain the dominant fuel in the Indian economy.

Despite significant increases in the total installed generation capacity during the last decade, the gap between the electricity supply and demand continues to increase. The resulting shortfall has had a negative impact on the industrial output and economic growth.

The coal production stood at around 551.71 Million tonnes by the end of 2013.

Long term energy scenario for India

Oil

India's demand for petroleum products rose from 97.7 million tonnes in 2001-02 to around 175.2 million tonnes by 2013. Domestic crude oil production was 37.788 million metric tonnes (MMT) for the year 2013-14.

India's self sufficiency in oil has consistently declined from 60% in the 1950s to 25% currently. Same is expected to go down to 8% by 2020. About 90% of India's total oil demand by 2020 would have to be met by imports.

Long term energy scenario for India

Natural Gas

In keeping with the world wide trend, the demand for natural gas in India has been on the increase. The production of natural gas which was negligible at the time of independence is now at the level of 35.407 Billion Cubic Meters. To meet the future requirements of natural gas, trans-national gas pipelines are being planned.

While gas pipeline projects would yield results only in long term, immediate relief can come in the form of LNG. Import of LNG will require special terminals to handle them at the ports. The constructions of such terminals have already started and some of them have been commissioned. The world trade in LNG is around 150 Billion Cubic Metres (BCM). Geographically, India is strategically located and is flanked by large gas reserves on both East and West. India is located relatively near to four of top five countries in terms of proven gas reserves viz. Iran, Qatar, Saudi Arabia and Abu Dhabi. The large natural gas market of India is a major attraction to the LNG exporting countries. In order to encourage gas imports, Government has kept import of LNG under Open General License (OGL) and permitted 100% Foreign Direct Investment (FDI)

LNG – Liquified Natural Gas

Long term energy scenario for India

Electricity

With India already reeling under peak demand and energy shortage, increasing economic growth is expected to put heavy pressure on the power sector. For sustaining the current economic growth rate, the capacity will have to be doubled every 10 years.

Accelerated Power Development & Reforms Programme was introduced by the Ministry of Power in 2002-03 in order to improve the power reliability at the distribution level and to achieve commercial viability of State Electricity Boards. The strategies include technical, commercial, financial and IT interventions to achieve the following objectives

- Targets towards the commercial viability of the utilities by reducing their Aggregate Technical & Commercial (AT&C) losses to 15%
- Improvement in quality, supply and reliability of supply
- Improved revenue collection and customer satisfaction

APDRP was later restructured as R-APDRP, the focus of which is on actual, demonstrable performance in terms of loss reduction.

Energy Pricing (in India)

In terms of purchasing power parity, power tariffs in India for industries and commercial establishments are among the highest in the world. The average tariff on PPP basis in India is 30.8 cents/kWh, while it is 7.7 in US, 15.3 in Japan and 20.6 in China.

Electricity tariffs in India are structured in a relatively simple manner. While high tension consumers are charged based on both demand (kVA) and energy (kWh), the low-tension (LT) consumer pays only for the energy consumed (kWh) as per tariff system in most of the distribution companies. The price per kWh varies significantly across States as well as customer segments within a State.

Introduction of Availability Based Tariffs (ABT) and unscheduled interchange charges for power, introduced in 2003 for inter-state sale of power, have reduced voltage and frequency fluctuations.

Energy Pricing (in India)

What is ABT?

- It is a performance-based tariff system for the supply of electricity by generators owned and controlled by the central government
- It is also a new system of scheduling and dispatch, which requires both generators and beneficiaries to commit to day-ahead schedules.
- It is a system of rewards and penalties seeking to enforce day ahead pre-committed schedules, though variations are permitted if notified one and half hours in advance.
- The order emphasises prompt payment of dues. Non-payment of prescribed charges will be liable for appropriate action.

Energy Security

The basic aim of energy security for a nation is to reduce its dependency on the imported energy sources for its economic growth. Energy security is defined as **"The continuous availability of energy in varied forms in sufficient quantities at reasonable prices".**

Energy security is a serious concern because India's energy needs are growing with rising income levels and a fast growing population. The dependence on imported energy is also increasing rapidly due to increasing energy needs. A special concern is that the import of oil is about 75% of total oil consumption. The domestic oil wells are all over 30 years old and the yield from these wells have started reducing. Oil demand is rising at a rate of about 5% every year leading to huge oil import bills.

Poor coal quality and high prices of domestic coal will drive the increase in coal imports from present level of 25%. The imports of gas and LNG (liquefied natural gas) are likely to increase in the coming years. Thus the energy import dependence implies vulnerability to external price shocks and supply fluctuations, which in turn threaten the energy security of the country.

Energy Security

Some of the strategies that can be used to meet future energy requirements include:

- Reducing energy requirements
  - Improving the efficiency of extraction of fossil fuels
  - Improving fuel efficiency of new coal-fired power plants by adopting new technology (i.e. super critical pulverized fuel fired boilers)
  - Adopting energy efficiency and demand side management
  - Promotion of public transport / mass transport (e.g. metro rail, light rail, monorail etc.) in urban areas
  - Developing renewable energy sources especially solar and wind
- Substituting imported oil/gas with domestic alternatives
  - Ethanol / Biodiesl as substitute for petrol / diesel
  - Biomass gasification for heat or power as alternative to gas / coal
  - Coal-to-oil technology as done in South Africa

Energy Security

- Diversifying energy supply sources
  - Mix of fuel comprising of coal, gas, nuclear, hydro and renewables with no dependence on any particular fuel
  - Sourcing oil / LNG from different countries
  - Importing gas through pipelines passing through countries who also benefit
- Expanding energy resource and developing alternative energy sources
  - Improved Oil Recovery (IOR) and Enhanced Oil Recovery (EOR) for improving exploitation of reserves
  - Recovery of oil and gas from abandoned or marginal fields
  - In-situ coal gasification
  - Capturing Coal Bed Methane (CBM) which escapes from coal seams during mining
  - Conversion of coal to oil

Energy Security

- Gas to Liquid (GTL)
- Stepping up exploration to find new reserves (only one-third of oil bearing area explored so far)
- Equity oil, gas, coal from other countries
- Setting up energy intensive units (i.e. fertilizer plants) abroad
- New domestic sources (nuclear –fast breeder reactor, thorium reactors, gas hydrates etc.)
- Promoting Community Biogas Plants
- Energy plantations

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Energy Conservation and its importance

Coal and other fossil fuels, have taken hundreds of millions of years to form, are likely to deplete soon. In the last two hundred years, we have consumed 60% of all resources. For sustainable development, we need to adopt energy efficiency measures.

Today, 85% of India's primary energy comes from non-renewable and fossil sources (coal, oil, etc.). These reserves are continually diminishing with increasing consumption and will not exist for future generations (see Figure).

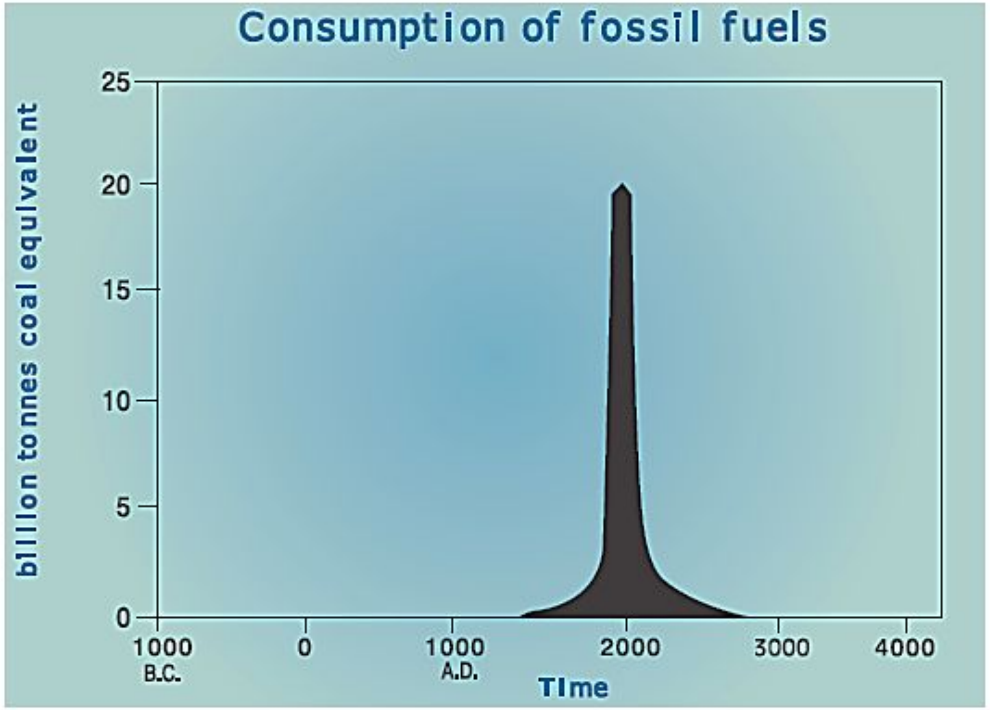


Figure. Consumption of Fossil Fuels

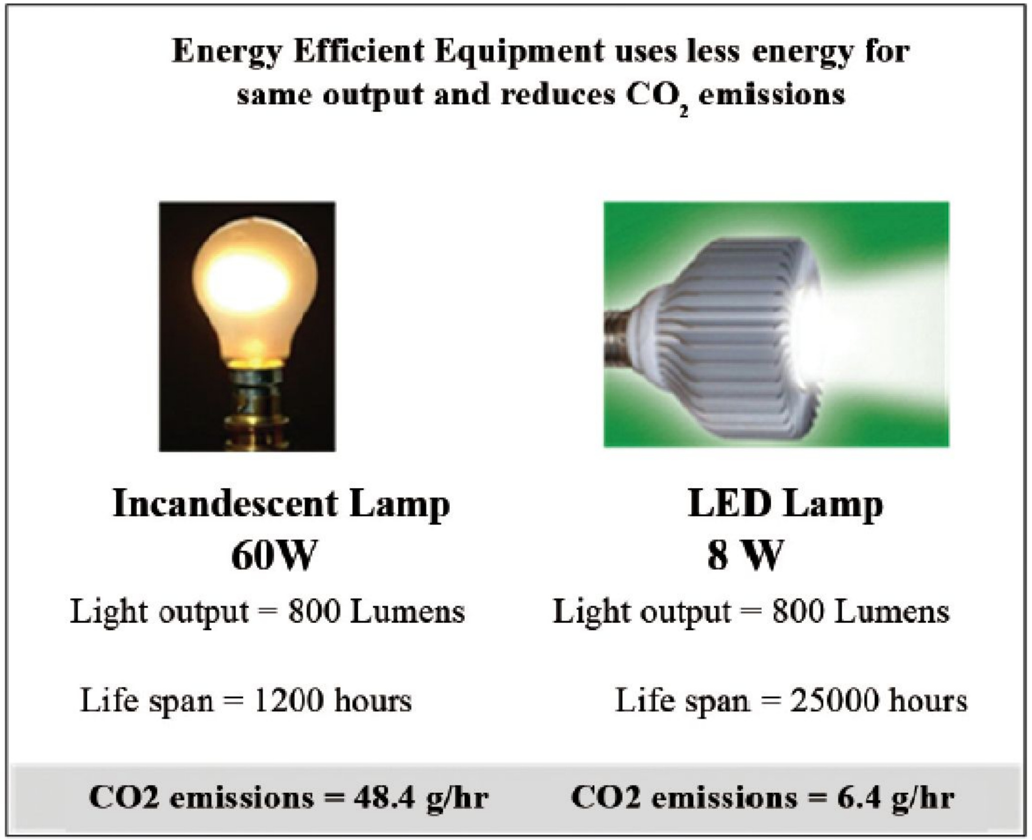
Energy Conservation and its importance

Energy Conservation and Energy efficiency:

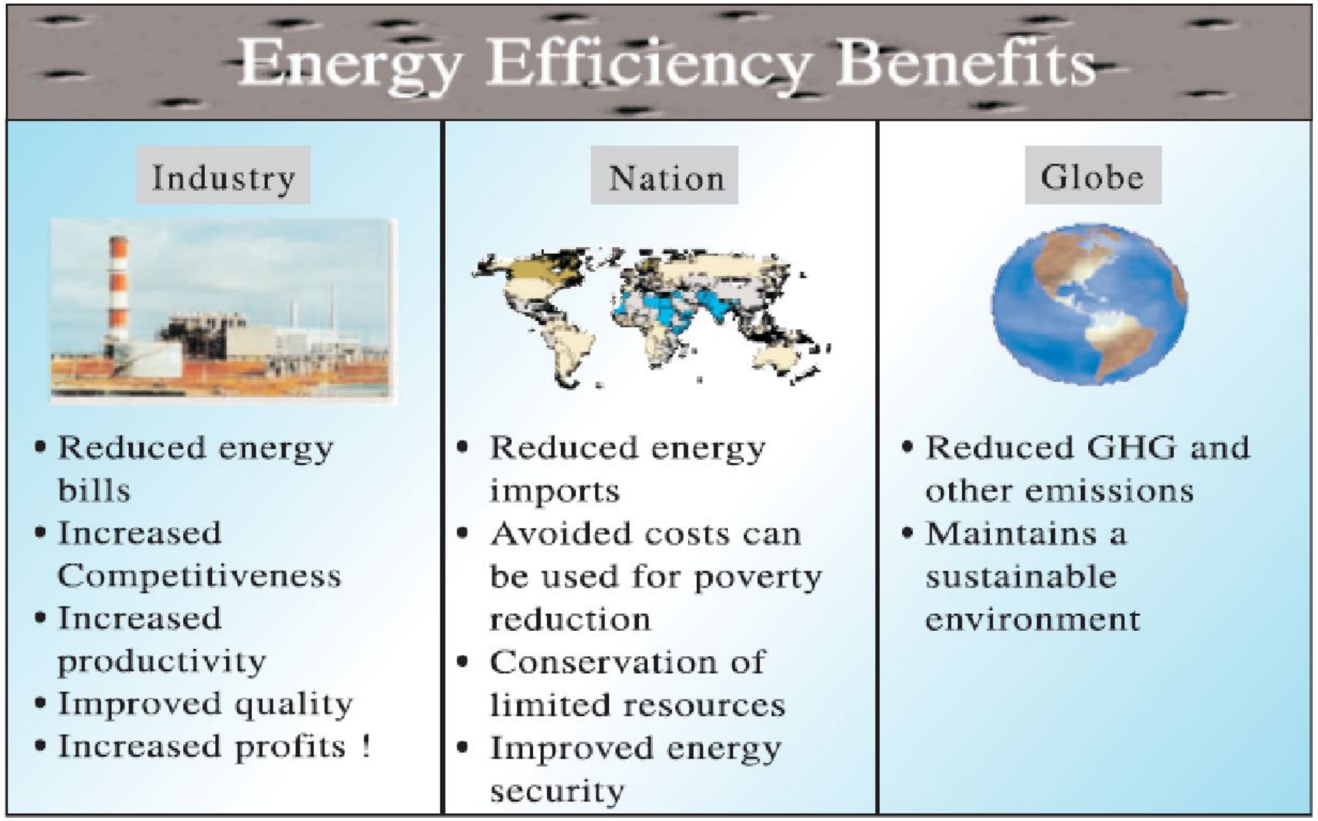
Energy Conservation and Energy Efficiency are separate, but related concepts. Energy conservation is achieved when growth of energy consumption is reduced in physical terms. Energy Conservation can, therefore, is the result of several processes or developments, such as productivity increase or technological progress. On the other hand Energy efficiency is achieved when energy intensity in a specific product, process or area of production or consumption is reduced without affecting output, consumption or comfort levels. Promotion of energy efficiency will contribute to energy conservation and is therefore an integral part of energy conservation promotional policies.

Energy Conservation and its importance

Energy efficiency is often viewed as a resource option like coal, oil or natural gas. It provides additional economic value by preserving the resource base and reducing pollution. For example, replacing Incandescent lamps with LED's means will require 1/8th of the energy to light a room. Pollution levels also reduce by the same amount



Energy Conservation and its importance



GHG – Green-House Gas

Energy Audit

Energy Audit is the key to a systematic approach for decision-making in the area of energy management. It attempts to balance the total energy inputs with its use, and serves to identify all the energy streams in a facility. It quantifies energy usage according to its discrete functions. Industrial Energy Audit is fundamental to a comprehensive energy management programme and is defined in EC Act 2001 as follows:

"Energy Audit" means the <u>verification</u>, <u>monitoring</u> and <u>analysis</u> of use of energy including <u>submission of technical report</u> containing r<u>ecommendations</u> for improving energy efficiency with <u>cost benefit analysis</u> and an <u>action plan</u> to reduce energy consumption.

<u>Need for Energy audit:</u>

In any industry, the three top operating costs are often found to be energy (both electrical and thermal), labour and materials. Among the three, energy has the highest potential for cost reduction. Energy audit will help to understand more about the ways energy is used in the industry, and help in identifying the areas where waste can occur and where scope for improvement exists.

Energy Audit

Types of Energy audit:

The type of energy audit to be performed depends on the type of industry, the depth to which final audit is needed, and the potential and magnitude of cost reduction desired. Thus energy audit can be classified into the following types: Preliminary Audit, Targeted Energy Audits and Detailed Audit.

Preliminary Energy Audit

Preliminary energy audit, which is also known as Walk-Through Audit and Diagnostic Audit, is a relatively quick exercise and uses existing, or easily obtained data. The scope of preliminary energy audit is to:

- Establish energy consumption in the organization (sources: energy bills and invoices)
- Obtain related data such as production for relating with energy consumption
- Estimate the scope for energy savings
- Identify the most likely and the easiest areas for attention (e.g. unnecessary lighting, higher temperature settings, leakage etc.)
- Identify immediate (especially no-/low-cost) improvements/ savings
- Set up a *baseline* or *reference point* for energy consumption
- Identify areas for more detailed study/measurement

Energy Audit

Some example of no-cost energy management measures are:

- Arresting leaks (steam, compressed air)
- Controlling excess air by adjusting fan damper

Some examples of low-cost energy management measures are:

- Shutting equipment when not needed (e.g. idle running of motors)
- Replacement with appropriate lamps and luminaires

Areas for detailed study/measurement are:

- Converting from direct to indirect steam heated equipment and recovery of condensate
- Installing / upgrading insulation on equipment
- Modifying process to reduce steam demand
- Investigating scheduling of process operations to reduce peak steam or water demands
- Evaluating waste heat streams for potential waste heat recovery

Energy Audit

Targeted Energy Audits

Targeted energy audits often results from preliminary audits. They provide data and detailed analysis on specified target projects. For example, an organization may target its lighting system or boiler system or steam system or compressed air system with a view of effecting energy savings. Targeted audits therefore involve detailed surveys of the target subjects and analysis of the energy flows and cost associated with the targets. Final outcome is the recommendations regarding actions to be taken.

Detailed Energy Audit

Detailed energy audit is a comprehensive audit and results in a detailed energy project implementation plan for a facility, since it accounts for the energy use of all major equipment. It considers the interactive effects of various projects and offers the most accurate estimate of energy savings and cost. It includes detailed energy cost saving calculations and project implementation costs.

One of the key elements in a detailed energy audit is the energy balance. This is based on an inventory of energy-using systems, assumptions of current operating conditions, measurements and calculations of energy use.

Energy Audit

Ten Steps Methodology for Conducting Detailed Energy Audit

Step No	PLAN OF ACTION	PURPOSE / RESULTS
PHASE I –PRE AUDIT PHASE		
Step 1	• **Plan and Organise** • **Walk through Audit** • **Informal Interview** with Energy Manager, Production / Plant Manager	• Establish/organize a **Energy audit team** • Organize Instruments and time frame • Macro data collection (suitable to type of industry.) • Familiarization with process / plant activities • First hand observation and Assessment of current level of operation and practices
Step 2	• **Introductory Meeting** with all divisional heads and persons concerned with energy management (1-2 hrs.)	• To built up cooperation and rapport • Orientation, awareness creation • Issue questionnaire tailored for each department

Energy Audit

PHASE II –AUDIT PHASE		
Step 3	• **Primary data gathering, Process Flow Diagram and Energy Utility Diagram**	• Historic data collection and analysis for setting up **Baseline energy consumption** • All service **utilities system diagram** (e.g. Single line power distribution diagram, water, and compressed air and steam distribution). • Prepare **process flow charts** • Design, operating data and schedule of operation • Annual Energy Bill and **energy consumption pattern** (Refer manual, logbook, name plate etc.)
Step 4	• **Conduct survey and monitoring**	• **Measurements** : Motor survey, Insulation, lighting survey etc. with portable instruments for operating data. Confirm and compare operating data with design data.
Step 5	• **Conduct of detailed trials /** tests for selected major energy equipment	• **Trials / Tests** - 24 hours power monitoring (MD, PF, kWH etc.). - Load variations trends in pumps, fan compressors etc. - Boiler Efficiency trials for (4-8 hours) - Furnace Efficiency trials - Equipments Performance tests etc

Energy Audit

Step 6	• **Analysis of energy use**	• **Energy and Material balance** • **Energy loss/waste analysis**
Step 7	• **Identification and development of Energy Conservation (ENCON) opportunities**	• Conceive, develop and refine ideas • Review ideas suggested by unit personnel • Review ideas suggested in previous energy audit report if any • Use brainstorming and value analysis techniques • Contact vendors for new / efficient technology
Step 8	• **Cost benefit analysis**	• Assess technical feasibility, economic viability and prioritization of ENCON options for implementation • Select the most promising projects • Prioritise by low, medium, long term measures
Step 9	• **Reporting and Presentation** to the Top Management	• Documentation, draft Report Presentation to the top Management. • Final report preparation on feedback from unit
PHASE II –POST AUDIT PHASE		
Step 10	• **Implementation and Follow-up**	**Implementation of ENCON recommendation measures** and Monitor the performance • Action plan, schedule for implementation • Monitoring and periodic review

Energy Audit

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Role and Needs of Energy Managers

Energy Manager basics:

The role of an Energy Manager (EM) involves facilitating energy conservation by identifying and implementing various options for saving energy, leading awareness programs, and monitoring energy consumption. As such, EMs play a critical role in the successful implementation of energy conservation and demand management programs within the industry.

- ✔ Saving Energy
- ✔ Annual Savings Targets
- ✔ Reporting
- ✔ Quarterly Report Reviews
- ✔ Annual Reviews

Role and Needs of Energy Managers

Saving Energy:

EM duties revolve around the identification, reporting and implementation of energy savings opportunities. For quick reference, the responsibilities identified in the EM Agreement are summarized below:

- ✔ Electrical Energy Saving Project Implementation
- ✔ Energy Tracking & Monitoring
- ✔ Primary Assessment
- ✔ Maintenance and Operating Schedules
- ✔ Energy Savings Opportunities & Action Plan
- ✔ Measurement & Verification Strategy
- ✔ Energy Management Behaviour and Business Process Improvements
- ✔ Employee Awareness Programs
- ✔ Assistance to IESO Projects
- ✔ Reporting

Role and Needs of Energy Managers

Annual Savings Targets:

- EMs must meet two targets as laid out in the IAP Energy Manager Funding Agreement:
  - ✔ Minimum 2,000 MWh Annual Savings Target
  - ✔ Minimum 10% of Annual Savings Target attributed to Projects not financed by IESO incentives (non-incented)
- Understanding that it can be challenging to reach the targets in the first year of the agreement, if the EM does not meet the Annual Savings Target in the first twelve month period of the Agreement, the shortfall will be added to the Annual Savings Target for the second twelve month period. There is no adjustment in the maximum funding amount if some of the missed target in the first year is carried over to the second year. And the transfer of the target is only available in the first year.
- Performance will be assessed based on Quarterly Reports submitted by EMs.

Role and Needs of Energy Managers

Reporting:

- Energy management activities and conservation measures must be reported in Quarterly Reports. Quarterly Reports are submitted to the IESO for review and approval under the EM Funding Agreement.
- As part of the reporting requirements under the EM Funding Agreement, EMs are required to prepare the following reporting documents:
  - ✔ Quarterly Reports within 30 days of the end of each quarter.
  - ✔ EMs are encouraged to provide the Quarterly Reports as close to the end of each quarter as possible.
  - ✔ It is recommended that the Quarterly Report be maintained as a living document and used for project tracking purposes, such that it can be provided to the IESO at any time, without need of significant updates.
  - ✔ An Energy Management Plan (EMP) for each Facility occupied by the Participant, no later than six (6) months after the EM's employment start date, unless an EMP already exists.
  - ✔ An updated EMP is required for each subsequent twelve (12) month term.
  - ✔ It is highly recommended that Energy Managers make use of the Quarterly Report Template.

Role and Needs of Energy Managers

Quarterly Report Reviews:

- Each Quarterly Report will be reviewed by the IESO’s Technical Reviewer so that the likelihood of targets being met can be assessed.
- Mid-term technical review of non-incented Measures can be valuable to IESO accounting.
- Quarterly Reports should include all Measures to date, including those in previous reports and those that have been reviewed.
- Quarterly Reports should also include Projects planned for the next term that show the potential to meet the next term’s targets.

Annual Reviews:

- At the end of the fourth quarter of each EM term, an annual review will be performed by the IESO’s Technical Reviewer to determine whether targets have been met.
- The annual review is based on the fourth Quarterly Report, which should identify all Projects that are complete and in-service such that they can be counted towards the current term’s Annual Savings Target.

Role and Needs of Energy Managers

Technical Review of Non-Incented Savings:

Technical review of non-incented savings are conducted as the pre and post project information becomes available. This review may occur during a Quarterly Report review or the Annual Review.

- During the Quarterly & Annual Review process for EMs, the IESO's Technical Reviewer will perform a technical review of significant non-incented projects in order substantiate and verify the reported savings.
- For all other non-incented savings, the IESO's Technical Reviewer will still perform a high level check to ensure that the reported savings are reasonable and to assign a persistence value.
- In order to enable the review of non-incented projects, it is recommended that additional documentation be maintained, such as spillover forms, supporting calculations, operating conditions and technical specifications for pre and post project equipment.
- In addition, it is also recommended that pre and post project Measurement and Verification (M&V) be conducted for non-incented projects, where feasible, to provide support for the claimed energy savings.
  - ✔ The best support of any project is robust pre-project and post-project power consumption data as collected with power meters or similar instrumentation.
  - ✔ IPMVP-level M&V may not be warranted, but reasonable M&V should be performed for the benefit of internal project management, as well as IAP reporting.
  - ✔ An M&V strategy for ALL substantial projects is a characteristic of successful energy management and a proven strategy for gaining management buy-in.

Instruments for Energy auditing

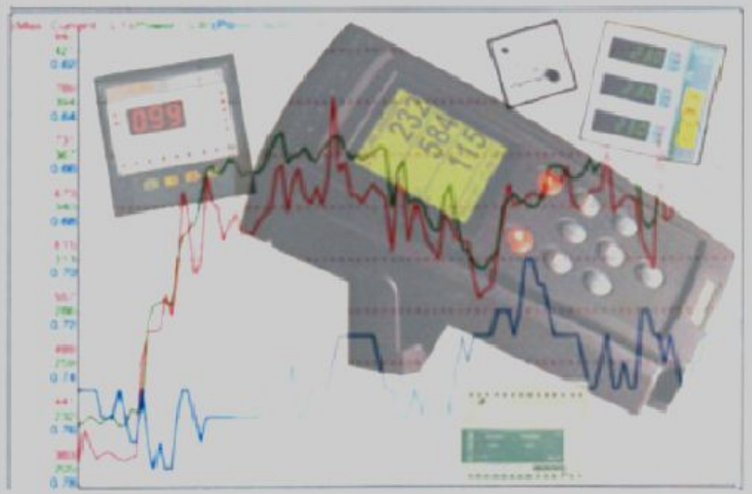
The requirement for an energy audit is to identify and quantify where energy is being used necessitates measurements. These measurements require the use of instruments. The basic instruments used in energy audit work are listed below. These instruments are portable, durable, easy to operate and relatively inexpensive.

Key Performance Parameters for Energy Audit

Basic Electrical Parameters in AC & DC systems – Voltage (V), Current (I), Power factor, Active power (kW), Maximum demand (kVA), Reactive power (kVAr), Energy consumption (kWh), Frequency (Hz), Harmonics, etc.

Parameters of importance other than electrical such as Temperature and Heat Flow, Radiation , Air and Gas Flow, Liquid Flow, RPM , Air Velocity, Noise and Vibration, Dust Concentration, TDS, PH, Moisture Content, Relative Humidity, Flue Gas Analysis – CO_2, O_2, CO, SO_x, NO_x, Combustion Efficiency etc.

Instruments for Energy auditing



Electrical Measuring Instruments:

These are instruments for measuring major electrical parameters such as KVA, KW, PF, Hertz, KVAr, Amps and Volts. In addition some of these instruments also measure harmonics.

These instruments are applied on-line i.e. on running motors without any need to stop the motor. Instant measurements can be taken with hand-held meters, while more advanced ones facilitates cumulative readings with print outs at specified intervals.

Some precautions and safety measures:

To avoid short circuits and potentially life-threatening hazards, never attach the clamp to a circuit that operates at more than the maximum rated voltage, or over bare conductors.

While using the instrument, use rubber hand gloves, boots, and a safety helmet, to avoid electrical shocks, and do not use the instrument when hands are wet.

Instruments for Energy auditing

Fyrite:

In this, a hand bellow pump draws the flue gas sample into the solution inside the fyrite. Thereafter, a chemical reaction changes the liquid volume that reveals the amount of gas percentage. Oxygen or CO_2 can be read from the scale. The FYRITE employs the well-known "Orsat method of volumetric analysis" using chemical absorption of a sample gas such as carbon dioxide or oxygen. The reagent used to absorb carbon dioxide (CO_2) is potassium hydroxide (dyed red), and chromous chloride (blue) is the absorbent for oxygen (O_2). The unique feature of the FYRITE is that the absorbing fluid is also used as the indicating fluid so that one vessel takes the place of both measuring burette and absorption pipette.

Fuel Efficiency Monitor:

This measures Oxygen and temperature of the flue gas. Calorific values of common fuels are fed into the microprocessor which calculates the combustion efficiency.

Instruments for Energy auditing

Combustion Gas Analyzer:

This instrument has in-built chemical cells which measure various gases such as CO_2, CO, NO_X, SO_X etc.

Gas analyzers are flexible in what must be measured depending on the requirements of the customer/user.

They have specific sensors sealed inside the equipment that can be changed to measure the different components in the gas. But because a maximum of two sensors can be connected, only two or three parameters can be measured at one time.

It is light and easier to handle compared to the fuel efficiency monitor.

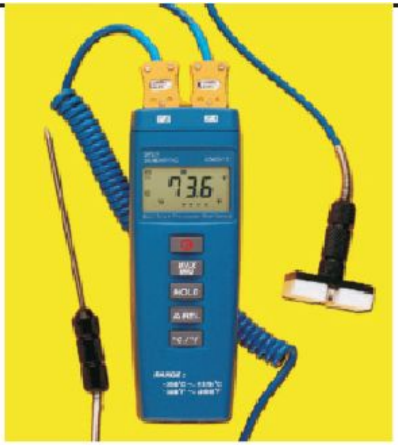
Instruments for Energy auditing

Manometer with Pitot Tube:

Digital flexible membrane manometer is used for measuring pressures in air ducts carrying exhaust flue gases (boiler, furnaces), or air from fans and blowers.

- To measure pressure in air pipes, manometers must be used in combination with a pitot tube
- Attach flexible rubber tubes to the inlet and outlet probes of the manometer. Tighten these to ensure that there is no leakage of air.
- Attach these two tubes to the ends of the pitot tube
- Make a 6-cm monitoring hole in the duct or pipeline
- Insert the pitot tube into the monitoring hole

Instruments for Energy auditing

	**Contact Thermometer:** These are thermocouples which measures for example flue gas, hot air, hot water temperatures by insertion of probe into the stream. For surface temperature a leaf type probe is used with the same instrument.
	**Non Contact Infrared Thermometer**: Infrared thermometers calculate the amount of thermal radiation (infrared radiation) emitted from the object. By knowing the emissivity of the object and the amount of infrared energy emitted by the object, the object's temperature can be determined. With the help of infrared thermometers, temperatures of the objects placed in hazardous or hard-to-reach places or other situations can be determined. The most common design of a IR thermometer consists of a lens to focus the infrared energy on to a detector. The detector changes the energy to an electrical signal that can be shown in units of temperature after being corrected for ambient temperature variation.

Instruments for Energy auditing

Ultrasonic Flow Meter:

This is one of the popular means of non-contact flow measurement. There are two main types of ultrasonic flow meters: Transit time and Doppler. Transit time ultrasonic meters have both a sender and a receiver. They send two ultrasonic signals across a pipe: one traveling with the flow and one traveling against the flow.

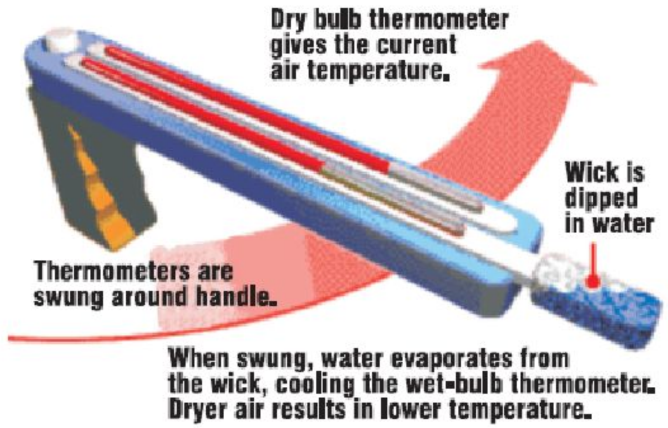
The ultrasonic signal traveling with the flow travels faster than a signal traveling against the flow. The ultrasonic flow meter measures the transit time of both signals. The difference between these two timings is proportional to flow rate.

Transit time ultrasonic flow meters usually monitor clean liquids. Doppler ultrasonic flow meters measure dirty liquids. They compute flow rate based on a frequency shift that occurs when their ultrasonic signals reflect off particles in the flow stream.

Instruments for Energy auditing

 Tachometer	 Stroboscope	**Speed Measurements:** In any audit exercise speed measurements are critical as they may change with factors such as frequency, belt slip, loading, etc. A simple tachometer is a contact type instrument, which can be used where direct access is possible. More sophisticated and safer ones are non contact instruments such as stroboscopes. A stroboscopic light source provides high-intensity flashes of light, which can be caused to occur at a precise frequency. When this light source is made to fall on an object with periodic motion it appears that the motion is slowed down, or stopped when both the frequencies bear a definite relationship. A stroboscope uses this principle for measurement of RPM.

Instruments for Energy auditing



Psychrometer:

A sling psychrometer - consists of two thermometers mounted together with a handle. One thermometer is ordinary and measures the dry bulb temperature. The other has a wet cloth wick, over its bulb and is called a wet-bulb thermometer. When a reading is to be taken the psychrometer is whirled around. The water evaporates from the wick, cooling the wet-bulb thermometer. Then the temperatures of both thermometers are read. If the surrounding air is dry, more moisture evaporates from the wick, cooling the wet-bulb thermometer more, so there is a greater difference between the temperatures of the two thermometers. By using these temperatures the humidity is computed.

Instruments for Energy auditing

Lux Meters:

A light sensitive cell measures the incident light (all light in the visible spectrum is measured) and evaluates that against the human daylight sensitivity curve. The resulting value is the measurement result in lux. This works well but it requires a different correction factor for every light spectrum.

The much more expensive lux meters with one cell are optimized and tuned with optical filters and lenses such that the sensitivity of this set of lenses and the cell itself directly matches the eye's light sensitivity curve (so only one correction value needed for light of any spectral content).

Instruments for Energy auditing

	**Smart Energy Meters** The term smart meter usually refers to electric meters which keep detailed statistics on usage, but it can be used for fuels or water applications as well performing the same job. The primary purpose of smart meters is to provide information on how end users use their electricity on a real-time basis. The smart energy meters use a wireless communication to help track the electricity consumption and thus save both electricity and money. It can be easily installed and gives an accurate reading of electricity consumption which can also be monitored / controlled through mobile or internet.

Instruments for Energy auditing

Thermography

Infra-red thermal monitoring and imaging (non-contact type) measures thermal energy radiation from hot/cold surfaces of an object and provides input for assessing health of equipment and predictive maintenance.

The thermal camera unit converts electromagnetic thermal energy (IR) radiated from an object into electronic video signals. These signals are amplified and transmitted via interconnected cable to a display monitor where the resulting image is analysed and interpreted for hot/cold spots.