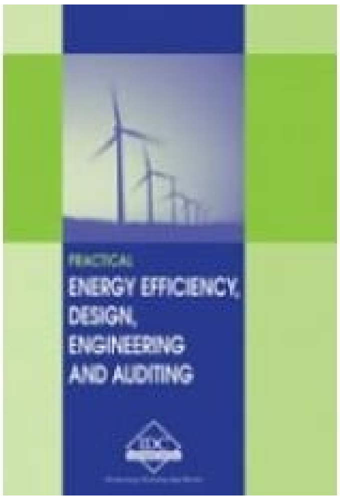
EE-E - Practical Energy Efficiency, Design and Auditing



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Short Description

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Description

This manual gives you practical tools to identify and implement programs and projects to reduce energy consumption in the most effective and practical ways. You can start such programs as soon as you wish, and start saving immediately thereafter.

This manual covers the fundamental principles of energy efficiency by way of looking for points of wastage, assessment of the cost of energy usage and benefits accruing from improved energy efficiency in the facility. Once you have the correct information from the audit, you will be able to apply a simple method of cost analysis to help you make the right decisions for improvement, based on the principle of rapid return on investment (RRI).

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The Need for Energy Efficiency

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The Need for Energy Efficiency

This chapter starts with a discussion on why energy and environment are becoming the most talked about subjects in almost all forums globally. It goes on to explain how energy sources are classified. An overall picture of the energy available from all the currently known sources is given. The chapter brings up the issues which are worrying the world community and covers the initiatives being taken to meet the twin challenges of energy security and environmental protection. Important aspects of the Kyoto protocol, which is currently the most ambitious enterprise undertaken by the member countries of the United Nations to limit the level of emission of green house gases into the atmosphere, are discussed in detail.

Learning objectives

- To appreciate the significance of energy efficiency and its implications for the future of our civilization
- To understand the linkage between energy, environment and climate change
- Discuss the effects of climate change on human, animal and plant lives
- Be introduced to world bodies tackling these issues, their composition and organizational structure
- To know the working of Kyoto protocol, its flexible mechanisms and how carbon credits are claimed and traded

1.1 Global energy scenario

Modern society today is critically dependent on energy for its development and in all likelihood will continue to be so for the foreseeable future. The known sources of energy are getting depleted at an ever-increasing rate. The effluents generated by the current technologies of production and consumption of energy are causing permanent damage to our natural habitat. These twin pressures have brought a certain urgency to plan measures for a more sustainable way of development. These measures are to be adopted by all sections of society: the government, utility companies, industries and individuals.

Energy as we know it is inextricably linked with our environment. Almost all the energy we use for electricity and fuel is sourced from natural resources such as wood, coal, mineral oil, hydro power, wind, solar and nuclear. Most of these resources are not renewable over a short period. The usage of energy is accompanied with huge wastages, to the extent of 60–70%, as we shall see later. The energy wasted in the form of heat or effluents is pumped back into the environment, from which it can neither be retrieved, nor utilized in any useful way.

The global primary energy consumption at the end of 2003 was equivalent to 9741 million tons of oil equivalent (MTOE).

The International Energy Agency (Figure 1.1) predicts that world electricity demand will double between 2000 and 2030, with the most rapid growth occurring in people's homes.

Figure 1.1

IEA Energy Predictions

Imagine that 60–70% of this was not only waste but also contributed to permanently denting the environment. Energy efficiency is all about how to contain this waste, preserve the environment and stretch the inventory of current energy resources, until alternative renewable and more sustainable sources of energy are developed.

Energy can be classified based on the following criteria:

- Primary or secondary
- Commercial or non-commercial
- Renewable or non- renewable

1.1.1 Primary or secondary energy

Primary energy sources are the ones found in nature. The common resources are wood, coal, oil and natural gas. Some other primary resources are nuclear energy stored in radioactive substances, thermal energy in earth’s interior and potential energy due to earth’s gravity.

Secondary energy is the energy derived from the primary sources such as electricity and heat from coal, oil and wood.

1.1.2 Commercial or non-commercial

Commercial energy sources are available in the market for a price. These are electricity, furnace oil, diesel, petrol, CNG and other natural gases, etc.

Non-commercial energy is produced from resources which are normally not available in a market for a price, such as firewood, cow dung or agricultural waste.

1.1.3 Renewable or non-renewable energy

Sources of energy which cannot be replenished by nature over a short period are known as non-renewable sources. These are coal, oil, and natural gas.

Renewable sources like hydro power, wind power and solar energy are continuously replenished by nature. A typical feature of renewable sources of energy is that they can be converted into secondary energy without producing harmful effluents.

1.1.4 Global primary energy reserves

- Coal: Proven global reserves of coal at the end of 2003 have been estimated to be 984453 million tons and expected to last for approximately 200 years
- Oil: The proven global reserves at the end of 2003 were estimated to be 1147 billion barrels and expected to last for 45 years
- Gas: The global proven reserve of gas was estimated to be 176 million cubic meters at the end of 2003 and expected to last for 65 years

1.1.5 Primary energy consumption by fuel, in the year 2003

- Oil: 3636.6 MTOE
- Gas: 2331.9 MTOE
- Coal: 2578.4 MTOE
- Nuclear: 598.8 MTOE
- Hydro: 595.4 MTOE

1.2 Climate change and environmental concerns

The production and consumption of energy at such huge scales has raised a number of environmental issues. In 1896, Swedish scientist Svante Arrhenius predicted that human activities would interfere with the way the sun interacts with the earth, resulting in global warming and climate change. Arrhenius's prediction has come true. Climate change and global warming are a reality now.

Major environmental issues of global concern are:

- Ozone layer depletion
- Global warming
- Loss of biodiversity

1.2.1 Ozone layer depletion

Ozone gas (O_3) forms a layer in the earth's stratosphere which extends up to 10–50 km from the earth's surface. This ozone layer absorbs the ultra violet – B (UV-B) rays from the sun, and protects the human, animal and plant life from harmful effects of UV+B rays. The content of ozone in the stratosphere remains constant by a natural process. However, man-made chlorine and bromine can react with ozone and deplete its content in the atmosphere. It has been found that over the years that a release of the chemicals (FCs, HCFCs, carbon tetrachloride, and methyl bromide) generally used as refrigerants in refrigerators and air conditioners, release chlorine and bromine gases. Under the influence of UV rays each of the Cl and Br atoms react with ozone a multiple number of times (estimated up to 100,000) and destroy it.

The ozone layer thickness is measured by using a Dobson ozone spectrophotometer (measured in Dobson units) by sensing the amount of UV rays reaching the earth's surface. These refrigerant gases have been depleting the ozone layer for the last 30 to 40 years, and have upset the natural equilibrium that existed for thousand of years.

The effects of ozone layer depletion can be seen in various ways:

- Human and Animal: increases in the UV radiation reaching the earth's surface causes eye diseases, skin cancer and infectious diseases
- Terrestrial plants: increased radiation is destroying certain species and causing a loss of biodiversity
- Aquatic Eco-system: UV radiation can affect the distribution of

phytoplankton, which form the foundation of aquatic food webs and can also impair all kinds of marine life

- Effects on biogeochemical cycles: increased solar UV radiation affects terrestrial and aquatic biogeochemical cycles and alters both sources and sinks of greenhouse and important trace gases, e.g. carbon dioxide (CO_2), carbon mono-oxide (CO), carbonyle sulphide (COS), etc. These changes contribute to a biosphere feedback responsible for the atmospheric build up of greenhouse gases

The role of the ozone layer in filtering out the dangerous UV+B radiation from the sun's radiation is extremely critical for human, animal, and plant life. The depletion of the ozone layer can result in harmful radiation reaching the earth's surface with dangerous consequences.

Ozone depletion countermeasures that have been put in place are:

- International cooperation (Montreal protocol) to phase out ozone depleting chemicals in 1974
- Taxes imposed on ozone depleting substances
- Ozone friendly substances - HCFC (less ozone depleting potential and shorter half-life)
- Recycling of CFCs and Halons

1.2.2 Global warming

Since the industrial revolution, human activities like fossil fuel burning, deforestation and altered agricultural practices have been affecting the composition of gases in the atmosphere causing significant climatic and environmental changes.

Studies have revealed the earth's climate to be increasingly warmer in the last 100 years compared to the previous 8000 years, when the temperatures were relatively constant. The present average global temperatures are 0.3–0.6°C warmer than a century ago.

The main greenhouse gas (GHG) causing the global warming is carbon-dioxide (CO_2). CFCs, even though they exist in very small quantities, are also significant contributors to global warming.

Sources of greenhouse gases

Gases in some sources like water vapor, carbon dioxide, methane, nitrous oxide and ozone occur naturally. Human activities (anthropogenic activities) are adding to the levels of most of these naturally occurring gases.

Combustion of fossil fuels, decomposition of solid organic wastes, industrial and agricultural activities are the main contributors to the rise in the level of greenhouse gases. Powerful greenhouse gases that do not occur naturally include Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs) and Sulfur hexafluoride (SF_6) are generated in a variety of industrial processes.

Estimates of greenhouse gases are presented in units of millions of metric tons of carbon equivalent (MMTCE) which weigh each gas by its global warming potential. Global warming potential (GWP) is an important measure of the strength of different greenhouse gases in the atmosphere.

Each greenhouse gas differs in its ability to absorb heat in the atmosphere. HFCs and PFCs are the most heat absorbent. Methane traps over 21 times more heat per molecule than carbon dioxide and nitrous oxide absorbs 270 times more heat per molecule than carbon dioxide. Conventionally the GWP of carbon dioxide is 1. The GWPs of all other GHGs are measured relative to the GWP of carbon dioxide.

Carbon dioxide, however, is still the most important greenhouse gas contributing to about 60% of the enhancement to the greenhouse effect, since the concentration of other greenhouse gases is much lower.

Effects of global warming

Some of the effects of global warming are:

- Rise in global temperature: There is strong evidence that most of the rises in global temperature in the last 50 years are caused by human activities. Climate models predict that the global temperatures will rise by about 6°C by the year 2100
- Rise in sea level: The mean sea levels are expected to rise 9-88cm by the year 2100, causing flooding of low lying areas and other damages
- Food shortages: Water resources are likely to be affected as precipitation and evaporation patterns change around the world. This may also affect agricultural output

1.2.3 Loss of biodiversity

Biodiversity refers to the variety of life on earth and its biologically diverse range. The number of species of plants, animals, micro-organisms, the enormous diversity of genes in these species, the different eco-systems on the planet such as deserts, rain forests and coral reefs are all a part of a biologically diverse earth. Biodiversity actually boosts ecosystem productivity and enables the ecosystem to sustain itself against a variety of natural disasters.

There is a World Resource Institute report, which shows a strong link between biodiversity and climate change. Global warming is known to affect the ecosystem's adaptability to nature. Deforestation is significantly contributing to the build up of carbon dioxide in the atmosphere.

1.3 Global responses

The earth's climate has always changed and evolved. Some of these changes have been due to natural causes but others can be attributed to human activities such as deforestation and to atmospheric emission from things like industry and transport which have led to gases and aerosols being stored in the atmosphere. These are known as greenhouse gases (GHGs) because they trap heat and raise temperatures near the ground, acting like a greenhouse on the surface of the planet.

Global warming has begun to affect sea levels, snow cover, ice sheets and rainfall. Shifts in regional patterns of climate marked by rising air temperatures are affecting water sheds and ecosystems in many parts of the world. The cost to national economies of coping with extreme weather events, crop failures and other emergencies related to climate is growing steadily higher. The human costs are also multiplying.

There is now a general consensus that most of the global warming creating the climate change are due to human activities, such as the burning of fossil fuels, automobile emission and changes in land use. It is estimated that 80% of all carbon dioxide emission originates from the combustion of fossil fuels used for energy generation.

1.3.1 United Nations framework convention on climate change (UNFCC)

The first world climate conference in 1979 identified climate change as an urgent world problem and issued a declaration calling on governments to anticipate and guard against potential climate change hazards. In 1990 the intergovernmental panel on climate change published the first report on the state of the global climate, which became the main base for negotiations under the United Nations general assembly on climate change convention.

In June 1992 the United Nations frame work convention on climate change was signed by 154 states in Rio de Janeiro. The climate convention is the base for international co-operation within the climate change area. The objective of the convention is to achieve stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. The objective is qualified in that it should be achieved within a time frame sufficient to allow the ecosystem to adapt naturally to climate change, to ensure that food production is not threatened and to allow economic development to proceed in a sustainable manner.

An important factor is that stabilizing concentrations of GHGs near current levels would actually require a steep reduction of current emissions. This is because, once emitted, the GHGs remain in the atmosphere for a considerable length of time. Carbon dioxide for instance, stays in the climate system on average for a century.

The principle commitment applying to parties of the convention is the adoption of policies and measures on the mitigation of climate charge, by leveling the anthropogenic emission of GHGs and protecting and enhancing greenhouse gas sinks and reservoirs. The commitment includes the preparation and communication of national inventories of greenhouse gases. The climate convention does not have any quantitative targets or time tables for individual nations. However, the overall objective can be interpreted as the stabilization of emissions of greenhouse gases by the year 2000 at 1990 levels.

1.3.2 The conference of the parties (COP)

The climate change process revolves around the annual sessions of the COP which bring together all countries that are parties to the convention. The COP is the supreme body of the convention and it is the highest decision making authority. The COP currently consists of more than 190 states.

The COP meets at regular intervals to examine the commitments made by the parties; it promotes and facilitates exchange of information, develops methodologies for implementing the measures of the convention and assesses their implementation.

Annex I parties

The convention currently lists 41 industrialized countries as Annex I parties (see

Table 1.1). They include both the relatively wealthy countries plus the states whose economies are in the process of transition (EIT) to market economies, including the Russian federation, the Baltic States and several central and European states.

Annex I parties have higher per capita emissions than most developing countries and they have a greater financial and institutional capacity to address climate change. The convention requires these parties to take the lead in modifying the long term trends in emission.

Table 1.1 *Annex I parties*

Australia	Liechtenstein
Austria	Lithuania *
Belarus *	**Luxembourg**
Belgium	Monaco
Bulgaria *	**Netherlands**
Canada	**New Zealand**
Croatia *	**Norway**
Czech Republic*	Poland *
Denmark	**Portugal**
European Economic Community	Romania *
Estonia *	Russian Federation *
Finland	Slovakia *
France	Slovenia *
Germany	**Spain**
Greece	**Sweden**
Hungary *	**Switzerland**
Iceland	Turkey
Ireland	Ukraine *
Italy	**United Kingdom of Great Britain and Northern Ireland**
Japan	**United States of America**
Latvia *	

* Countries that are undergoing the process of transition to market economy.

Annex II parties

Annex II of the convention currently contains 24 parties (listed in bold in Table 1.1) who have a special obligation to provide new and additional financial resources to developing countries to help than tackle climate change. They must also facilitate the transfer of climate friendly technologies to both developing countries and EITs.

Non-Annex I parties

All the other parties, most of whom are developing countries, are called Non-Annex I parties, and have small emission levels on a per capita basis. Furthermore, their economies are less able to absorb the cost of changing to cleaner fuels. These parties must report in more general terms on their actions to address climate change and to adapt to its effects.

1.4 Kyoto protocol

When it became apparent that major nations such as the United States and Japan would not meet the voluntary stabilization target by 1995, the COP decided to enter into negotiations on a protocol to establish legally binding limitation or reduction in greenhouse gas emission. It was decided by the parties that this round of negotiations would establish limitation only for the developed countries, including the EITs. In December 1997, the protocol known as the Kyoto protocol was completed. The Kyoto protocol is an agreement made under the United Nations Framework convention on climate change. Countries ratifying the protocol are committed to reduce their emission of 6 major GHGs given below:

<u>Gases</u>

- Carbon Dioxide (CO_2)
- Methane (CH_4)
- Nitrous Oxide (N_2O)
- Sulfur hexafluoride (SF_6)

<u>Gas groups</u>

- Hydro fluorocarbons (HFCs)
- Perfluorocarbons (PFCs)

Emission of these gases is to be limited or reduced in six key sectors:

- Energy
- Transport
- Industrial processes

- Agriculture
- Land use change and forestry
- Waste

The core element of the Kyoto protocol is the legal binding of Annex I parties who are also parities to the protocol, to specific commitments on GHG limitation or reduction. The reduction or limitation objectives of all these parties are shown in Table 1.2.

The amounts for each are listed as percentage of the base year 1990 and range from a reduction of 8% for most European countries to an increase of 10% for Iceland. The reductions envisaged are calculated to reduce the overall emission by at least 5% below the baseline level for the group as a whole, the normal baseline year being 1990 (with provision for flexibility for EITs and certain types of gases). The limitation and reductions are not targeted at a single year but are calculated as a mean of reduction logged over a five year commitment period from 2008 to 2012.

The maximum amount of carbon dioxide emission units (or the equivalent of such units in the case of other GHGs) that a party may emit during the commitment period, if it is to fully comply with its emission target, is referred to as its assigned amount. Removals of GHGs by sinks can be counted towards a country's commitment subject to certain provisions.

Table 1.2

Countries included in Annex B to the Kyoto protocol and their emission targets

Country	**Target***
EU**	-8%
Bulgaria, Czech republic, Estonia,Latvia, Liechtenstein,Lithuania, Monaco, Romania, Slovakia, Slovenia, Switzerland	-8%
US***	-7%
Canada, Hungary, Japan, Poland	-6%
Croatia	-5%
New Zealand, Russian Federation, Ukraine	-0%
Norway	+1%
Australia	+8%
Iceland	+10%

* Some EITs have a baseline other than 1990

** The EU’s 15 member states will redistribute their targets among themselves taking advantage of a scheme under the protocol known as ‘bubble’. The EU has already reached agreement on how its target will be redistributed.

*** The US has not ratified the Kyoto protocol. Although they are listed in the Annex I. Belarus and Turkey are not included in the protocols Annex B as they were not parties to the convention when the protocol was adopted.

The Kyoto protocol had to be signed and ratified by a minimum of 55 countries including those responsible for at least 55% of the developed world’s 1990 carbon dioxide emissions before it could be enforced. The protocol came into force on February 16, 2005 after its ratification by the Russian federation. To date, 148 countries have signed and ratified the protocol. To achieve their targets, Annex I parties must put in place domestic policies and measures. The protocol provides an indicative list of policies and measures that might help mitigate climate change and promote sustainable development.

Parties may offset their emissions by increasing the amount of greenhouse gas removed from the atmosphere by so allied carbon “sinks” in the land and forestry (LULUCF) sector. However, only certain activities in this sector are eligible: aforestation, reforestation and deforestation and forest management, crop land management, grazing land management and re-vegetation. Greenhouse gases removed from the atmosphere through eligible sink activates generates credits known as **Removal Units** (RMUS). Any greenhouse gas emission from eligible activities in turn must be offset by greater emission cuts or removed elsewhere.

1.4.1 Flexible mechanisms (FI)

Although each listed party has its individual reduction or limitation commitment, the protocol contains a range of provisions for flexibility. Parties may form a group whose emissions are counted together rather than individually for each party, an approach chosen by the European Union. The protocol introduces three “Flexible mechanisms” allowing countries to achieve a part of their commitments by earning credit for GHG emission avoided or GHG removals achieved in other countries. These mechanisms are joint implementation, clean development and emissions trading.

1.4.2 Joint Implementation (JI)

Under JI an Annex I country that has commitments to reduce or limit its GHG emission can obtain from another Annex I country GHG emissions reduction and count the **emission reduction units** (ERU) against its own target. These emission reductions come from projects which reduce the anthropogenic emissions from sources, or increase the anthropogenic uptake in sinks.

JI projects must lead to proven emission reduction compared to what it would have been otherwise and should be accepted by both the parties in advance.

The JI mechanism facilitates one industrial country to invest in another industrial country to achieve the emission reduction target at a lower cost. JI projects are most likely in EITs where there tends to be more scope for cutting emissions at lower costs. The JI projects can be implemented in two ways:

- Track I: In cases where all the eligibility criteria and reporting requirements of the KP are met by the Annex I country , it can issue the ERUs to a project which can be transferred to the investing entity
- Track II: Where the Annex I country is unable to satisfy all the requirements of the KP, the ERUs would need to be certified by an external agency just like in the case of CDM procedure. The host country cannot issue and transfer the ERUs unless it meets all the conditions regarding the assigned amount and national registry.

1.4.3 Clean development mechanism (CDM)

The objective of CDM as defined by the Kyoto protocol is to:

- Contribute to sustainable development in developing countries
- Help Annex I countries under the Kyoto protocol to meet their targets
-

Under CDM, the Annex I countries with committed targets of emission reduction may finance projects in Non-Annex I countries. These projects should reduce the emission of greenhouse gases and the **certified emission reduction** (CER) can be used by the Annex I countries to meet their own targets.

To be acknowledged as a CDM project, the project has to be accepted by both the countries in advance and it should be proven that the project will lead to emission reduction. The difference between JI projects and CDM projects is that JI projects are undertaken between countries that both have a commitment, while CDM projects are between one country which has commitments and another country which does not have commitments.

Accredited independent organizations known as operational entities play an important role in the CDM project cycle, including the validation of proposed projects and certification of emissions reductions and removals.

CDM project cycle: It revolves around a document known as ‘Project Design Document’. The document is to be prepared by the participants in a CDM project and must describe the baseline, the technologies to be used, the methodologies for monitoring and an analysis of the environmental benefits expected to be generated by the project. The project design document is first to be submitted to the national CDM authority for validation. On validation by the national CDM authority the project gets registered in the host country. Next, the document is submitted to the UNFCC. The UNFCC reviews and validates the document after inviting public comments on it and taking them into account. After receiving the UNFCCC validation the operational entity forwards it to the executive board for registration .The project is now in operation and is continuously monitored by the host country. The CDM project cycle has seven steps:

1. Submission of the project design document to the national CDM authority
2. Registration of the project in the host country

- Validation by UNFCCC

1. Registration with UNFCCC executive board
2. Monitoring by host country
3. Verification and

- Issue of CERs

A CER is equivalent to one ton of CO_2. The CERs are either for a fixed credit period of 10 years or first credit period of 7 years extendable twice for a period of 7 years but subject to revalidation of the project. The consultants for CDM projects are Ernst & Young, TERI, Winrock, PricewaterhouseCoopers.

1.4.4 Emissions trading (ET)

ET mechanism involves the trading of permits to emit carbon dioxide and other GHGs, calculated in tonnes of carbon dioxide equivalent (tCO_2e). The countries have the option to delegate this right of emission trading to companies or other organizations.

In the system of emission trading, the total amounts of emissions are capped at a pre-defined level. The corresponding emission allowances (assigned amount units AAUs) are then issued to the emitting installation through auction or issued freely. Through trading, installations which have low costs for reducing their emissions, are encouraged to make the reduction and sell their surplus of AAU's to organizations for whom the cost of emissions reduction is too high. The system allows the countries to know in advance the amount of GHGs that will be emitted and is a cost effective way to reach a pre-defined target.

In 2004, 107 million tons of carbon dioxide equivalent (t CO_2e) was exchanged through projects: a 38% increase relative to 2003 (78 tCO_2e).

Since the cost of emission reduction is substantially less in developing countries that do not have any obligation to reduce their emission under the Kyoto protect, they can earn huge revenues by selling their surplus credits to organizations in developed countries that have commitments to limit or reduce their emissions.

The trading of carbon credits (CC) takes place on two stock exchanges, the Chicago Climate Exchange and the European Climate Exchange. CC trading can also take place in the open market. European countries and Japan are the major buyers of carbon credits. For trading purposes, one credit is considered equivalent to one ton of CO_2.

Carbon sequestration projects

These flexible mechanisms also include projects for carbon sequestration such as forestry. Under the KP, a forest planted on a clear land after 1990 can be taken as a carbon sink. Under the KP carbon credits, only from carbon sequestered after 2008 and up to 2012 or a subsequently agreed date can be traded.

'Emissions trading' facilitates strategies for emissions reduction in a cost effective way. The KP defines the carbon credits in terms of tons of carbon dioxide from burning of fossil fuels.

Emissions trading market

The total market for emissions trading is estimated to be 320 MtCO_2e. The ET market volumes are generated in three ways:

- Reductions in actual emissions.
- Avoidance of potential emissions
- Carbon sequestration

The actual reduction or offset achieved by a project depends upon the type and location of the project and the objective of the transaction. The reductions are calculated by taking the difference between the volumes of each of the six green house gases with or without the project.

The exchanges for the actual trading are Chicago climate exchange, CO_2E exchange in U.K. and the CDM exchange in Europe.

The 2007 price range for a ton of CO_2 ranges from €6 to €12. Japanese firms are currently the largest buyers accounting for 41% of the market share. Table 1.3 shows the market share of buyers for CO_2.

Table 1.2

Market share of buyers

Buyers	**Market share**
Japan	41%
The Netherlands	23%
Carbon finance business*	24%
USA	3%
Canada	3%
Australia and New Zealand	3%
Other EU	3%

* These consist of state agencies and intermediaries such as The International Finance Corp., The International bank for Development and Reconstruction, The Coporacion Andina De Fomento and The Carbon Finance through the Prototype Carbon Fund.

Countries and organizations can also transfer CERs, ERUs and RMUs acquired through the CDM project, joint implementation or sink activities, in the same way. In order to address the concern that some countries could overly sell and then be unable to meet their own targets, the protocol rule book requires Annex I parties to hold a minimum level of AAUs, CERs, ERUs and/or RMUs in a commitment period reserve that cannot be traded.

Compliance

The protocols compliance system consists of a compliance committee enlisted to ensure that all parties meet their commitments. It has powers to apply certain consequences on parties not meeting their commitments.

Prototype Carbon Fund (PCF)

The World Bank managed Prototype carbon fund is a partnership between seventeen companies and six governments. Its mission is to pioneer the market, for project based greenhouse reductions within the framework of joint implementation and clean development mechanism. The PCF will invest contributions made by companies and governments in projects designed to produce emission reductions fully consistent with Kyoto protocol. Contributors or participants in the PCF will receive a pro rata share of the emission reductions verified and certified in accordance with agreements reached with the respective countries hosting the projects.

1.5 Can we make better use of the energy?

The needs and benefits of energy efficiency measures

Increased energy demands necessitates energy efficiency for the following reasons:

- Reduce pollution
- Reduce the potential for extreme **global warming**and **climate changes**
- Economic and security**:**costs of relying on imported fuel from unstable regions of the world
- Social: impacts on human health, costs to communities where fuels are extracted
- Delay the onset and severity of fossil fuel shortages a report from the International Energy Agencywhich concludes that world oil production will, indeed, peak on or about 2010 and that by 2020, production will begin to decline, with potentially serious consequences to the world's developed and developing nations.

Energy efficiency refers to products or systems designed to use less energy for the same or higher performance than regular products or systems. It is about getting the maximum amount of goods and services out of each unit of energy consumed. In addition to the obvious economic benefits, energy efficiency measures also directly contribute to a reduction in the amount of carbon dioxide emissions into the earth’s atmosphere. By enabling a building to do twice the work with the same amount of energy expenses, energy efficiency measures directly contribute to mitigation in the amount of carbon dioxide emissions into the earth’s atmosphere. This benefit of energy efficiency has gotten wide spread attentions recently thanks to heightened awareness of the adverse impact of global climate change on the earth's ecosystems and human habitats. Energy efficiency is becoming even more important as energy resources become increasingly scarce, difficult to exploit and expensive. Building generation capacity fuelled by renewable resources will help to meet demand, but decreasing consumption by reducing waste is a faster, cheaper, easier and more sensible approach.

Energy efficiency improvements are usually technically simple, relatively low cost and quick and easy to implement. The first step in any energy efficiency campaign is to understand how energy is being used and where it can be used more effectively. The application of proven technologies and best practices on a global scale could save between 25 EJ and 37 EJ of energy per year (1.9 Gt CO2 to 3.2 Gt CO2 emissions per year), which represents 18% to 26% of current primary energy use in industry. The largest savings potentials can be found in the iron and steel, cement, and chemical and petrochemical sectors.

A set of indicators has been developed to analyze the energy efficiency of electricity production from fossil fuels on a global level and for a number of key countries. The technical potentials for energy and CO2 savings from improving the energy efficiency of electricity production are also calculated. The global average efficiencies of electricity production are 34% for coal, 40% for natural gas and 37% for oil. For all fossil fuels, the global average efficiency is 36%.Electricity production accounts for 32% of total global fossil fuel use and around 41% of total energy related CO2 emissions. Improving the efficiency with which electricity is produced is therefore one of the most important ways of reducing the world's dependence on fossil fuels, so helping both to combat climate change and improve energy security. Additional fuel efficiency gains can be made by linking electricity generation to heating and cooling demands through high efficiency.

Industry is the major user of energy in modern society, accounting for roughly 40% of final energy use. Coal or oil is heavily used, especially by primary industry and manufacturing and refining. Gas is being used increasingly to replace coal because it is a cleaner fuel producing less impact on the environment. Electricity is only a minor component of industrial energy use although its use in driving electric motors is very important. The major sectors within industry can be categorized as follows:

Manufacturing – this includes the processing of primary resources into consumer products. Mineral refining, oil refining and chemical manufacturing are some areas of energy use where considerable savings could be made. Such activities often occur in the industrial zones of major cities.

Power Generation - the power generation industry is a massive user of fossil fuels and accounts for more than 50% of international greenhouse gas emissions. Many power stations are very inefficient and there are strong economic and environmental incentives to save energy in the power supply industry. Most cities have major power stations and these are often a cause of air pollution as well.

Mining – this is a primary industry which generally occurs outside cities, often in remote parts of the country. Energy intensity is high in most mining operations but there is an incentive to save energy because energy wastage is reflected in the cost of the minerals.

Agriculture – another major user of primary energy which takes place in rural areas.

Construction – is a modest user of energy, particularly liquid fuels because this activity often takes place at sites where electric power is not readily available. Considerable savings are available in this sector because there is often a large amount of wastage in construction activities.

The main focus will therefore be on energy savings in manufacturing and power generation as these are the major users of industrial energy.

There are many ways in which we can make our lives more energy-efficient, either by changing our behaviour to save energy or by choosing energy-efficient products. Some of the steps that should be taken for achieving energy efficiency in any industry are:

- Carry out an energy audit: Energy auditing in industry takes a similar approach to audits undertaken in the commercial sector. An analysis of existing energy consumption records to determine where, how and how much energy is being used in the plant. It will also seek to identify trends in consumption data. A walk through audit that documents where the main areas of energy consumption exist within the plant could be conducted. This phase will identify any obvious areas of wastage together with the most promising areas for potential savings. A detailed analysis phase which will take the data obtained in the previous two phases and prepare detailed plans for energy savings options. These plans will include details on the energy use and cost of each stage of the production process as well as costings and expected payback periods of the various energy saving options proposed.

- Set up Short Term Energy Efficiency Targets: Energy efficiency targets, which can be achieved in the short term, as a result of streamlined operation of the plant, are known as housekeeping targets. These energy savings will usually be the result of the efficient use of energy consuming equipment, a reduction in the amount of waste energy, timely maintenance of equipment and continual monitoring of the energy consumption of the industrial process. Specific examples of housekeeping targets are for electric motors, compressed air systems, process heating, steam and heat recovery.
- Exploring Technical Options: The technical options available for energy savings in the industrial sector are as diverse as the industries themselves. However, they principally revolve around the saving of energy in areas such as :

  - Electric Motors
  - Compressed Air
  - Steam
  - Furnaces
  - Heat Recovery
  - Illumination Systems

1.6 How do we channel waste energy into useful output?

Energy recycling is utilizing energy that would normally be wasted, usually by converting it into electricity or thermal energy. Energy recycling -- which can be undertaken at manufacturing facilities, power plants, and large institutions such as hospitals and universities -- generally increases efficiency, thereby reducing energy costs and greenhouse gas pollution simultaneously. The process is noted for its potential to mitigate global warming profitably

1.6.1 Forms of energy recycling

Waste heat recovery is a process that captures excess heat that would normally be discharged at manufacturing facilities and converts it into electricity and steam. A "waste heat recovery boiler" contains a series of water-filled tubes placed throughout the area where heat is released.

When high-temperature heat meets the boiler, steam is produced, which in turn powers a turbine that creates electricity. This process is similar to that of other fired boilers, but in this case, waste heat replaces a traditional flame. No fossil fuels are used in this process. Metals, glass, pulp and paper, silicon and other production plants are typical locations where waste heat recovery can be effective.

Combined heat and power (CHP), also called cogeneration, is, according to the U.S. Environmental Protection Agency, “an efficient, clean, and reliable approach to generating electricity and heat energy from a single fuel source. By installing a CHP system designed to meet the thermal and electrical base loads of a facility, CHP can greatly increase the facility's operational efficiency and decrease energy costs. At the same time, CHP reduces the emission of greenhouse gases, which contribute to global climate change.” When electricity is produced on-site with a CHP plant, excess heat is recycled to produce both processed heat and additional power.

Both waste heat recovery and CHP constitute "decentralized" energy production, which is in contrast to traditional "centralized" power generated at large power plants run by regional utilities. The “centralized” system has an average efficiency of 34 percent, requiring about three units of fuel to produce one unit of power. By capturing both heat and power, CHP and waste heat recovery projects have higher efficiencies. A 2007 Department of Energy study found the potential for 135,000 megawatts of CHP in the U.S. and a Lawrence Berkley National Laboratory study identified about 64,000 megawatts that could be obtained from industrial waste energy, not counting CHP. These studies suggest about 200,000 megawatts or 20% of total power capacity that could come from energy recycling in the U.S alone. Widespread use of energy recycling could therefore reduce global warming emissions by an estimated 20 percent. Denmark is probably the most active energy recycler, obtaining about 55% of its energy from CHP and waste heat recovery. Capturing wasted energy could cut CO_2 by 20%. A typical industrial facility can realize savings of up to 25% in process heating systems, up to 20% in steam systems, and as much as 18% in motor systems. These savings can reduce a company's natural gas and electric bills—directly affecting profits.

1.7 Australia and the energy scenario

Australia’s energy supply is utilised for export and for meeting Australia’s domestic consumption needs. Energy exports account for 66 per cent of domestic energy production and domestic consumption accounts for the remaining 34 per cent. Australia is the world's eighth largest energy

producer, accounting for around 2.4 per cent of the world's energy production. Given Australia's large energy resources, Australia is well positioned to continue to supply a significant proportion of the world's energy needs, while maintaining domestic energy supply. The rate of growth in Australia's production of energy has been increasing. Over the 10 years from 1996-97 to 2006-07, energy production increased at an average rate of 4.3 per cent a year, compared with 3.4 per cent over the previous 10 years, being driven largely by a growing global demand for energy.

The Australian energy industry is an important part of the economy. The coal, petroleum, gas and

electricity industries contributed around $57 billion to industry gross value added in 2006-07, representing 6 per cent of the Australian total. The oil and gas extraction industries were the largest contributors to industry. Statistics pertaining to energy related industries is provided in Table 1.3.

Table 1.3

Energy related industries in Australia 2006-07

Energy exports

Australia is a net energy exporter, exporting approximately two-thirds of its domestic energy production. However, Australia is a net importer of crude oil and refined petroleum products. Coal is Australia's largest energy export earner, with a value of $24 billion in 2007-08, followed by crude oil and LNG. Crude oil and LNG are also among Australia's 10 highest value commodity exports. Energy exports accounted for 18 per cent of Australia's total exports of goods and services in 2007-08.

Domestic energy consumption

Although Australia's energy consumption is growing, the rate of growth has been decreasing over the past 50 years. Australia's energy consumption increased at an average rate of 2.3 per cent a year over the 10 years from 1996-97 to 2006-07, compared with 2.7 per cent over the previous 10 years. In 2006-07 energy consumption increased by 2.3 per cent to 5770 petajoules, representing 34 per cent of total Australian energy production. Over the past 20 years, domestic energy consumption has increased at a slower rate than production. Rapid growth in global demand for Australia's energy resources has driven growth in domestic production. As a result, the share of domestic consumption in Australian energy production has been decreasing, from around 50 per cent in the 1980s, to an average of 42 percent in the 1990s, and down to 34 per cent over the past eight years.

Energy intensity

During the past five decades, Australia's growth in energy consumption has gradually slowed. Following growth of around 5 per cent during the 1960s, annual growth in energy consumption fell during the 1970s to an average of around 4 per cent a year, largely as a result of the two major oil price shocks. During the 1980s, economic recession and sharply rising energy prices resulted in annual growth falling to an average of 2.3 per cent a year. Despite falling real energy prices and robust economic growth, annual average growth in energy consumption has remained around 2.3 per cent. This trend indicates a longer term decline in energy intensity of the Australian economy which can be attributed to two main factors. First, greater efficiency has been achieved through technological improvement and fuel switching. Second, rapid growth has occurred in less energy

intensive sectors such as the commercial and services sector relative to the more moderate growth of the energy intensive manufacturing sector. Trends in energy intensity are not uniform across Australia. For example, in recent decades the growing resources sector of Western Australia has contributed to energy intensity being higher in this state than in Victoria, where the services sector has grown strongly. The Energy Intensity Trends are depcted in Figure 1.2.

Figure 1.2

Energy Intensity Trends

Energy consumption by Fuel

Australian primary energy consumption consists predominantly of petroleum and coal. Black and brown coal accounted for the greatest share of the fuel mix, at around 40 per cent, followed by petroleum products (34 per cent), natural gas (20 per cent) and renewable energy sources (5 per cent). The share of natural gas in Australian energy consumption has increased in the past 30 years and this trend is likely to continue in the longer term.

Tale 1.3 shows the yearwise consumption of fuels data.

Table 1.3

Consumption of Fuels

Figure 1.3

Primary Energy Consumption in Australia

Energy revolution scenario for Australia

Australia is also well placed to become much more energy efficient and reduce costs of energy as well as emissions. By setting strong targets to reduce greenhouse pollution domestically and taking the lead on climate change, Australia could steer international negotiations towards a binding agreement that ensures global greenhouse gases fall to levels that avoid runaway climate change. This scenario is based on the global energy scenario produced by The European Renewable Energy Council (EREC) and Greenpeace International, which demonstrates how global CO2 emissions can be halved by 2050.The Australian scenario provides an exciting, ambitious and necessary blueprint for how emission reductions can be made in the energy and transport sectors and how Australia's energy can be sustainably managed up to the middle of this century. At the core of this revolution will be a change in the way that energy is produced, distributed and consumed.The five key principles behind this shift will be to:

- Implement renewable solutions, especially through decentralized energy systems
- Respect the natural limits of the environment
- Phase out dirty, unsustainable energy sources
- Create greater equity in the use of resources

- Decouple economic growth from the consumption of fossil fuels

Reducing energy related CO2 emissions

For avoiding runaway climate change, Australia must reduce its greenhouse gas emissions by greater than 40% below 1990 levels by 2020, moving to decarbonisation as quickly as possible thereafter.While energy related CO2 emissions in Australia will increase under the Reference Scenario by about 20% by 2020 - far removed from a sustainable development pathway - under the Energy Revolution Scenario they drop significantly, decreasing from 370 million tonnes (Mt) in 2005 to 232 Mt in 2020, a reduction of 37%. The Energy Revolution scenario emission pathway turns the present-day situation into a sustainable energy supply using the following measures:

- Renewable energy: 40% of Australia’s electricity to be provided by renewable sources in 2020. The electricity sector will have the strongest growth in renewable energy utilization. The current share of renewable energy in electricity generation is 9.2%. By 2020, approximately 40% of electricity will be produced from renewable energy sources, increasing to 70% by 2050. A capacity of 23 gigawatts (GW) will produce 82 terrawatt hours per year (TWh/a) of electricity by 2020.
- Energy efficiency: Australia can cut its energy consumption by 16% by 2020. Exploitation of Australia’s existing large energy efficiency potential will reduce primary energy demand from 4,761 PJ/a in 2005 to 3,982 PJ/a in 2020.This compares with a 29% increase in demand to 6127 PJ/a by 2020 in the Reference Scenario. It is vital to significantly reduce the energy consumption in order to ensure that renewable energy sources meet a significant proportion of our electricity supplies, compensating for reducing the consumption of fossil fuels.
- Coal-fired power will be phased out entirely by 2030 : The aggressive implementation of energy efficiency measures, efficient use of gas as a transitional fuel and up-scaling of renewable energy will take place. Technologies allows Australia to relieve the energy market of the most polluting fossil fuels. By 2010, largely driven by energy efficiency, 5.3 GW of coal-fired capacity will have been removed from the grid. By 2030, coal-fired electricity is phased out entirely and from 2030 to 2050, the installed capacity of gas diminishes from 13 GW to 10 GW, as renewable energy-based electricity continues to take the place of fossil fuel-based electricity.
- Smarter use of resources : capitalizing on the current wastage of heat – a by-product of electricity production – by using it to warm building interior spaces, especially those located close to the source of power generation. This technology – called combined heat and power generation (CHP) –

will make power plants more efficient. The use of fossil fuels for CHP will be steadily replaced by biomass and geothermal energy.

- Using electricity for the transport system and cutting consumption of fossil fuels through efficiency : Electric vehicles will quickly take the place of petrol/diesel vehicles on Australia's roads. Standards governing fuel efficiency will be introduced more quickly resulting in a decisive shift towards smaller, more fuel-efficient cars.

Figure 1.3

Prediction for Primary Energy Consumption in Australia under Energy Revolution Scenario

- Primary energy consumption : Taking into account the assumptions discussed above, the resulting primary energy consumption in Australia under the Energy Revolution Scenario is shown in Figure 18. Compared to the Reference Scenario, primary energy demand will be reduced by 55% in 2050. Over 27% of the remaining demand is covered by renewable energy sources.

1.8 Summary

The world is critically dependant on energy. The known sources of non renewable energy such as coal, petroleum and gas are depleting fast. Renewable sources are yet to be fully exploited. The burning of fossil fuels for generation of power and transport is mainly responsible for emitting unacceptably large amount of green house gases (GHGs). The high concentration of these gases is damaging the environment by way of ozone layer depletion, global warming and loss of bio diversity adversely affecting human, animal and plant life.

The United Nations Framework Convention on Climate Change (UNFCCC) was signed in June 1992 by 150 nations for international cooperation in the area of climate change with an overall objective of limiting the concentration of green house gases in the atmosphere. In 1997 the Kyoto protocol, a binding obligation to reduce by 2012 the overall emission of GHGs to a level 5% below the 1990 levels was negotiated by the industrialized countries. To achieve individual targets of reduction the protocol provides for three flexible mechanisms: joint implementation, clean development mechanisms and emissions trading. These mechanisms have created a market for emissions/carbon trading.

Energy efficiency refers to products or systems designed to use less energy for the same or higher performance than regular products or systems. It is about getting the maximum amount of goods and services out of each unit of energy consumed. In addition to the obvious economic benefits, energy efficiency measures also directly contribute to a reduction in the amount of carbon dioxide emissions into the Earth’s atmosphere. By enabling a building to do twice the work with the same amount of energy expenses, energy efficiency measures directly contribute to mitigation in the amount of carbon dioxide emissions into the Earth’s atmosphere.

Energy recycling is utilizing energy that would normally be wasted, usually by converting it into electricity or thermal energy. Energy recycling -- which can be undertaken at manufacturing facilities, power plants, and large institutions such as hospitals and universities -- generally increases efficiency, thereby reducing energy costs and greenhouse gas pollution simultaneously. The process is noted for its potential to mitigate global warming profitably.