1. INTRODUCTION

Energy production and use are a major part of climate change problem. Therefore, energy and the way we use it must be a major part of the solution. The potential in developing countries for large percentage increase in emission of greenhouse gases (GHG) over the next decade has resulted in suggestion that control over such emissions should be considered as a part of near-term development.

To find out Iran's responsibility (or ability) to contribute in CO_2– mitigation, in this report-study, I will:

- Give a background of economic situation in Iran. Macroeconomic and energy policies are presented. There is also information about energy-reserves, supply, demand and energy pricing. The barriers to energy efficiency in country are described, and reforms policies to reduce these imperfections and barriers are briefly discussed.
- To put environmental issues in perspective; levels, trends and geographical changes in world energy consumption are considered. All available analysis shows that wealthy countries are still the major users of energy. However the developing countries have now emerged as the major growth centers for energy consumption.

This report-study shows the environmental implications by energy consumption and by energy sources. There is focus on CO_2 which is the most important anthropogenic greenhouse gas, and contributor to global warming. Fossil fuel use cause about 3/4 of man-made CO_2 – emissions.

Chapter 3 gives us a close picture of different regions' share in growth in energy demand and resulted CO_2 emissions. National circumstances of a country are a crucial determination of a country's baseline pattern of energy use and CO_2 emissions, and need to be accounted.

There is shown that to achieve any agreement between nations, the choose of indices do matter and that efficiency and equity are important criteria for choosing "right" indices.

Global warming became a prominent global problem. There was need for work to assess the economic impact of global warming and valuation of environmental damage for policy decision and still, far more work is needed. A body of literature is developing on the cost of prevention. I represent a simple economic approach for analyzing policy when the environmental problem is due to accumulating pollutant like CO_2.

The use of different economic instruments and other instruments such as direct control and voluntary approaches are discussed and suitably of each of these options in the case of climate problem are shown. There is also shown some alternative options to economic instruments, which consider the economic dimension of actions as well as the level of ecological improvement, like energy efficiency and energy conservation. The difficulty of determining environmental damage cost is also discussed and the usual methods are briefly mentioned.

- estimates of the cost of GHG's emission reduction are sensitive to assumptions about appropriate model structure, demographic growth, the cost and availability of both demand-side and supply-side options. Different assumptions lead to different cost estimates. However, there is agreement that some energy efficiency improvement can be realized at negative to slightly positive costs. The existence of substantial market or institutional imperfections prevents cost-effective emission reductions measure form being taken. To arrive at the most cost-effective strategies to reduce emissions an integrated approach, considering all important effects of measure is necessary. Most feasible measures will affect emissions of several compounds which may have many local and regional effects. Such integrated approach needs good data base which are not available in Iran. However there are many studies which focus on potential for energy saving in Iran.

One energy-saving scenario point out an amount of 245 mboe/year oil product and 7800 GWH electricity per year in 2020, as a feasible target .But there is no information about the cost of implementing this savings program.

The marginal cost of reducing CO_2-emission can be low, but the total cost is too high as percent of GDP. However, by assessing the benefit of reduce local pollution; it may becomes to be a so-called "win-win" options.

With large potential for energy saving, Iran should be a good candidate for joint implementation-options. Then the knowledge about marginal-cost of CO_2 – reduction is important.

* * *

2. ECONOMY AND ENERGY

Energy is an essential factor of economic activity. It is both a traded commodity and an essential factor in moving goods that are traded internationally, as such, it also contributes indirectly to economic growth. There is a close link between energy use and economic activity. Therefore it is important to get a brief knowledge about economic situation and energy market in the country.

2.1. Macroeconomic Context

The Islamic Republic of Iran has an area of 1.648 million sq.km and a 1992 GNP per capita of US$ 2.190. Iran has substantial mineral resources and some of the largest hydrocarbon reserves in the world. But economic disequilibria and rapid population growth, if not controlled, could threaten the social stability. Fueled by an annual growth in population of 3.2%, Iran's population doubled over the last 25 years to 56 million and is expected to rise to 100 million in the next 25 years at a forecasted growth rate of 2.3%.

Per capita income fell during the 1980s as GDP growth, between 1979 and 1990, averaged a meager 0.6 percent per year and the performance of the Iranian economy deteriorated. The GDP share of "services" increased during the period with the "trade" subcomponent of the "services sector" tripling its share. The original roots of the situation can be traced to the import substitution policy by the Government during the 1963-1978 periods. Large and growing revenues from oil permitted to launch a state-driven economic development program with large state investment in infrastructure and larger capital intensive industries. The high rents derived from oil revenues cushioned the socio-economic consequences of production inefficiency; it permitted the Iranian governments before and after the revolution to continue to provide subsidies to both industry and to consumers thereby compensating for organizational and production inefficiencies.

During the 1980s economic policies and performance were influenced by the revolution in 1979, by the war with Iraq and by the decline in oil prices during last ten years. Ultimately, the policy led to a slow down in economic growth. The Iranian revolution increased the direct involvement of the state in the economy.

2.1.1. The Economic Reform Program since the First F ive-Year Plan (FFYP) 1989-93

The steep decline in oil revenues and rapid population growth had brought the economic rent per capita form the oil sector activities down to low levels, thereby eliminating the cushioning effect provided by these. This had two major consequences for national planning:

*First and foremost, there was a clear understanding of the need for the implementation of a cohesive economic strategy rendering economic decision-making more responsive to the international market forces. Therefore, FFYP included the progressive eliminating of financial imbalances, the decentralization of economic decision-making and the privatization of state enterprises in various part of the economy. The key policy reforms were:

-the gradual replacement of a multiple exchange rate system by a unified exchange rate in 1993 which was accompanied by a large effective depreciation of the Rial

- decontrol of many domestic prices and the dissolution of enforcements

-steep increases in public utility rates

-abolition of a less onerous income tax-schedule

- and a decision to permit private non-bank financial institutions

*Secondly, within this overall strategy, attention was paid to the need to optimize the macroeconomic benefits from the operation of the energy sector. This sector like the rest of the economy suffers from economic distortions and state intervenation which affect productive and allocative efficiency. Price distortions are substantial with both industries and consumers receiving large implicit subsidies as fuels are sold at a fraction of international cost, management accountability is low as government involvement in sector operations is very direct with the supply companies being organized as departments of ministries.

The reform policies aim to increase efficiency through the introduction of more market oriented pricing policies (gradual elimination of subsidies to consumption) and through the privatization of some of the state companies.

During the Second Five-Year Plan (SFYP) 1994-1999 the government intends to intensify the reform process by reducing subsidies to consumption and by implementing the commercialization and privatization policies that scarcely started.

2.2. Energy – Reserves,-Production and Consumption

Iran's primary resource-base is substantial and includes oil, natural gas, hydropower, coal and solar energy. The hydropower potential amounts to about 20,000 MV on the two of biggest rivers alone.

The present estimates of proven reserves of oil and of natural gas are approximately of the same size expressed in ton oil equivalent (toe): oil reserves amount to 95 billion barrels (about 10% of world total) and natural gas reserves to 17 trillion cubic meters (close to 20% of world total and second largest in the world). At the rates of production planned for the medium term the country's petroleum deposits could last 70 years and its natural gas deposits 300 years. By international standards, the development and production cost of both type of hydrocarbon resources are relatively low, thereby generating large potential rents particularly in the oil industry. Oil was the key domestic fuel during the 1960, 70s and 80s, but its most important role was as generator of export- income and of surplus finance and this function will remain the preoccupation of energy policy also during the implementation of the economic restructuring program of the 1990s.Previously, annual crude oil production in Iran fluctuated widely, reaching a peak of 6 mb/d in 1974, plummeting to 1.3 mb/d in 1981 and then increasing after the end of the war to 3.4 mb/d. The annual level of production is now no longer determined by production constrains, but is regulated by OPEC's production quota. This means that the exportable surplus of oil is determined (at least in the short run) by the domestic level of demand. The reduction of oil consumption by energy saving and by fuel substitution therefore has became the most important policy objective in the national energy policy.

Several hydropower projects were implemented during the 1960s and 1970s and come to provide a substantial share of national power production through with oil fired station supplying the rest. During the 1980's hydropower development stagnated reaching an installed capacity of 1953 MV and annual production of around 7 TWH. Although several large hydropower projects are in the pipeline for implementation, the lower cost of investment of gas fired power plants makes a major revival of hydropower projects unlikely during the 1990.

In view of this background and because of its vast reserves, natural gas is destined to become the fuel of future, replacing other fuel use wherever it is economic.

Natural gas production started in 1966 for exports to the USSR, but already during the 1970s its use in Iran, started to be developed as well. Natural gas became increasingly important during the 1980s. The annual production of natural gas is about 30 billion cu.m, of which 30 % is flared, 30% is used in power production, and the rest is used in the residential and industrial sectors. Gas export to the USSR restarted in March 1990 after a ten year hiatus but the break- down of the USSR led to a temporary break- down of this export prospect.

The Iranian energy sector assists Iran's economic development and increase consumers welfare by:

(i) covering the needs of energy of final consumers amounting to 58 mill. toe in 1992.

(ii) by providing 85% of export revenues(1990)

(iii)by providing about 15% of the central government revenue(1991).

The value added of production in the energy sector contributed about 24 percent of GDP in 1992 and has important multiplier effect through its impact on export income and on the level of investments.

Table 2.1

Energy Sector and Economy, 1991	% of Nat. total
GDP	23
Exp.revenue	85
Employment	1
Investment	9
Govern.revenue	15

Source: Ministry of Power & Energy

During the 1989-92 period, investments in the energy sector amounted to some 2.5% of GDP, representing about 10% of total investments and a third of public sector investments. The energy sector is less important as a generator of employment, equal to be 1.7 percent of national employment. In addition, its investment demand has provided direct employment to several thousand persons in the supplying industries.

2.2.1. The Composition of Energy Demand

The supply of primary energy is dominated by oil products which accounted for about 70% of primary energy supply in 1370 (1991), with natural gas a clear second with 27%, where as hydro electricity and the consumption of solid fuels account for 1% and 0.2% respectively.

As concerns the fuel mix for final energy demand, table 2.2 shows that the share of petroleum products amounted to 69% in1370 (1991), the share of natural gas to 21%, of electricity to 7% and of solid fuels to 2%.

Table 2.2

Final Energy Demand In 1370(1991)		
	mboe	%
petroleum products	40	69
Natural gas	12	21
Electricity	4	7
Solid fuels	1	2
Total	57	100

Source: Sustainable Energy Development, Iran 1993.

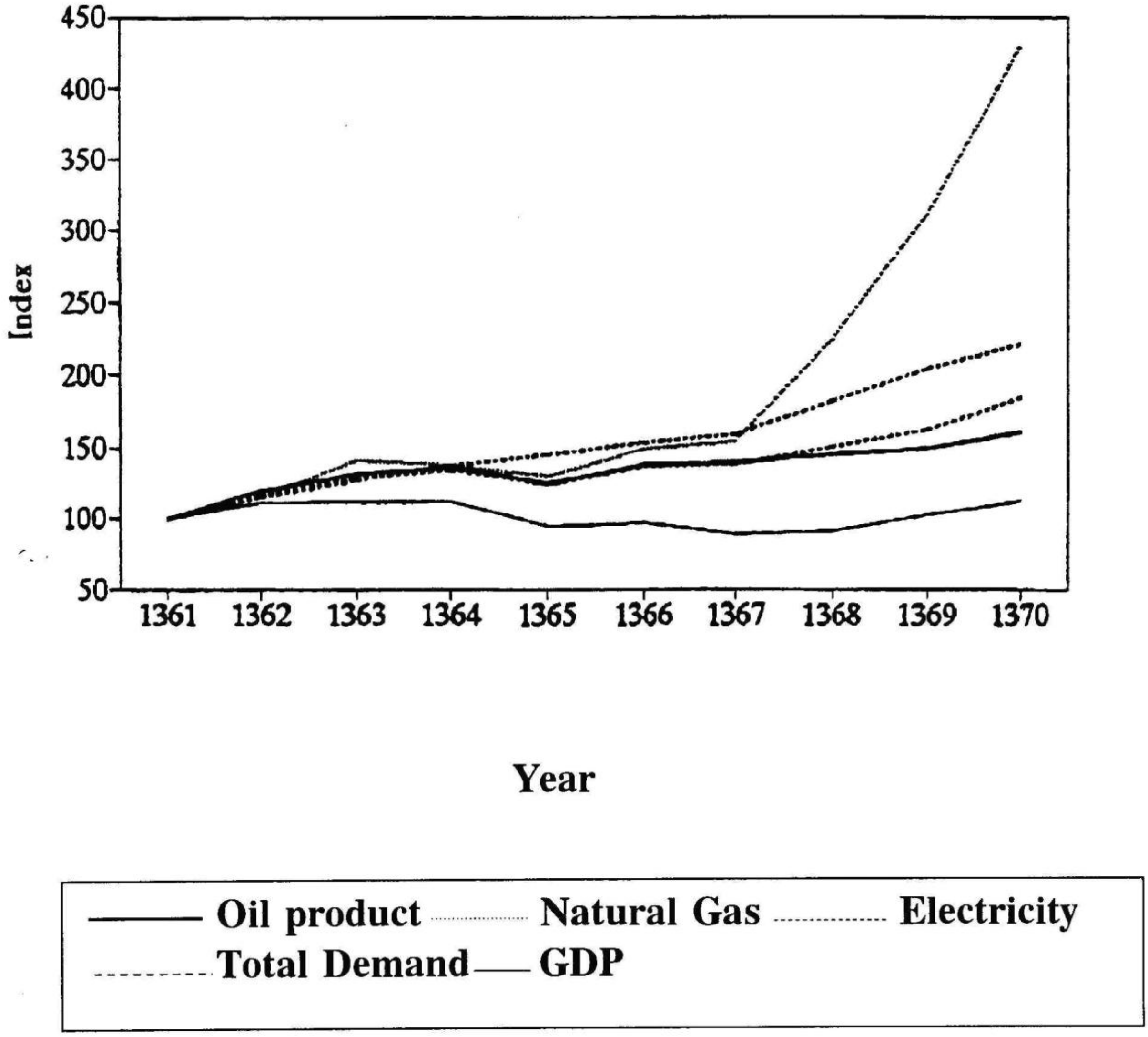
Energy Consumption in Social and Economical Sector:

As regards the sectoral consumption, the residential/commercial sector was the most important energy consuming subsector in 1370 (1991), accounting for more than a third of total consumption; transport demand accounted for almost one fourth of the total; industrial demand for a little more than one fifth; where as agricultural and "other" accounted for the remaining one fifth of the final demand.

Development in Overall Energy Demand

During the 1980s the real price for energy felt for all products and the energy demand/GDP growth elasticity rose to record levels as it evident from Figure 2.1, which shows the growth in fuel demand during the 1361-1370 (1982-1991).

Figure 2.1: FUEL DEMANAD AND GDP



From 1979 to 1990 the growth rate of energy demand was 6.2% per year, although GDP averaged no more than 0.6% per year. The exception from the rising trend in demand which can be evidenced in 1364-65 (1985-86) was supply imposed. Some productive and refinery capacity was destroyed during the early war years which led to a rationing of supply, and to imports of mass consumption fuels such as LPG and kerosene. The success of the government's oil substitution policy through the increased penetration of natural gas can be witnessed by the strong growth in demand of natural gas from 1367 (1988) onwards which more than quadrupled domestic consumption during the period. This kept the growth in the demand for oil relatively flat.

Next to natural gas, electricity was the fastest growing fuel and the only fuel which did not witness a fall in demand during any period in the 1360s (1980s).

Trends in Sectoral Demand

- Household: Final energy use per unit of private consumption in urban areas has increased from 5 BOE per million Rials of private household consumption (in price of 1982) to 15 BOE per million Rials in 1990. Distribution of Final energy consumption in rural and urban areas indicate that in 1982 more than 50% of final energy carriers was consumed in urban areas, and this share increased to 60% in 1990. In general we can see two major developments in this sector:

1) The total energy consumption of household in the higher income groups has had an increasing trend.

2)Household in higher expenditure groups consume much more energy than household in the lower expenditure groups, which stem from the fact that households in higher expenditure groups enjoy a better living standard than the population in lower groups .

- Industry: Industry is a growing sector of the economy and its share in GDP (in constant prices) has increased from 5% in 1959 to more than 15% in 1990. Expansion of industrial activity has been more rapid in the last decade.

With increased contribution of industry to the economy growth, the energy consumption in this sector has risen. The share of natural gas has been increasing, and it reached just about 40% in 1990. More than 30% of final energy consumption in large industries was attributed to non-metal mining industries in 1971 and increased to more than 40% in 1990. The other largest industrial energy consumers are basic metal and food and drinks industry respectively. Trend of energy consumption and value added indicate that total energy consumption has increased in the recent years, although the activity level has declined in some years. This is mainly due to the fact that production capacities were under-utilized. The ratio of value added to capital stock has fallen. This situation results in increased energy intensity in industry.

•Transport sector is an important element of the economic system and technical infrastructure of the country. The share of transportation in GDP was just above 3% in 1970, but it increased rapidly in the 1980. It was more than 6% in 1990.

The overland transportation (i.e. road and rail transportation) has the largest share in the activity level of the transport sector, which was more than 90% in 1987. Fuel consumption in this sector has increased from 12 Mill.boe / year in 1970 to 70 Mill.boe/year in 1990. More than 50% of final energy consumption in the transport sector is allocated to truck. The second largest consumer of final energy in the transport sector is private car.

2.3. Energy Pricing

The low energy prices in Iran do not reflect economic costs. Further distortions exist in the tariff structures of most energy sources and in their relative prices. The present level of fuel prices is between 5% (fuel-oil) and 20% (gasoline) of the economic cost of supply. (Technical Report, World Bank, Jan.1994)

The long-standing subsidization of energy consumption has led to excessive, low priority consumption, to a habit of energy waste and to a situation where the energy sector- companies can not even cover operating costs. Given the fact that the cost of supplying both oil and electricity are increasing, the practice of low energy prices is becoming even more costly and antithetical to pursuit of efficiency of supply, of optimal substitution in consumption and of the minimization of the environmental impact of energy operation. The positive impact this policy may have had on low income groups is partly undone by the free rider effect for those groups that can pay higher prices, while the negative impact on the government budget and the allocation of resources is obvious. This situation has further led to financial limitation for investment in energy efficient technology and programs. This is especially the case for the industrial sector, where, given the financial constraint for the government to allocate the necessary foreign currency for capital investment and procurement of raw materials, the financing of large energy efficient schemes would not be a priority despite their prospective large impacts.

In the building sector, private developers have little incentive to construct efficient, often more expensive, housing schemes and buildings, since they will not be the ones, to benefit from energy savings achieved ultimately. In the residential sector, financing is also a constraint, since consumer loans are expensive and difficult to obtain, and as a result consumers will be discouraged by the often significant up-front cost of energy efficient appliances and equipment

2.3.1. Impact Of Policy On Energy Demand

That the low cost of energy increased the national demand for energy is obvious. But in addition it has also some other indirect micro-economic consequences.

In the agricultural sector, for example, because of the relative cheapness of electricity, two tendencies can be noted. Firstly, there is a tendency to replace diesel pumps and traditional systems of irrigation by electric pumps; secondly since no consideration needs to be taken to the cost of energy, there is an over consumption of both source, water resources – resulting in ecological damages- and of electricity contributing to the 20% per year growth in rural power consumption that took place during the 1980.

* * *

3. ENERGY AND ENVIRONMENT

Economic and social change is putting increasing pressure on the world's environmental resource. Understanding the environment and its link to economic activity requires a sound of data and indicators. Some indicators deal with environmental "goods" such as protected areas or biodiversity. Other measures "bads" (deforestation, soil loss, air pollution, etc).

Many of indicators are related to energy production and consumption. This is because energy use is both pervasive in economic activities and pollution intensive.

Energy is an essential factor of economic activity. It contributes directly to meeting both basic and more sophisticated human needs, whether it takes the form of primary energy source such as biomass, coal,oil, natural gas, renewable energy sources or a secondary or transformed of energy such as refined oil products or electricity (based on fossil fuels, renewable or nuclear energy).

Energy is both a traded commodity and an essential factor in moving goods that are traded internationality, as such; it also contributes indirectly to economic growth.

Since the beginning of the industrial era, fossil energy has fuelled economic growth, leading to a sharp increase in greenhouse gas emission levels and their build-up in the atmosphere. Fossil fuels currently amount to 84% and 92% of commercial energy use in IEA countries (the International Energy Agency Participating countries) and in the rest of the world, respectively. (IEA source-book 1997)

The close link between energy use and economic activity is by no means "one for one". On the contrary, the experience is that amount of energy required to produce output in terms of GDP (i.e. "energy intensity") tends to be decrease over time. In brief, the general dynamics of energy intensity are influenced by three overlapping phases:

- a shift from non-commercial to commercial energy
- an increase in efficiency of commercial energy use
- a substitution of electricity for direct fossil fuel uses for many energy services

Energy intensity varies widely across regions and countries. Some countries with a comparative advantage in energy resources have attracted energy-intensive activities, thus raising their energy intensity.

Figure (3.1) and (3.2) indicate that the primary energy requirement per GDP in Iran has been increasing continuously since 1971. The figures also indicate that in Japan, the energy intensity has decreased from 4.722 Kcal/US$ in 1974 to 2.964 Kcal/US$ (37% reduction).

Figure 3.1:

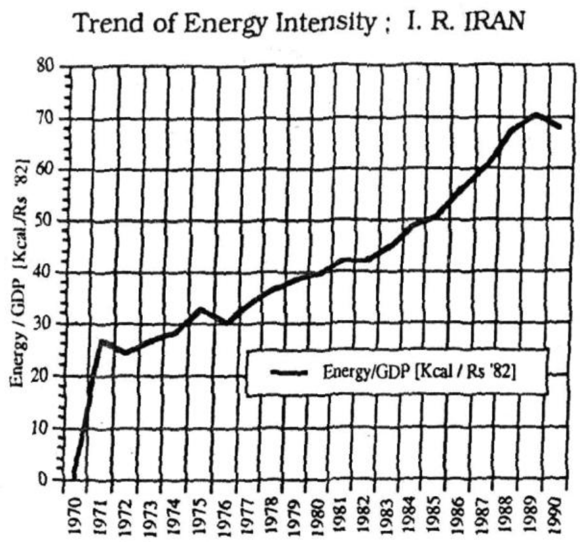
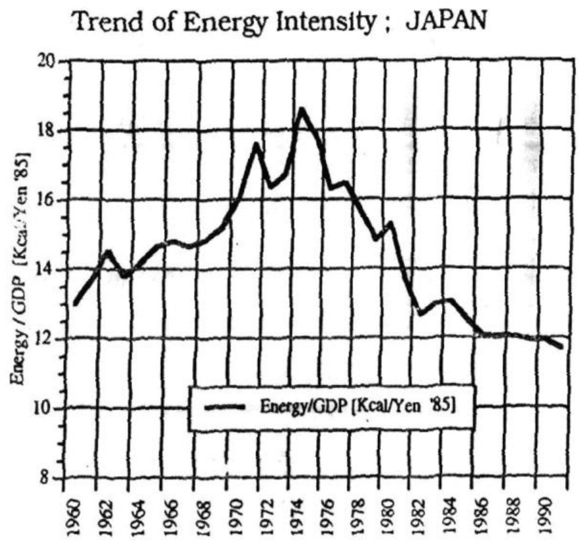


Figure 3.2:



The energy intensity in Iran in 1985 is estimated to be 3.557 Kcal/US$. This figure is derived from the parameters as follows:

- Exchange rate	89.5	Rls/US$
-Primary energy requirement	412.28	mboe
-GDP	$15.168*10^{12}$	Rials
-GDP per capita	3655	US$/capita

The value of energy requirement/GDP based on US$ depends on the exchange rate which is difficult to be evaluated. (The collaborative study on Comprehensive Energy Development Plan in Iran, CEDP, 1994)

According to World Bank Figures, the 1992 per capita consumption of about 1 toe per year corresponds to the average of countries with similar levels of GDP. Since Iran is well-endowed with energy resources and energy price have been kept very low even by developing countries, this result is rather favorable.

However, first of all, the average figures for the so-called middle income countries are heavily influenced by energy inefficient Eastern European countries such as Czech Republic and Poland. Secondly, the final energy consumption per unit of GDP (about 1.64 kg.oe/US$ in 1991) is relatively high in view of the high share of service sector in GDP (61%), and the low GDP share of industry sector (18%) with agriculture accounting for the remaining 21% of GDP. Thirdly, the energy consumption per unit of GDP figure is sensitive to the GDP estimating for Iran which because of the previous multiple exchange rate regime were particularly difficult to estimate (World Bank January 1994). The Iranian committee on energy conservation concluded in its March 1993 study that the energy intensity in Iran was almost three times higher than the energy intensity of Turkey and five times as in Indonesia. Compared to the best practice, as illustrated by the energy consumption per unit of production in the industrialized countries, Iran is far behind in energy efficiency. (See table 3.1)

Table 3.1: Energy Efficiency in Iran and "Best Practices"

Industry sector	Specific Energy Consumption, Iran	Specific Energy Consumption, "best practice"
Cement plants	Electricity consumption: 120 kwh / ton Specific fuel consumption: 970 kcal / kg of clinker (Tehran C)	Electricity consumption: 100 kwh/ ton (Japan) Specific fuel consumption: 706 kcal / kg of clinker (Japan)
Isfahan Iron and Steel Mill	Specific fuel consumption: 9Gcal / ton crude steel	Specific fuel consumption: 5.7 Gcal / ton crude steel
Refrigerators	Domestically produced models: 46 kwh per month	Imported models: 27 kwh per month
Car Transport	Domestically produced passenger cars: 12 – 14 liters of gasoline per 100 kms	Imported passenger cars: 7- 12 liters of gasoline per 100 kms
Thermal Power Plants	Average Thermal efficiency:31.2 % (Denmark) loses in transmission and distribution: 13.3%	Average Thermal efficiency: 39.8% (Denmark) loses in transmission and distribution: 8.1%

Source: Sustainable Energy Development, Iran 1993: Power Sector Statistics.

3.1. Energy Consumption and Environmental Implication

To put environmental issues in perspective it is firstly worth considering levels, trends and geographical changes in world energy consumption. All available analyses show that developing countries have now emerged as the major growth center, not with standing the economic shocks of the 1970s and 1980s. In 1970 they accounted for only 15% of world consumption, in 1989 for 25% and within 20 year their consumption will probably exceed that of the Organization for Economic Cooperation and Development (OECD) economies combined, being over 100 Mill. barrels of oil equivalent energy per day (mbdoe) assuming a gradual recovery of the African and Latin American economies (Economic Development Institute, Word Bank, 1993).
There are several factors contributing to the emerge of developing country markets:
(i) high per capita income elasticity and population growth
(ii) growth of urban areas and industry

(iii) growth of vehicle fleets

(iv)substitution out of fuel wood to commercial fuels, itself is an important source of environmental improvement. This energy related environmental issues are likely to become more pressing in developing regions.

●***Current Pattern Of Demand***

In 1970, the developing countries' total consumption of commercial energy (oil, gas, coal, nuclear and hydro) accounted for 16 mbdoe or 15% of the world total of 104 mbdoe. In the next two decade, despite the oil price shocks in the 1970s and the crises of debt in Africa and Latin America, consumption rose significantly in all developing regions, currently around 45 mbdoe (estimated) accounting for 25% of world consumption and 44% of the growth during this period.

Table 3.2: Commercial Energy Consumption by Economic Grouping

	Mbdoe		%distribution	
	1970	1990(e)	1970	1990
OECD	66	85	73	50
Dev.Count	16	45	15	26
& USSR				
Eastern Eurp.	22	40	21	24
Total	104	170	100	100

Source: World Bank, Country Department, 1994. [(e) = estimated]

Though, according to indicators presented in World Development Indicators 1998, wealthy countries are still the major user of energy and they consume a disproportional share of the world's energy (20% of the world's population uses about 60% of its commercial energy, while 80% of world's population uses about 40% of its energy). In developing countries growth in commercial energy use is closely related to growth in the modern sectors-industry, motorized transport and urban areas.

This connection is less robust in more developed countries. Thus commercial energy use per capita reflects the size of the modern sector as well as climatic, geographic, and economic factors (such as the relative price of energy). Because commercial energy is widely traded, it is necessary to distinguish between its production and use. Commercial energy use refers to domestic primary energy use before transformation to other end-use fuel (such as electricity and refined petroleum products).

Table 3.3:

	Commercial energy use thousand metric tons 0f oil equivalent		average annl.gr %	Commercial energy use per capita Kg of oil Equivalent		average annl.gr %
	1980	1995	1980 - 95	1980	1995	1980 - 95
World	$6.325.10^3$	$8.2\ 4\ \ 10^3$	3.2	1.456	1474	1.1
Low income	578.10^3	227.10^3	5.5	252	393	3.3
Middle income	$1.935.\ 10^3$	$2.342.\ 10^3$	5.8	1.604	1.488	2.6
Low & middle Income	$2.522.\ 10^3$	$3.569.10^3$	5.6	706	751	3.1
High income	3.80310^3	$4.075.10^3$	1.7	4.611	5.123	1.1

Source: World Bank indicators 1998

Commercial energy use in Iran is increased from 38.347 thousand metric tons of oil equivalent (tmtoe) to about 84.069 (tmtoe) with average annual 6.3% growth during 1980 – 1995. This is a growth double as much as what it is in average in the world (3.2%). From an environmental – economic point of view, the commercial energy use per capita does make sense here. This rate was about 1347 koe in 1995 in Iran, while for two other oil producing countries like Venezuela and Norway, it was 2154 koe, and 5439 koe respectively. The average annual growth in commercial energy use per capita in Iran during 1980 – 95 was around 3.2%, but it was 1.4% in Norway and 0.9 % in Venezuela. Past behavior may or may not be a good guide to the future, but the pressure that growth in incomes could place on the urban environment in developing countries are evident, thus without policies to curb pollutant emissions, especially of particulates, serious health consequences could follow.

Turning to future demand possibilities, the problem is best approached in two steps: The first is to estimate aggregate demands and the second is to estimate the fuel and energy mix. There are six major factors which influence the aggregate demand for energy, where two of these (i & v) often pull in opposite directions from the others. (Energy Investments and the Environment, World Bank 1993)

(i) Managerial and technical efficiency

(ii) Per capita income growth

(iii) The position of the various on the "S"- curve for energy using mechanism, equipment and vehicle fleets. (Developing countries are still on the early to middle ranges of the S-curve)

(iv) Population growth

(v) Prices

(vi) Substitution for fuel-wood.

International Energy Agency (IEA) in its World-Energy Outlook (1996) presents the following key result of the business-as-usual case:

- World primary energy demand is projected to be 46% higher in 2010 than in 1993. The average annual growth rate is projected to be 2.2%, the same growth rate as from 1971-93. This increase in demand is expected to be met almost entirely by fossil fuels, which are projected to account for almost 90% of total primary energy demand in 2010. World oil demand is projected t0 rise from 70 million barrels per day (mb/d) in 1995 to97 mb/d in 2010.

The fuel mix in primary demand is not projected to change significantly. Oil remains the main fuel, with 40% of demand in 2010, followed by coal with 25% and gas, the share of which increases by two percentage points to 24%. The share of nuclear power is project to decrease from 7% in 1993 to 6% in 2010.

A structural shift in the share of different regions in world energy demand is projected to occur. The OECD share of world energy demand falls from around 55% in 1993 to less than 50% in 2010. The share of the developing countries is projected to increase from 28% to almost 40% over the same period, due to rapid economic growth and industrial expansion, high population growth and urbanization and the replacement of traditional non-commercial fuels by commercial energy.

Comprehensive Energy Study in Iran (1996) present following results of the business-as-usual case. Iranian primary energy consumption will increase from 822.4 mboe per year in 1999 to 1942 mboe per year in 2020, with an average annual growth about 3.3%.

Oil share will decrease from 40.9% in 1999 to 38.3% in 2020. Gas share of energy consumption will increase from 41.4% in 1999 to 47.5% in 2020.

3.2. Environmental Impacts by Fossil Fuels

Some environmental impacts of the principal energy source, fossil fuel, are briefly mentioned in follow:

A) Air Pollution:

The combustion of fossil fuels gives raise to a number of air bone effluents, the most important of which are sulfur oxides, nitrogen oxides, carbon monoxide and carbon dioxide. The quantities of these emissions vary according to the fuel used, its composition, and the measures adopted to reduce emissions.

Air pollution comes in the forms of smog, acid pollution, and particulate pollution. By far the most common cause of smog (also called photo chemical smog) is automobile emissions (at least 90%). The interaction of the hydrocarbons and nitrogen oxides emitted by automobile exhausts interact in various ways in the presence of ultraviolet radiation, and produce toxic products that effect human health and plant life.

B) Particulate Pollution and Cooling Effect:

Dust and other light particles (including those emitted from power plants and cars) which remain suspended in the air for prolonged periods can, by reflecting incoming light, reduce the amount of solar radiation reaching the earth, thereby producing a cooling effect.

C) Greenhouse Effect:

Global climate warming is the result of certain long-lived atmospheric trace gases (carbon dioxide, chloro fluoro carbon (CFC), halons, methane troposfheric zone, and nitrous oxide) to trap some of the radiant heat which the earth emits after receiving solar energy. Because this phenomenon is similar to the capacity of greenhouse to trap heat, it is commonly referred to as the "greenhouse effect".

3.3. Carbon Dioxide

In particular, carbon dioxide in the atmosphere allows ultraviolet radiation from the sun to pass on to the surface of the earth. It,however, also block the infrared radiation from the warmed earth from escaping out of the atmosphere. The earth is habitable because of this radiation differential at some "natural" range. If infrared induced heating were not present, the atmosphere of the earth would not sustain life.

The increasing amount of carbon dioxide (CO_2) is leading to climate change and will produce, on average, a global warming of the earth's surface because of its enhanced greenhouse effect. Climate change is a major global issue with profound implication for the way the world produces and consumes energy.

The Second Assessment Report of the Intergovernmental Panel on Climate change (IPCC) states that in spite of remaining uncertainty," the balance of evidence suggest a discernible human influence on global climate". As of 3.september 1997, the United Nations Framework Convention on Climate Change (UNFCCC) had received 169 instruments to ratification by parties. These parties include most OECD countries, practically all Central and Eastern European countries (including the Russian Federation, Kazakhstan and Uzbekistan), and most other major CO_2-emitting countries, such as China, India, Indonesia, and Brazil. The ultimate objective of the UNFCCC, as set out in Article 2, is to stabilize greenhouse gas concentration in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. The UNFCCC calls for a comprehensive approach addressing all greenhouse gases not covered in the Montreal Protocol (i.e. ozone depleting substances such as CFCS and HCFCS), all sources and sinks, and both mitigation of and adaptation to climate change. The concept of climate change has recently acquired a number of different meanings in the scientific literature and in relevant international fora. Often "climate change" denotes those variations due to human interference while "climate variation refers to the natural variations".

For the purposes of the United Nations Convention on Climate change, the definition of climate change is, "a change of climate which is attributed directly or indirectly to human activity that alter the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods".

This definition thus introduces the concept of the difference between climate with the effect of human-induced increase in the concentration of greenhouse gases and that which would be realized without such human interference.

CO_2 is the single most important anthropogenic greenhouse gas. CO_2 concentrations have increased from about 280 ppmv (parts per million by volume) in pre-industrial times to 358 ppmv in 1994. (See table 3.4)

Table 3.4: Annual average anthropogenic carbon budgets for 1980 to 1989. CO_2 sources, sinks and storage in the atmosphere are expressed in GtC/ year.

	CO_2 sources	
(1)	Emission from fossil fuel combustion and cement production	5.5 ± 0.5
(2)	Net emissions from changes in tropical land – use	1.6 ± 1.0
(3)	Total anthropogenic emission = (1) + (2)	7.1 ± 1.1

There is no doubt that this increase is largly due to human activities, in particular fossil fuel combustion, but also land-use conversion and to a less extent cements production. In this study I pay more attention to the CO_2 emissions from fossil fuel combustion. Anthropogenic emissions CO_2 by sources and removals by sinks of all other greenhouse gases, as well as CO_2 from other sources, are not included.

Fossil fuel production and use represent about three –quarters of man-made CO_2 emissions. Other energy related greenhouse gases include methane (CH_4) from production, transportation and use of natural gas and coal, nitrous oxide (N_2O) primarily from fuel wood use and other precursors to tropospheric ozone (O_3).

The energy sector has been the major source of CO_2 build-up in the atmosphere and reducing the emission from this sector is a necessary component of action to address climate change.

Energy related CO_2 emissions have increased substantially over the past 50 year, along with economic development and demographic growth. The growth in emission has occurred mostly in the OECD countries, but increasingly in regions outside OECD over the past two decades. Historical emission which have contributed to the concentration of the greenhouse gases in the atmosphere have come overwhelmingly from industrialized countries.

Development of targeted and efficient emission mitigation policies is greatly help if policy makers have the most accurate picture possible of sources of CO_2 emissions and the underlying trends of energy supply and demand. An understanding of how fuel switching, changes in economic activities and efficiency gains have influenced past trends of energy and CO_2emissions can help to identify promising policies to mitigate emissions of CO_2 from the energy sector.

<u>Geographical Coverage in UNFCCC</u>

The participating countries in UNFCCC are divided into Annex I countries which have commitments relating to emission limitation and non-Annex I countries.

***Annex I countries**

Annex I countries to the convention aim to return, individually or jointly, to their 1990 emissions level by 2000. These commitments are not specific to energy-related CO_2, but refer to all anthropogenic emission of CO_2 and other greenhouse gases not include in the Montreal protocol. It is therefore possible for a country to increase its energy-related CO_2 emissions while reducing its net emissions of greenhouse gases.

The national circumstances of a country are often a crucial determinant of a country's baseline pattern of energy use and CO_2 emissions, and need to be taken into account when doing cross-country analyses. There is a huge variety in different countries' energy use and CO_2emissions, on an absolute, per capita and per GDP basis . Some of the more important reasons behind such diversity include:

-The level of energy sources within a country

- Climate
- Economic development
- Land area/population density/ urbanization

-The population's level and growth rate

- Structure of the economy
- Industrial structure
- Access to energy markets
- Energy pricing

Only some of these factors can be affected by policies aiming to curb energy use and/ or greenhouse gas emissions. Moreover annual variations due to temperature fluctuations, economic activity and/or trade in goods or energy means that for some countries the benchmark year of 1990 may be atypical in one or more respects.(IEA)

The energy supply and – situation in a country not only determines the current level of energy use and CO_2emissions, but also influences the potential for future CO_2-emissions reduction from the energy sector. For example, a country may not easily be able to reduce the carbon-intensity of electricity production if its electricity is produced primarily from non-carbon emitting sources such as nuclear or hydropower. There are large variations in the energy supply situation among countries, and therefore, any policies and measures intended to limit energy related CO_2 emissions will also vary greatly. For this reason Annex I countries are divided into Annex II countries (industrialized) and those countries undergoing transition market economies, Economics In Transition (EITS).

Annex II countries:

The availability of large quantities of relatively low cost energy in net energy exporting countries, such as Australia, Canada and Norway, has affected their pattern of domestic energy use. This is most marked in fuel inputs to electricity production (the sector where substitutability of fuels is greatest), with Australia producing almost 80% of its electricity from domestically produced coal, and Norway generating more than 90% of its electricity from hydropower. These economies are also often more electricity or energy intensive than other Annex II countries.

Other Annex II countries such as the United States and United Kingdom are significant energy producers, although they may not be entirely self sufficient in energy. The indigenous energy resources have, however, greatly influenced current patterns of energy use, especially as fuel inputs to electricity generations.

For net energy importing countries such as Japan, question of energy security and diversity are more pressing than for other Annex II countries. Supply security concerns after the first oil shock triggered many of these countries with limited reserves of fossil fuels to pursue programs that either increased the efficiency of use of imported fuel (such as combined heat and power in Denmark), or that reduced the important of fossil fuels in their energy mix, f.exp., by encouraging the uptake of nuclear power or of indigenous (often renewable) energy sources.

Countries with Economies In Transition (EIT)

In all EIT countries the transition to free market economies was characterized by deep economic crises, the collapse of traditional foreign markets, a slump in domestic consumption, decreased industrial output and a drastic drop in GDP. In particular, the break-up of the USSR, declining Russian supply of fossil fuel and Russia's need for hard currency (obtained from energy exports) caused spectacular declines in the energy supply of the Baltic States, Belarus and the Ukraine, all of whom are highly dependent on Russia for energy supplies.

Energy use and energy-related CO_2 emissions dropped sharply in all EITs except Poland in the early part of the decade, although this trend has slowed or slightly reversed in some of these countries since 1994.

Non – Annex I Countries

These countries have no emissions commitments under the convention, although they have reporting requirements including periodic dissemination of emission inventories. These countries, despite substantial diversity, can generally be characterized by a much lower per capita use of fossil fuels(and energy) and therefore lower per capita CO_2 emissions. The recent growth rates of both, however, have been high in many countries, and the link between energy use and CO_2 emissions is strong in non-Annex I countries because of the predominance of fossil fuels in commercial energy supply and demand.

Iran's formally participation in convention on climate changes (signed in New York in1992) began since 1996. The availability of large quantities of low cost energy in Iran which is net energy exporting country has also affected the pattern of domestic energy use. Fuel inputs to electricity production in 1995, consisted of 55.7% gas, 35.8% oil and 8.5% hydropower. The share of oil has decreased 25.3% since 1980, and gas share has increased with 19.9% during15 years (World Bank indicator 1998). There is no coal as an energy input in electricity generation which emits twice as much carbon dioxide as does burning on equivalent amount of natural gas.

3.3.1. CO_2 – Trends

Emissions of CO_2 from fossil fuel combustion, which accounts for the majority of anthropogenic CO2 emission increased from 14.3 Gt (Gt : gigaton) CO_2 in 1971 to 21.4 Gt CO_2 in 1990 and 22.1 Gt CO_2 in 1995.

The effect of the two oil crises on energy consumption is reflected in energy-related CO_2 emissions, which stabilized for a small post-shock period before continuing their upward trend. The most recent slowdown in global emissions growth started in 1989. This was caused by the drop in CO_2 emissions from the countries of the former

USSR and Central and Eastern Europe, and the stabilization in Western Europe partially offsetting growth in emissions from all other world regions. The rapid of energy growth in certain non-Annex I regions (especially China and Asia), combined with the recent declined of some Annex I regions, means that the relative share of different world regions has changed significantly since 1971.

Regional Shares of CO_2 Emissions

*****Annex I emissions were 13.4 Gt CO_2 in 1995 (60.5% of world emissions), compared to an estimated 14.5 Gt CO_2 in 1990 (65% of world emissions, IEA- 1997).

***** Annex II countries' emissions (industrial countries) as a whole grew 457 Mt CO_2 (mega ton carbon-dioxide) between 1990 and 1995. The United States, European Union, and Japan contain 13 percent of the world's people, but accounted for 42% of global CO_2 emissions. (World Bank indicator 1998)

Although emissions from the Annex II group of countries have risen steadily since the beginning of the 1990s, they were only slightly higher in 1990 than in 1973 despite a growth in energy supply of 17%. This success in (partly) breaking the link between energy use and CO_2 emissions is due to many factors, including the increasing electrification of Annex II countries and to the "decarbonisation" of electricity generation, via increasing use of nuclear and renewables and a switch from coal to gas. Structural change has also brought about a significant shift in the importance of different sectors in total CO_2 emissions.

The CO_2 emissions of certain Western European countries (such as Germany, United Kingdom, France and Luxembourg) declined between 1990 and 1995. The largest drop of almost 100 Mt CO_2 , was seen in Germany, largely due to recession and to energy improvements in former eastern Germany. CO_2 emissions fell from all sectors except transport. The reduction in CO_2 emissions seen in France and the United Kingdom (16 and 19 Mt CO_2 respectively) were due to a change in fuel mix of electricity inputs. The decline in CO_2 emissions in Luxemburg (small in absolute terms, but a significant proportion of the country's total emissions) was due to a decline in iron and steel production in 1995. Significant variations in annual emissions, especially from the electricity / heat sector, are caused by a number of factors including changes in electricity trade and temperature fluctuations. Emissions from North America countries(U.S. & Canada) rose 6.8 % in the five years to 1995, driven by an increase in emissions from the transport sector of 138 Mt CO_2 (8,7%), but also by rise in emissions from electricity/ heat production, residential energy use and other sectors. Emissions of CO_2 from transport in Canada and the U.S.(1.72 Gt CO_2) accounted for 7.8% of total global CO_2 emissions from fossil fuel combustion in1995.

Pacific Annex II countries'(Japan, Australia and New Zealand) CO_2 emissions rose 8.2% from 1990 levels, to stand at 1,47 Gt CO_2 in 1995, with the fastest increase in transport (16.1%) and residential (15.4%) emissions.

The decrease in CO_2 emissions was consistently felt across all EITs(although to different degrees). Between 1990-95, total CO_2 emissions dropped 28%.

The importance of coal in many EITs' energy mix, the presence of energy-intensive industry, the historical lack of pricing incentives and the decline in GDP resulted in this region remaining one of the most CO_2-intensive.

* Non Annex I emission in 1995 were 8.3 Gt CO_2 (37.6%word emissions). The majority of this was accounted for by Asia and China (62%) followed by the Middle East (10%), Latin America (10%) and Africa (8%). The reminder was made up of the former USSR and European countries not in Annex I. Average non-Annex I per capita energy demand and emission are low, due to the level of development and to the lack of access to commercial energy by much of the population.

* Iran's CO_2 emissions in 1995 were about 233 million tones of CO_2 (0.01% 0f world emissions that were about 22149.6 mt CO_2). This index for Iran in 1995 in World Bank indicator (1998) is 263.8 mt CO_2. The average annual growth rate in CO_2 emission from 1990 (about 199.73 mt CO_2) is 3.3 percent.

**** Sectoral Emissions***

In 1995, the sector emitting the most CO_2 from energy use on a world wide basis were electricity and heat production (17.7 Gt CO_2), industry (5.0 Gt CO_2), although there are considerable variations between countries and regions. Electricity and heat production is the largest emitting sector for 34.7% of global CO_2 emissions in 1995, compared to 31.6% of global CO_2 emissions in 1990.

Annex I countries accounted for 66% of the total CO_2 emitted from this sector in 1995. The 24 Annex II countries emitted 50% of the global total from this sector in 1990 but 48% in 1995. This slight drop reflects the increasing electrification in other countries. This is also a result of the increasing decarbonisation of electricity and heat production (Fossil fuels provided 58% of Annex II's electricity in 1995, down from a high of 74% in 1973). Industry is the second most important of fossil fuel emissions at a world level, and accounted for 24.1% of global CO_2 emissions in 1990 and 22.5% in 1995.

The variation in importance of this sector between regions is due to a number of factors. These include the location of energy intensive and non-energy intensive industries in country/regions, differing energy efficiency of the same industry in different countries, the degree of electrification of industrial processes and the level of economic development.

Transport is the second-fastest growing area of fuel emissions at a global level, and is also the end-use sector with the lowest degree of flexibility in fuel use, relying almost exclusively on petroleum products. Emissions from transport sector grew from 19.3% of the world total in 1990 to 20.2% in 1995 (Annex II countries emitted 66% of total transport emissions in 1995 and Annex I emitted 71%).

Non-Annex I countries have a much lower relative use of energy in transport than Annex I countries because of low levels of car ownership and less widespread use of other forms of transport requiring the use of fossil fuels. This means that there is potential for a tremendous growth in transport CO_2 emissions in this region. Emission from other sectors (residential, commercial, public services, agriculture, etc) also varies in importance by region. These sectors are an indirect source of CO_2 emissions.

Iran –sectoral emissions

Electricity generation and heat production is also the most important of fossil fuel emissions in Iran. CO_2 emissions in this sector grew from31.95 mt CO_2 in 1990 to 43.65mt CO_2 in 1995. The second most important emitting sector in 1990 was transport which emitted 20.44mt CO_2, but this sector became at third place after industry sector in 1995 with 50.12mt CO_2. Industry sector's contribution of total CO_2emissions in Iran rose from 16.20mt in CO_2 1990.

I must note that IEA's statistic do not include CO_2 emissions produced from electricity generation, although "other" sector are an indirect source of CO_2 –emissions.

Figure (3.3) and (3.4) shows sectoral emissions in world and Iran respectively, based on IEA's emissions estimating (IEA STATISTICs, 1997).

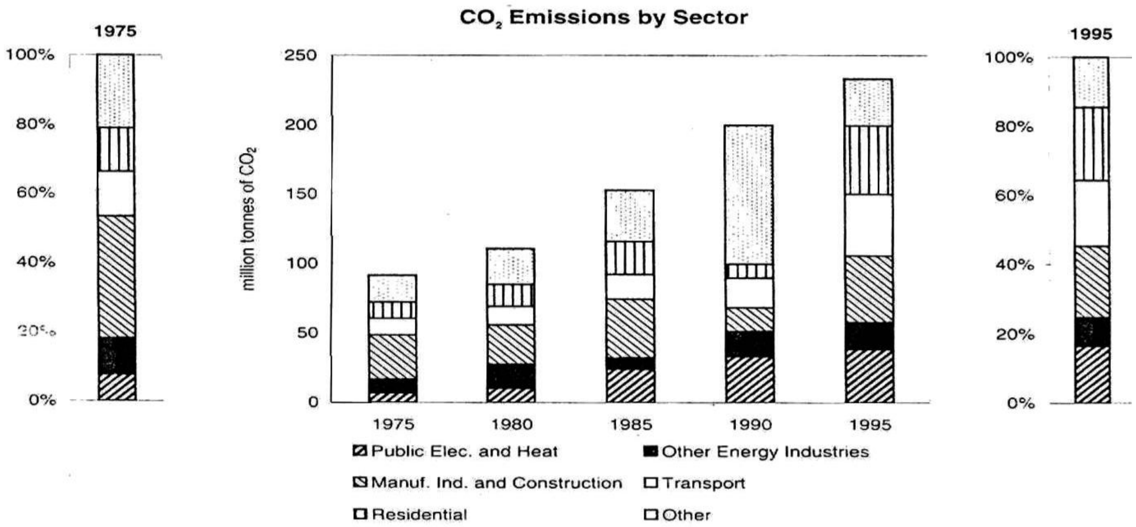


Figure:3.3-World

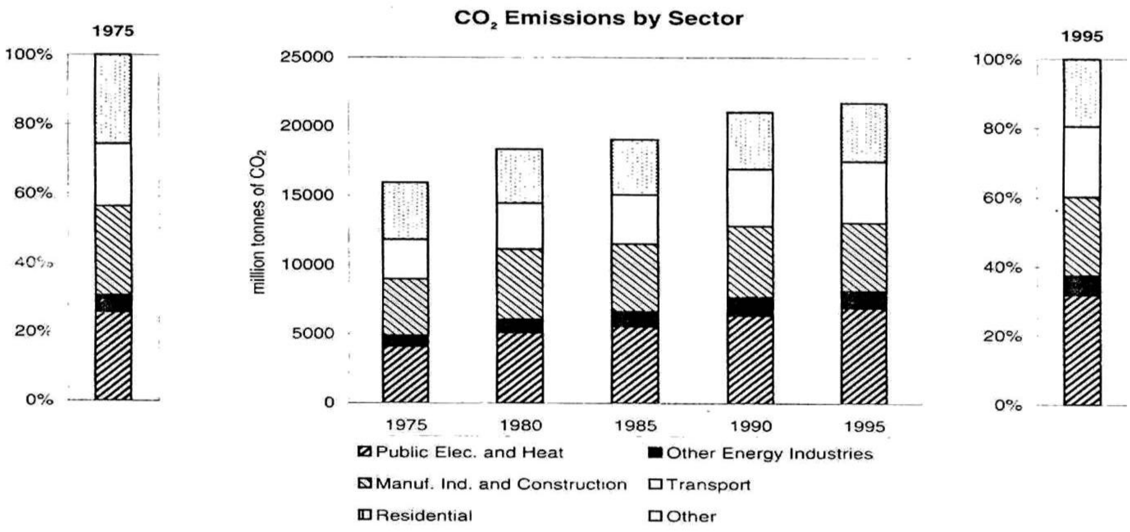


Figure:3.4-Iran

In CEDP-study (1994), past trends of emission volumes of various pollutants are estimated on the basis of the energy balance table. According to this study total CO_2 emission has been increased about 4 times during the period from 1970 t0 1990. The sector classification and CO_2 – trends are as follows:

Table 3.5: CO_2-emissions by sector (million ton CO_2)

Year	1970	1975	1980	1985	1990
TOTAL EMISSIONS	44.66	71.83	98.45	160.35	185.08
Convertion Sector	5.67	10.96	13.21	29.34	39.90
Industry Sector	6.25	13.73	21.63	31.74	38.25
Transport Sector	6.72	15.02	21.59	35.40	38.29
Agriculture Sector	1.64	3.34	5.03	9.49	10.65
Resid & Comrs. Sector	24.37	28.79	37.00	54.38	57.98

Source: Collaborative study on the Comprehensive energy Development Plan in Iran (1994).

Table (3.5) shown that the emissions volume in energy sector has been increased during the last decade.

3.3.2. CO_2 / GDP

The emission volume per unit GDP represents economic efficiency from the viewpoint of the pollution emissions. The small value of this index indicates the high economic efficiency. The CO_2/GDP ratio of many regions including China, North America and Europe (and the OECD as a whole) has fallen steadily over the last few decades. In China this is due to the growth in GDP outpacing that of energy use and emissions, in part as energy efficiency of basic processes has improved in North America and Europe. The fall in CO_2/GDP owes more to increasing energy efficiency as well as to a shift towards gas in some countries.

Other regions' energy intensities have been approximately stable (Latin America) or increasing more or less rapidly (Middle East, Africa, Asia). This ratio for world in average, Annex I parties, and Non-Annex I parties in 1995 is about 0.94, 0.72, and 1.78 Kilograms CO_2/US$, using 1990 prices and exchange rates.

This ratio for Iran, in 1995, is about 1.55 kg CO_2/1990 US$. This ratio has fallen from 1990 (1.66 kgCO_2/1990 US$), but has risen significantly during the last decade.

In world indicator (World Bank 1998), the ratio of real GDP to energy use is a measure of energy efficiency. Differences in this ratio over time and across countries are influenced by structural changes in the economy, changes in the energy efficiency of particular sectors of the economy, and differences in fuel mixes. This ratio in Iran in 1995 was 2,2 1987$ per kg oil equivalent , which is less than the world's average that is about 2.4 1987$ per kg oe. The CO_2/GDP ratio, in the world indicator 1998, for Iran in 1995 was 1, 4kg/1987$ of GDP.

In CEDP-study, the GDP value is converted into the constant price of 1980. It shows that the CO_2 emissions per GDP increases as GDP per capita increases up to the level between 1000$ and 3000$. Then the trend is reversed as the economy grows beyond this level.

3.3.3. Per Capita CO_2 Emission

There is a marked diversity in per capita CO_2 emission. In1995, Annex I, non-Annex I and world per capita emissions were 11.2 ton CO_2, 1.9ton CO_2 and 3.9 ton CO_2 respectively.This compares to 12.0, 1.7, and 4.1 ton CO_2/capita respectively in 1990.

Per capita CO_2 emission in Iran, in 1990 and 1995, were 3.5 and 3.6 ton CO_2 respectively. The regions with the highest annual per capita emissions of CO_2 are Annex II countries and countries of the former USSR and Central and Eastern Europe. The high per capita emission levels are due to the large importance of the transport sector in CO_2 emission, to the importance of electricity in energy of electricity/heat production in many of the larger Annex II countries.

3.4. Indices Do Matter

Any successful program to slow or revers the build up of greenhouse gases in Earth's atmosphere will require cooperation among a wide range of nation. This is because the problem is truly global in character. Because the mixture of activities is so different in each country, there are significant differences among nations in their patterns of emissions, requiring negotiation from a number of view points in the development of mitigation programs.

The requirement to achieve any agreement, parties must be agreed on an indexing scheme. Deciding which projects to fund and who should pay implies the use of indices to weight potential projects and donors against one another. Efficiency and equity criteria are important for choosing appropriate indices. Choosing indices, is the crux of efforts to decide which projects fund by whom.

Consider for example, that one country ranks third or fourth in the world as an emitter of greenhouse gases (GHG). This might imply to some observes that this country could be held responsible for a good proportion of the present world problem and, on this basis, might be a good candidate as a significant donor to an international program. This would be an unfortunate interpretation, however, for the index used to create this ranking is inappropriate to the question at hand. In particular, responsibility is best judged on a per capita and not on a per nation basis. On the other hand, the population size of country could be one appropriate indicator for incorporation into an index designed to rank countries as to the potential for energy efficiency programs that could have the biggest effect on GHG emission. In this case, governments of populous nation may well be able to achieve larger reductions. The point is that : the index must be chosen with regard to the question being asked. Per capita indices are generally more suitable for questions of responsibility. But the best index for determining responsibility is per capita cumulative emissions. This is based on the physical reality that the most critical single parameter for determining the global warming at any one time is the cumulative amount of the GHG in the atmosphere. Consider fossil-fuel carbon dioxide from India and the United States.(There are second most populous developing nation and developed nation, respectively, each with about 22% of the populations of its group). The amount placed into the atmosphere since 1950 as part of the United States industrialization process is equivalent to about 155 tons per person in 1986, about 50 times that of the average Indian, at 2.8 tons. What will be their relative responsibilities for increasing GHG emissions over the next 35 years? To answer this question there are some scenario which shown that : the Indian per capita cumulative contribution would increase by a factor of 8 over the period, while the United States contribution would only double. Because of the large difference in initial values, however, during these 39 years, the Indian's contribution would increase by 19 tons, while the average U.S citizen's contribution would rise more than 10 times as much, i.e. 200 tons. The ratio of total cumulative amounts at the end of the period would, at16, be lower than what it was in 1986(55), but still high. At that point, the average Indian would still be responsible for only a minor part of the total atmospheric accumulation, less than 6% that of the average U.S. resident (Economic Development Institute of World Bank, 1990).

* * *

4. ECONOMIC THEORY AND ENVIRONMENTAL ISSUES

Concerns for environmental damage can collide with goals for expanding economic activity which is closely related to energy consumption. Therefore environmental concerns occupy an important place in the world-wide energy debate. It is widely recognized that the production, supply and use of all forms for energy result in a range of environmental impacts that affect air, land and water and carry consequences for ecological and human health on local to global scales both in the immediate and longer term. In 1987 the World Commission on Environment and Development, led by Norway's Prime Minister Mrs. Harlem Brundtland, focused on the need for sustainable development, the need to balance the requirements for human, social and economic development with environmental protection, now and in the future. The World Commission stressed that "sustainable development can not be achieved without a versatile sector and dynamic industrial sector". Nor can it be achieved without the energy to run that industrial sector. Five years later the United Nations Conference on environment and Development (UNCED), held in Rio de Janeiro, reinforced this focus on sustainable development.

Sustainability as such is of course not a new problem to economists studying economic growth and utilization of resources, but the global scale of disastrous effect if the present economic development should turn out to be non-sustainable, has caught the imagination of, if not policy makers, at least their electorate.

Now economists do not have quite a clean record as to dealing with the sustainability issues. In the heydays of growth models in the fifties and sixties just following the golden rules into infinity was the recipe for maximal consumption per head. First the question of the sufficiency of the recourse base, an old economic issue, surfaced again, and then emerged a new issue:

The survival of ecological systems under the weight of ever-increasing loads of growth-related pollution. The two prominent global problems now are the global warming issue and the depletion of the ozone layer, which are typical examples of transbandary environmental problems. We have a transbandary environmental problem whenever the environment in one country is directly affected by actions taken in one or more other countries. For many environmental problems, it is not the flow of depositions of the pollutant which matters for the environment, but the accumulated stock.

4.1. Global Warming

Global warming problem depending on the development of the atmospheric concentrations of a large number of greenhouse gases (of which CO_2 is the most important one) . The development of each of these atmospheric concentrations in turn depends on the emissions of the greenhouse gas from all countries.

Scientists estimate that total emissions of greenhouse gases in 1880-1989 have committed the earth to temperature increasing ranging from 0.5 to 1.5 degrees.

Carbon dioxide (co_2) is responsible for 55-60 percent of the contribution. The inter-governmental Panel on Climate Change (IPCC1994) claimed that the atmospheric content of CO_2 increased at an average rate of about 1.5 parts per million volumes (e.g.3.2 billion tons of carbon) per year, over 1980-89 due to human activities. While the rate of increase in the atmospheric concentrations of CO_2 slowed substantially during 1991-93, the CO_2 growth rate began to increase again in the later half of 1993.

There are many scientific uncertainties about the greenhouse effect and the extent of global warming's impact. However, uncertainty is not necessarily grounds for policy inaction. Indeed, if policymakers are risk avers, they should attach a higher weight to the upper-bound warming and damage estimates. Policymaker will need more scientific work on the extent and effect of global warming in the very-long term for more informed decisions.

Far more work is needed on the economic impact of global warming, including the appropriate valuation of ecological damage for policy decision purposes. A body of literature is developing on the cost of prevention. If preventive action is to be taken, it is Likely to include some form of carbon taxes or tradable emission permits. There will have to be substitution of less-carbon-polluting natural gas for oil and coal, and substitution of nuclear, biomass, solar, wind and other energy technologies for fossil fuels. Although reduction of tropical forest burning can help, afforestation is an inherently, limited policy. Just to remove one GTC annually from global emissions over a century, it would require the planting of 913 million acres, approximately the entire farm area of the United States (W.R.Cline1991).

In what fallows I will represent a simple approach for analyzing policy when the environmental problem is due to accumulating pollutant like CO_2 and then will discuss the role of economical instruments that may be used to tackle environmental problems in the field of energy, especially in the context of potential global climate change.

4.2. The Economics of Pollution Control

A crucial aspect of carbon dioxide accumulation is that it is essentially irreversible over periods of hundreds of years. The nature of pollution problems necessiate policy measures both across and along the time axis. The time dimension is essential when the negative effects of residuals are due not to current flows, but to stocks of accumulated flows of residual.

A very simple two period model will bring out some essential features of the problems we face when pollutants are accumulating. Let all interaction between environment and economy be captured by a partial two relationship model consisting of monetized(social) damage functions, $D_i(.)$, being strictly convex, and (social) benefit functions,$B_i(.)$, being strictly concave, the periods, (i), are indexed (t) and (t+1):

$D_t = D_t\ (p_t)$ $\qquad D'_i > 0\ ,\ D''_i > o$ (1)

$D_{t+1} = D_{t+1}(p_t + p_{t+1})$ $\qquad i = t,\ t+1$

$B_i = B_i(p_i)$ $\qquad B'_i > 0\ ,\ B''_i < 0\ ,\ i = t, t+1$ (2)

The partial character of the model is obvious, not showing explicitly the trade-off between environmental quality and man-made goods. The case of pure accumulation of pollutants (p_i) is shown in the damage function for period (t+1), the initial level of accumulated pollutants being included in the functional forms. There is no decay of the pollutant. The benefit function is based on the value to the consumer of man-made goods and least cost ways of reducing the discharge of the pollutant, including conventional purification and reduction of production (i.e. optimal behavior lie back these (social) benefit functions, (B_i)).

The social planning problem is to find the discharge of pollutants that maximize benefits minus damage costs (net benefits). This procedure implicitly takes care of the linkage including the generation of pollutants and physical environmental impacts through dose-response relationship, i.e. the trade-off between environmental quality and man-made goods.

Let us start by considering solving the decision problem for the first period. Since accumulation occurs, the future period damage must be taken into account:

$$\text{Maximize}_{p(t)} \{ B_t (p_t) – D_t (p_t) - D_{t+1} (p_t + p_{t+1}) \} \quad (3)$$

Two important lessons can draw from this simple model formulation:

*firstly, the discharge in future periods,(p_{t+1}), must also be decided upon in period(t) in order for the problem to have a solution. Thus the society faces a simultaneous multi-period problem.

*secondly accumulation implies that the concept of marginal damage of current pollution extended to cover not only the current marginal damage, but all future periods marginal damages too.

The relevant social planning problem is therefore:

$$\text{Maximize}_{p(t),p(t+1)} \{ B_t (p_t) + B_{t+1} (p_{t+1}) – D_t (p_t) – D_{t+1} (p_t + p_{t+1}) \} \quad (4)$$

Yielding the first order conditions:

$$B'_t = D'_t + D'_{t+1} \quad (5)$$

$$B'_{t+1} = D'_{t+1}$$

This is two questions in the two endogenous variables having a solution under our assumptions (p^*_t and p^*_{t+1}, are optimal levels of pollution which maximize net social benefits).

So far we are concerned with pollutants that are “non-degradable”,(such as PCB,DDT).

In the case of degradable pollutant where it is judged that the threshold for pollutant stock(S) is “large”, it is often convenient to ignore the range beyond this threshold and to simplify and suppose that the pollutant depreciate at a fixed percentage rate, sayδ, where δ is a positive number. In this case we have:

$dS_t / dt = p_t^{-\delta\, S}{}_t$ (6)

where $p_{t,}$is the emitted level of a particular pollutant in period t and S_t is the stocks level of same pollutant in period t. In such cases damages depend solely on the pollutant stock (S), D = D(S).

Then the maximizing problem (4), can generally writes as follows:

$$\text{Maximize}_{\ p(t)} \int_0^{\infty} \{B(p_t) - D(s_t)\}\, e^{-rt} dt \qquad (7)$$

However, if we want to see what will the cost of reducing emissions level of a particular Pollutant for society be, we can just try to solve the following problem:

$$\text{Minimize}_{\ pt} \int_0^{\infty} \{C(p_t) + D(S_t)\}\, e^{-rt}\, dt \qquad (8)$$

Equation (7) and (8) is just two side of one coin. C (p_t) denote the cost of reducing p_t for society, i.e.:

$$C\,(p_t) = B\,(Y_t) - B\,(p_t) \qquad (9)$$

When B (Y_t) denote the flow of social benefits where production flow is(Y_t),in period (t), and there is no pollution control. Solving minimizing problem (8), yield the first order condition:

$$C'(p_t) = \int_t^{\infty} D'(S_{\tau})\, e^{-(r+\delta)}\, d\tau \qquad (10)$$

This condition tell us that the optimal emissions level (p^*_t) occur when the marginal cost of reducing emissions is equal to the marginal damage (in monetary terms) due to the concentration of that particular pollutant. Or put slightly differently, (10) says that pollution control measures should be pursued by each polluting agent to the point at which the marginal benefits from reduced pollution equal marginal abatement cost. This is the least- cost way of attaining the target within a specified period. When the environmental goals, whatever they are, are reached at as low cost as possible, we have a cost-effective solution.

4.3. Implementation of Optimal Emissions Level (p_t*)

There is a vast variety of options for environmental protection. They range from direct regulation policies, voluntary approaches and joint implementation , to economic incentives and instruments, including tradable permits, subsidies and tax. In what fallows I will discuss the suitably of each of these options in the case of climate problem.

4.3.1. Direct Regulation

Direct regulation has historically been the most common means which governments have used to limit emissions based on a "command and control" approach. Regulators issue a" command" that sets emissions standards ($p_t^{*)}$ and then follow up with" controls" that enforces those standards. There are two types of command and control categories, either technology-based or performance-based. Technology-based standards typically require the use of specific equipment, processes or procedures, whereas performance-type standards specify the allowable levels of pollutant emissions, whilst leaving the specific method of achieving those levels up to the regulated individuals, businesses and sectors etc. The performance standard method has been used to set standards for air and water quality, waste disposal, pollutant emissions from mobile and stationary sources and fuel quality.

Under direct regulation, the operators of emitting processes are issued a command to reduce the emissions, and are forced to comply via a threat of financial penalty(fine) or the imposition of a ban to operate or even imprisonment of the operator. Assuming effective enforcement, the command is enforced no matter how grate the cost of the reducing emissions: there is no effort to maximize the potential of a least cost solution.

In the context of climate change policy, technology-based standards could be envisaged that requires particular types of energy efficient motors, combustion processes, etc.

The performance-based standards for reducing greenhouse gas emissions levels could include minimum levels of energy efficiency for appliance, maximum allowable levels of CO_2 - emissions from combustion etc.

Although the command and control approach is effective in achieving established environmental goals and standards, it does not tend to secure those targets, e.g. emissions reductions, at the lowest overall cost and is economically inefficient.

This means that direct regulation does not offer a practical solution to many of the problems faced today.

4.3.2. Economic Instruments

There are alternative policy approaches to direct regulation which make use of market principles in achieving objectives:

These are known as economic instruments. The dynamic efficiency, flexibility and relate ease of enforcement of economic instruments has led to an increasing interest in their adoption. For an economic instrument to function effectively as a stimulus for sustainable development it must effect market and social behavior, by creating an incentive powerful enough to make polluters and consumers change their decisions about which processes to use and which products to buy. There are several different types of economic instrument: tradable permits, subsidies and taxes, which are described in what follows;

a) *Tradable permits*

Tradable permits aim to reduce emissions and distribute resources effectively promoting emission reduction at a relatively low level of marginal expense. Companies (countries) which find ways of reducing their emissions to below the limits authorized by their permits (p_t^*) and could do so more cost-effectively than others would have the incentive to do so and sell the unused portion of their permits, provided that the price is right (right price in our case means a price equal to marginal reduction cost, $C'(p_t^*)$). In contrast to direct regulation, tradable permits allow for the most cost-efficient reductions, or looking at it from a different point of view, tradable permits provide a greater reduction of emissions at the same cost. The effectiveness of the tradable permit system in these situations has depended upon the number of emissions sources. The global nature of the greenhouse gas problem remove this regional barrier and amplifies the benefits provide opportunities to offset local obligations through actions undertaken in other regions, such as technology transfer.

Tradable permit schemes can address transbandary emissions, whilst ensuring that more sensitive and more localized environments are still protected. The tradable permit system effectively constrain emissions within a “regional bubble” to below a specified limit (p_t^*) . To take account of smaller geographical areas, within the entire bubble-region, that contain particularly sensitive ecosystems, the permit trading system can be weighted , so that a greater number of permits(or a more expensive unit charge per permit) is required to operate in sensitive areas.

There is increasing interest in the possibility of a global tradable permit system for controlling CO_2 emissions. An international tradable quota or permit scheme could coexist with domestic permit within each country, or particular countries may choose to meet their emissions targets by some other means, such as taxes, regul -atory systems and voluntary approaches.

However an efficient international tradable quota system presupposes a market or Organization for quota trade and that there is a reasonable probability of detecting and penalizing those responsible for unautothorised emissions. An international tradable quota system would permit industrialized countries to emit greenhouse gases, providing that they purchase surplus (unused) quotas from developing coun -tries. This would result in a transfer of investment capital from the North to the South - not as aid or charity- but as trade. A global tradable CO_2 emissions permit scheme would also provide economic incentives to the developing countries to emit less CO_2 during their economic growth and would provide a greater incentive for developing new, cleaner technologies and a market for the implementation of such technologies. However, further discussions are required to reach agree- ment on how to distribute initial permits and quotas.

The Kyoto Protocol which was adopted at the third conference of the parties to the (UNFCCC), held in Kyoto, Japan, in December 1997,provide for possible carbon emissions trading among Annex I countries. Provided free trade between them, Center for international Climate and Environment Research in Oslo(CICERO) has projected a quota price about 14 US $/ton CO_2(51 US$/tC) . Another example is an American’s firm (Mohawk power) which sold 100,000 ton CO_2 – equivalent to a Canadian firm (Suncor-Energy) . Probably the price was about 2.18 US$/tC (0.6 US$/tCO_2), and finally Cost a –Rica , had in Mars 1998 bidden out the so-called carboncertifiaction for international sale. These certificates which shall sells in Chicago bourse, will sells for ca.10 US$/t$CO_2$ or 36.6 US$/tC (these examples are shown in Report 1998:2 from CICERO).

Within national tradable permit schemes, governments may choose to distribute permits to individual companies in one of two main ways. "Grand fathering" allocates permits on the basic of the share of an individual company to total historical emissions. The alternative approach is for governments to auction permits. In the context of an international tradable permits system for CO_2 emissions it is easy to understand why there may be difficulties in reaching an agreement on the equitable allocation of initial permits. A grandfathering approach would exclude the needs of developing countries. Under an auctioning allocation approach, the initial allocation of tradable permits to national governments could be made on the basis of one of a number of criteria, including GNP, real GNP, total population, adult population, land area, "basic needs" as defined by present industrial mix or/and local climate, dependence on fossil fuel production, etc.

Whichever approach is adopted, it is clear that the developing countries will have little intensive to participate unless they see clear economic benefits from an agreement.

United Nation Conference on Trade & Development (UNCTAD) recently launched a proposal to introduce a pilot scheme in 1997 to establish an international market in CO_2-emissions permit. The UNCTAD report recommends establishing a UN Global environmental protection Agency, which would allocate to each country would be based on existing and/ or future acceptable levels of national and global CO_2 emissions. It would then be up to each government to distribute its national quota between its industrial emissions sources. The reports estimate that a pilot market in which the US, the EU and Japan participate, would cover 40% of total global emissions, which in 1990 were nearly 70 bn tones. It concludes that a tradable CO_2 program would be the cheapest solution to mitigating potential global warming.

b)Subsidies

Subsidies are traditionally used by governments to alter economics in order to achieve a particular goal. For example, subsidies have been used to promote particular forms for energy. The resulting artificially reduced cost of energy has the effect of increasing that particular form of energy consumption and often has the net effect of increasing greenhouse gas emissions in a non-sustainable manner. World Development Report (1992), states that removing world energy subsidies, presently estimated at US$230 bn.(20-25% of the value of world fossil fuel consumption at world prices) could reduce global carbon emissions by 9% if there was no change in world prices, or 5% accounting for changes in world prices (World Energy Council 1995).

Short term subsidies, however, have played an important role in the evaluation and market penetration of some form of renewable energy, which can result in low greenhouse gas emission forms of power generation. Subsidies also may be used to encourage activities which reduce environmental pollution and restore environmental resources. Special loans with lower intrest rates for pollution control investments; tax exemption measures such as accelerated depreciation to encourage turnover of more polluting stock and investment in pollution prevention facilities; side payments for reaching environmental goals (in our case to reach at the optimal emissions level p*) are included within the category of subsidies. In some instants, subsidies have helped in the research and development of renewable energy by providing an economic market for the energy produced. However, long-term subsidies for energy tend to distort the market and the resulting lower energy price can lead to the unsustainable use of resources and unchecked environmental impact.

C/ Taxes

The policy often proposed for reducing carbon emissions is a carbon tax. It would be applied to fossil fuels used for combustion in proportion to the carbon dioxide the fuels emit when burned.

From the stand point of energy efficiency, a carbon tax is the ideal way to reduce carbon dioxide emissions because it is very close to a tax on the externality itself: if firms and individuals must pay to emit carbon dioxide, they will emit less. A carbon tax would stimulate users to substitute other inputs for fossil fuels and to substitute fuels with lower carbon contents, such as natural gas, for high-carbon fuels such as coal. A carbon tax would have effects throughout the economy. It would raise the price of energy, increase the cost of products produced by energy intensive processes, reduce employment in energy sectors, increase employment elsewhere, generate tax revenue and finally reduce carbon dioxide emissions.

Precisely how the tax revenue is used will have a large effect of the overall economic cost of slowing greenhouse gas emissions. In particular, if revenue were used to reduce distortionary taxes elsewhere in the economy or if it were used to lower government budget deficits, there would be large welfare gains which would offset some or all of the welfare losses associated with the carbon tax itself. This is what environmental economist called for “double dividend”: both reducing tax-distortion and increasing environmental improvement or/and increasing employment.

At the other end of the spectrum, energy subsidies, and their possible removal, can be interpreted in similar ways as regards their welfare impacts. Subsidies represent a distortion, with resulting welfare costs, so that their removal can be welfare enhancing. Energy subsidies are especially prevalent in developing countries. Total world energy subsidies in 1990 are estimated to be in excess of US$ 230 billion (World Energy Council, 1995) and elimination of those subsidies would translate into a 20% reduction in carbon emissions in the subsidizing countries.

Based on a survey of cost estimate to achieve an equivalent reduction in tons of emissions in OECD countries, a carbon tax of US$60 per ton would be imposed in the OECD countries. This would result in a total annual cost of US$15.5 billion. This amount could represent the upper bound for OECD compensatory transfers to the subsidizing countries instead of imposing a US$ 60 per ton carbon tax in the OECD countries.

The removal of these subsidies would reduce global carbon emissions by 9 ½ percents and improve allocative efficiency, generating a welfare gain in subsidizing countries (IPCC working groupIII, Jan.1994).

*****Optimal Carbon Tax

Consider first that we have a national target for reducing, for example, CO_2 emissions. According to standard environmental economic, the optimal tax should be equal to the marginal environmental cost(damage cost) in country(i), i.e.:

$t^* = D_i'(p_t)$ i= country i

Except for the special case in which abatement cost and environmental cost functions are equal across countries, this tax rule will generally imply that environmental taxes will differ across countries [because $D_i'(p_t) \neq D_j'(p_t)$].

But the climate problem is a special case of the general transnational environmental problem. This special case has the property that it is only the sum of emissions from all countries which matters for the climate, i.e. for the environment of each country. For this special case international cost effectiveness requires that the marginal cost of reducing CO_2 emissions should be equal across countries, and equal to the sum of marginal environmental cost over all countries [i.e. $\Sigma_i D_i'$].

This could be achieved through an agreement specifying an equal tax in all countries;

$(t_i^* = t_j^* = \ldots = t_n^*)$

There are however, at least two important difficulties with an agreement which harmonized carbon taxes across countries. The first difficulty is the associated distribution of cost between countries. Even if marginal costs are equalized across countries, total cost of reducing emissions will generally differ between countries. An analysis by Kverndokk (1993) suggests that the cost as percent of GDP differs sharply between countries when CO_2 emissions are allocated in a cost-efficient manner. Moreover, Kverndokk's analysis suggest that it is richest countries in the world which would have the smallest total cost of reducing emission relative to GDP. An international Climate agreement with such distributional properties will be unacceptable to a large group of countries, and will therefore in practice be infeasible unless it is supplemented with some kind of side payments between countries (M.Hoel, 1996).

The second important difficulty associated with harmonizing carbon taxes is related to the question of whether an internationally harmonized carbon tax should be an addition to existing tax on fossil fuels, or should replace such taxes. M.Hoel (1996) concludes that: "in general, the optimal total taxes on fossil fuel will differ between countries. This suggests that a uniform, harmonized carbon tax should not be a tax which replace existing taxes on fossil fuels, but should be added to these, while the existing taxes might at the same time require an appropriate adjustment".

There is still another difficulty. That is "free rider" incentive each country will have. This implying that it is in each country's interest to have little or no restriction on its own CO_2 emissions, given the emission from or given the policies of other countries. If a government is required to have a specific carbon tax through an international agreement, it is therefore in the interest of that government to try reducing the effect of this tax, for instance by reducing other domestic taxes on fossil fuels.

**energy tax as an instrument for energy and environmental policy*

The impact of taxes depends in part upon how they are presented and introduced: the dividing line between revenue-raising and environmental mitigation is not always clear out. The impact may depend on what other taxes and policy measures are in force, to what extent existing taxes and subsidies are distortionary and from an ecological point of view whether environmental tax revenue will be used to reduce more distortionary taxes.

-In terms of energy policy, energy taxes are an ambiguous phenomenon. On the one hand, these taxes can favor or protect indigenous energy production if they respond flexibly to fluctuation in the price of corresponding imported energies. On the other hand, they are not considered effective as a means of cutting energy consumption; where price elasticity is low, tax level would have to be significantly higher to achieve significant demand reductions in such a situation.

-In terms of environmental policy, i.e. to bring about cut in energy-related emissions, the use of energy taxes is difficult for two main reasons. First , demand elasticities of those energy consumers who are able and willing to pay higher energy prices will not lead to a significant reduction of energy-related emissions, which means that the intended steering effect is not achieved for this group, the application of energy taxes to the domestic sector also raise the problem of distributional burden: a higher burden can fall on those less able to pay, thus raising the request for a parallel support mechanism for low-income households. Second, given the existing tax structure, relatively less demanding energies such as gas and oil are often subject to higher taxation, while coal, the most carbon intensive fuel, is frequently taxed less, or even in part , subsidized. Thus the application of environmental taxes, in terms of economic and environmental efficiency, will depend on how they are introduced and to what extent existing taxes are distortionary in terms of environmental policy objectives. To place a blanket of harmonized CO_2 taxes on top of varying tax rates is thus senseless, because in general, current energy taxes do not necessarily reflect the comparative differences in environmental impacts and/or carbon content, associated with different energy options.

- From an energy efficiency and investment point of view, the use of energy taxes may even be counter-productive and will be so if not introduced in a harmonized manner world-wide. The application of an energy tax will effect the ability of industry to invest in energy conservation and job creation. Industry is strongly influenced by its level of capital investment and the effect of an energy tax will be to remove capital from the industrial sector that could otherwise have been used for energy saving and job creation initiative. The most contentious aspect of energy taxes is their impact on the competitiveness of export oriented industries with energy-intensive production (W.E.C. 1995).

**Prices Vs Quantities*

In a world of perfect knowledge, marketable emission permits are, in principle, a fully equivalent alternative to unit taxes. Instead of setting the proper Pigouvian tax and obtaining the efficient quantity of waste discharges as a result, the environmental authority could issue emission permits equal, in the aggregate, to the efficient quantity and allow firms to bid for them.

The market – clearing price will produce an outcome that satisfies the first-order conditions both for efficiency in pollution abatement activities in the short run and for entry-exist decisions in the long run. The regulator can set: either “price” or “quantity” and achieve the desired result.

In a setting of imperfect information, the outcomes under two approaches can differ in important ways. Depending on the shapes of the marginal damage- and marginal abatement cost functions, the authority will be better advised under some circumstances to use one of them, and under other circumstances to employ the other.

Under uncertainty about control cost, a system of marketable permits, if enforced, guaranties a ceiling on emission, no matter how high or low the cost of keeping them to that level. Similarly , the choice of an effluent fee guaranties that if the polluters are minimizers of the cost, the marginal cost of emission control will be equated to the level of the effluent charge that has been selected, no matter how large or small the resulting quantity of emissions.

When the position of the marginal cost curve is lower than expected, the emissions reduction will generally be inadequate under a system of permits and excessive under an effluent charge if both are set at what appear to be their optimal levels ex ante; the reverse will be true if the actual cost curve is higher than the expected one.

The emissions reduction achieved under a system of marketable permits will be inadequate because it yields just the size of reduction the regulator initially thought to be optimal; the permit system offers no flexibility in adopting itself to the facts which emerges subsequently , that additional emissions reduction are less costly that had been expected.

The fluent fee, on the other hand, forces adoption of a level of emissions reduction that incurs the same marginal cost as had initially been thought optimal; the fee approach does not adopt itself to the fact that at this new level for emission reduction,the marginal benefit will have fallen below its level at initial emission reduction as a result of the diminishing marginal benefits to increased emissions reduction.

In situation where the marginal benefits is constant over the relevant range, it recommends the use of fees, but where the marginal benefits function is quite step, control over quantity becomes important.

Where the marginal benefit function is unknown, given any marginal cost function, the regulator can be sure in a competitive market that optimal emissions reduction(q*) will emerge if price(the effluent fee) is set equal to marginal cost(t*=MC) and t* will emerge as the equilibrium price of a unit emissions permit if a quantity of permits just sufficient to require optimal emissions reduction is available.

The prices and quantities depend exclusively on the cost function and are entirely independent of the shape or position of the benefit function.

The choice of a fee (t*) is identical in its effects to the issue of optimal marketable permits (q*).

4.4. Are there Alternative to High Carbon Taxes?

Although the implications of increasing greenhouse gas emissions cannot be neglected in environmental and energy policies, it seems appropriate and sensible to follow a middle-of-the-road, precautionary policy which could be called a “minimum regret” philosophy. Such a policy would consider the economic dimension of actions as well as the level of ecological improvement to be secured, as long as the basis for estimating potential effects retains a sound scientific approach. The “minimum regret”-strategy has an analogy to an insurance policy,i.e. a precautionary measure, and reflects the concept of insurance premia comminsurate with the magnitude and probability of the risk. The level of risk, however, is uncertain but it is better to be approximately right than precisely wrong.

In order to satisfy the appropriate criteria for precautionary measures of a “minimum regret”- nature, policy and actions should be broadly framed and not confined to climate change mitigation. Such measure should have as their first priority, in the field of energy, the increase of efficiency and encouragement of energy conservation. Fiscal measures addressing the potential global climate change issue are not expected to be sufficient or effective without other measures to improve energy efficiency and reduce CO_2 emissions, for example, through fuel switching in favor of lower carbon emitting fuels and less energy consuming technological options, as well as with R&D of new energy forms and of new technologies for the existing ones, taking into account the overall environmental impact of the different energy sources.

To achieve a sustainable solution to the potential climate change problem, it is essential for climate protection policy and energy policy to be in harmony. Tax policy alone has limited effects. The IEA (1994) has shown that a tax of US$300 per tone of carbon is barely sufficient to stabilize CO_2 emissions in OECD countries at 1990 level by the year 2000 under the reference case in its world energy outlook.

4.5. Calculation of Environmental Costs

It is difficult to determine environmental damage costs, ($D(p_t)$). In particular, there is the difficulty in assigning an economic value to the determined level of impact, in particular in the case of intangible damage, e.g. illness, loss of cultural monuments, etc.

There is a variety of valuation methods that may be used to determine the cost of actual or perceived environmental impact and damage. In what follows, I mention these methods in brief:

A) Conventional Market Approaches(CMA):

Does –response: a given levels of pollution is associated with a change in output.

Replacement cost: this approach identifies the cost of restoring a damaged environmental asset.

B) Household Production Function(HPF):

Consider the expenditure on commodities that are substitute or complements for the environmental characteristic to be valued.

C) Headonic Pricing Methods(HPM):

Use house and land prices to imply the value of environmental attributes. These methods are limited in application to tangible and localized effects.

D) Contingent Valuation Methods(CVM):

There are two main approaches:

-Willingness-to-pay: how much an individual is prepared to pay to preserve a particular environment or environmental attribute, e.g. a forest, a species, etc.

-Willingness-to-accept: how much an individual is prepared to accept (as compensation) for the loss of a particular environmental asset or attribute.

4.5.1. Uncertainty Surrounding Impact Evaluation and Costing

The question of valuing the damage from pollution caused by energy use and how easily the avoided environmental damage can be equated to the use of one fuel or another is difficult to answer. There have been many studies that attempt to determine the external environmental costs, but it is extremely difficult to compare the results of such studies. Not all of the studies have included cost estimates for potential global climate change. Most studies focus heavily on air emissions, which are only one dimension of the sustainable development targets.

A recent OECD/IEA study (1994) has estimated damage cost of potential global warming by region, based on the costs of warming impacts associated with a doubling of CO_2 concentrations from preindustrial levels, i.e. from a level of 280 parts per million volumes (ppmv) to 560ppmv, which could occur in about 2050. The study estimates the total cost to be approximately US$285 billion. Cost within different word regions varies dramatically: 6.5bn US$ in the EC; 64.1bn US$ in the USA; 16.8bnUS$ in the former Soviet Union and 21.6bn US$ in China.

It should be emphasized that there are substantial uncertainties to the possible impacts that would be associated with potential global warming. One of those uncertain parameters is the discount rate used in assessing the impacts in analysis.

In cost-benefit analysis discounting normally takes place to reflect our individual time preferences to receive an immediate benefit, or “return”, on any money or investment, we spend today. The discount rate mirrors how we would assign a lower value to benefits received in the future, i.e.” intrest”, on any investment made today. The higher the discount rate, the lower the level of investments required today to cover the same level of damage in the future.

The critical question is what rate to use in cost-benefit analysis of environmental policy. The theoretical basis for estimating people’s propensity to save in the long term is far from sophisticated. The clues for estimating the return on capital are better, but unfortunately they may give different results and there is no obvious best choice. For instance, the return on capital varies considerably among private sectors. The default criterion for ranking development paths and investment projects, including environmental conservation projects, is provided by the discount utilitarian framework which introduced the best path, the one which provides the greatest present discounted value of net benefits.

Cline and Broome have argued for the use of zero discount rate in the context of global warming; Ramsey and Harrod commenting respectively that discounting" is ethically indefensible and arises merely from the weakness of the imagination", and that is a "polite expression for rapacity and the conquest of reason by passion". Geoffry Heal in Valuing the future (1995) argue that:

"A positive utility discount rate forces a fundamental asymmetry between the treatments of, and the implicit valuation of, present and future generation; particularly those very far into the future. This asymmetry is troubling when dealing with environmental matters such as climate change. An any positive discount rate the consequences will clearly not loom large (or even loom at all) in project evaluations".

He means to apply a discount rate which varies with the time horizon and is quite high over short periods (15%-20% over a few years), but which falls rapidly with the length of the horizon under consideration, being as low as 2% for horizons of several decades, make more sense. He noted that:

Although valuing the long-run, valuing environmental assets and respecting the constraints they place on us, do not themselves describe precise sustainable policies on issues such as climate change, they are necessary conditions for the systematic and consistent selection of sustainable policies as "optimal".

Another difficult question, related to discounting is to estimate the value of mitigated climate change in the future. The standard approach in cost-benefit analysis is to apply today's values. However, if climate change affects the yields negatively, there will be an increasing shortage of crops, which may be further strengthens by an increasing world population. As a consequence the price of food will increase.

To approach such problems, one might apply a macro-economic model and solve all prices endogenously, including the discount rate. However by including local effects of climate policy, which in general appear quickly after measures have been implemented, the relative importance of very long-term climate impacts of the policy decreases. The evaluation of measures thereby becomes less dependent on the discount rate (An integrated approach, CICERO, 1997).

There is still another issue which deserves much more detailed study in environmental cost-benefit analysis. Very few valuation studies include detailed analysis of distributional issues. B.Kristrom and P.Riera (1996), means that the income elasticity of environmental improvement is clearly important in the shaping of an efficient environmental policy:

"Consider for example, efforts to construct an international agreement to curb carbon dioxide emissions. If this is to be done by an emission permit program, it can be shown that poorer countries should be allocated larger shares of the total number of emission rights at an efficient allocation, if the income elasticity of environmental improvements is between zero and one. If the income elasticity of environmental improvements is greater than one, this involves ethical judgments that they consider much more appealing than in the opposite case".

They estimated the value of this parameter, for a number of European data-sets, to be less than one (Environmental and Resource Economics, 1996).

4.6. Voluntary Approaches

Voluntary Approaches(VA) are measures taken specifically to achieve environmental benefit, although these actions have not been mandate but they have been taken due to the foreseeable social demand or against the threat of expected direct regulation.

Voluntary measures may have benefits other than environmental but the investment is not based solely on economic return. For the investment to be classified as voluntary, the investment must have been maid with the highest priority on environmental benefit.

A distinction can be made between voluntary "approaches" and voluntary "agreements".

Voluntary approaches which formally involve local or national governments as participants are more often referred to as voluntary.

4.6.1. Joint Implementation

Joint Implementation (JI) has been proposed as a particular form of voluntary agreement aimed at establishing international joint co-operation ventures to reduce anthropogenic greenhouse gas emissions, under the auspices of the UNFCCC.

There are two possible ways in which JI could proceed, either as the first step towards establishing an international tradable quota system for greenhouse gas management among Annex I countries to found emissions reductions in non-Annex I countries that have made no such commitments. For example, under a JI scheme an electricity utility in an industrial company could gain a CO_2 reduction credit either by investing in its own plant and bringing an incremental increase in energy efficiency, or by providing the equivalent expertise and resources to improve energy efficiency in a power generating facility in a developing country.

Industrialized and developing countries have disagreed on the practicalities of how JI should proceed. There have been three main concerns from the developing countries.

First , that investment in JI will diminish or deflect existing and contributions to developing countries. Second, that JI is a cheap "opt-out" for industrialized countries, providing a mechanism for national boundaries. Third, mitigation initiatives rest primarily with Annex I parties to the UNFCCC, due to their historical contributions, and thus actions should be restricted to Annex I countries.

E.J.Bush & L.D.Danny (Global Environmental Change, No.3,1997) have discussed that JI could play a role in "technological Leap-frogging", providing modern technologies to the power and industrial sectors of developing countries.

However, JI as currently envisaged cannot be expected to significantly reduce the growth in global CO_2 emissions. Rather, strong emission reductions targets will have to be set by industrialized countries, coupled with significant technical and financial support for developing countries outside the framework of JI, if the ultimate objective of the FCCC is to be achieved.

Nevertheless, some projects which could fall within the broad definition of JI have taken place. The price of three types of measures in existing projects are as follows (CICERO, Report 1998:2):

1) Fuel-switching: 4,48 – 120 US$ / t CO_2

2) Energy efficiency: 0.00 – 31.63 US$ / tCO_2

3) Renewable energy: 3.14 – 14 US$ / tCO_2

* * *

5. THE COST OF REDUCING CO_2-EMISSIONS FROM FOSSIL FUEL PRODUCTION AND USE

Estimates of the cost of greenhouse gas emission reduction are sensitive to assumptions about appropriate model structure, demographic growth, the cost and availability of both demand-side and supply-side energy options, and the choice of policy instruments. Different assumptions have led to a wide range of emission reduction cost estimates.

5.1. Energy Efficiency

Despite significant differences in view, there is agreement that some energy efficiency improvements can be realized at negative to slightly positive costs. The existence of such a no-regret potential costs depends on the existence of substantial market or institutional imperfections that prevent cost-effective emission reduction measures from being taken. The key question is whether such imperfections can be removed cost effectively by policy measures. Energy related emissions can be reduced through both demand-side (energy efficiency) and supply-side(alternative source of supply) options. In the short term, demand-side options seems to be cheapest in most countries. One of the principal reasons for pursuing energy-efficiency improvements is that energy consumption leads to pervasive externalities, ranging from local pollution and global greenhouse gases to energy and nuclear security risks, that are not reflected in energy supply costs and planning efforts. By mitigating these problems with technical improvements that are cost-effective relative to new energy supplies, energy efficiency programs appear to offer a “win-win” solution to both economic and environmental issues. Thus, energy efficiency is a key strategy for reducing carbon emissions. Moreover, it appears that such cost-effective technical opportunities are also present in developing countries (J.N.Swisher, 1996).

5.1.1. Barriers to Energy Efficiency

The economic situation regarding demand for energy services (f.exp.:cooking, transportation, etc), which drives the demand for energy supplies, is fundamentally different from product markets.

Energy efficiency is one of many characteristics of the products using energy. It therefore dose not exist as a tradable good in many market in the traditional sense. Energy consumers demand energy services, but they buy and sell energy commodities as fuel and electricity. The resulting end-use "market failure" includes the following categories of barriers (Swisher, 1996; IEA1997):

1- Lack of information and experience among both energy users and equipment suppliers ,
2- Difference in economic and risk criteria between users and suppliers,
3- Separation between those who receive the benefits and those who pay the costs of efficiency improvements,
4- Fuel and electricity prices that do not reflect the full social cost due to subsidies and/or the emission of environmental and national security externalities.

The implicit high discount rates applied by energy-users to energy efficiency investment (20-200%), compared to utility discount rate of 6-10 %(Ruderman,et al.1987), and small price elasticities of energy-demand (Nielsen. Et al.1992) suggest that non-price policies, like:

- information policies, such as energy labeling, partial or full financing of energy audits, creation of energy centers that provide energy-saving advice and information and advice on technology procurement ;
- regulations that limit consumers' choices or require changes in their behavior, including building regulations, energy-efficiency standards and speed limits;
- voluntary agreements with industrial and commercial establishments to meet agreed targets, work better if they can stimulate technical innovation.

Progress has been maid in a number of countries in cost-effectively reducing imperfections and institutional barriers in markets through policy instruments based on voluntary standards, and energy efficiency incentives, product efficiency standards, and energy efficiency procurement programs involving manufactures, as well as utility-regulatory reforms. Where empirical evaluations have been made, many have found the benefit-cost ratio of increasing energy efficiency be favorable, suggesting the political feasibility of realizing “no-regret” potentials at negative net cost.

Analysis of energy intensity trend in OECD region from 1961 to 1995 and projection of percentage change in CO_2 emissions from1990-2010, suggest that much more effective and onerous energy efficiency policies than have been used so far will be necessary to achieve ambitious reductions in CO_2 emissions by 2010. Clearly, fuel switching and the use of more carbon-free fuels can also contribute to reducing CO_2 emissions.

5.2. Methods Used in Environmental Decision Making

To arrive at the most cost-effective strategies to reduce emissions an integrated approach, considering all important effects of the measures, is necessary. By doing so, mitigation of man-made climate change may then turn out to be less expensive than most earlier studies indicate. The premise is of course that local and regional effects are substantial. In many areas, in particular in some developing countries, this is, unfortunately, likely to be true for many decades (Aaheim, Aunan, Seip,1997).

In most cost-benefit estimates the benefits not directly related to climate, are ignored. Most feasible measures will affect emissions of several compounds which each may have many local and regional effects. Actually it may in many cases be more appropriate to consider the improvement of local and regional pollution damage as the primary objective. Solving them in the right way may give reduced emissions of greenhouse gases as a bonus. For example, if energy-saving programs make the building of a new fossil-fuelled power plant super fluous, emissions not only of CO_2, but also of $NO_{x,}$ SO_2 and particles, are likely to decrease. This may greatly reduce local harmful effects to health and materials as well as regional effects (e.g. acidification). When estimating the benefits of measures, all these effects must be considered. Paul Ekins(1996) means that there are “secondary benefits” of the same order of magnitude as gross cost of medium to high level of CO_2 abatement. He noted that: “policies to reduce CO_2 emissions by reducing the burning of fossil fuels will also reduce other emissions (e.g. SO_2, NO_2, CH4, VOC, etc). They may also reduce road traffic. It is well accepted that pollution from these other emissions, and effects from road traffic apart from emissions, such as accident, congestion, road damage, and noise are responsible for substantial external costs. It is the reduction of these various negative external effects associated with fossil fuel use, pursuant on policies to abate CO_2 emissions that are the secondary benefits of such policies".

5.2.1. Bottom-Up versus Top- Down Methods

Basically two approaches have been used to find cost-effective abatement strategies against pollution damage (Aaheim 1994; Swisher 1996).

In the" top-down approach" (T-D) the assessment is done by the use of macroeconomic models, which are particularly suited for analyzing the impact of indirect measures, such as taxes, on main macroeconomic variables. From the predicted change in economic activity the emission reductions are deduced, and the benefits from these reductions may be fed back into the macroeconomic variables. In the "bottom-up approach"(B-U) specific abatement measures, for instance emission standards for vehicles, considered appropriate for solving a problem, are explored in detail. Their potentials for reducing adverse exposure of recipients (people, crops, forests, materials, etc) and thereby damage, are estimated. Assessment of the values of the costs and benefit can be made according to observed or estimated market prices. The social net benefit provides the basis for ranking of measures.

The T-D and B-U approaches both have strengths and weakness. T-D studies apply when environmental policy is expected to have important impacts on the structure of the economy. Structural change is closely related to changes in relative prices, and environmental policy may thereby influence all economic activities. The most significant price change are likely to take place in activities directly affected by the environmental policy, such as the price(or value) of health impacts as a result of measures to improve air pollution. Hence, a top-down approach may be useful even if the environmental policies and values of the environmental aspects are affected.

The major weaknesses of the T-D approach are, firstly, that descriptions of environmental measures and of the effects of environmental policy, are poorly represented, or simply left out. Secondly, non-fiscal policy measures are usually disregarded (Aaheim, 1997). The B-U approach allow for a detailed description of the effects of specified measures, and may help decision-makers to find low cost, or even no-regret measures to improve the environment. To showing how specified measures to reduce emissions of greenhouse gases may affect other environmental problems as well, and thereby add to the benefits of the measures, one can concentrate on the B-U method, which is satisfactory for showing this importance.

5.3. Economic Valuation of Benefit

The aim of attaching economic values to environmental change is to form a basis for decision-making by comparing and aggregating different environmental effects. Environmental qualities are usually not traded in markets, and the values are rarely observed in terms of prices. To attach values to environmental variables, market prices have to be estimated, as if the environment were traded.

A fairly straightforward method for estimating the value of the environment is to limit the effects of environmental change to the impact on commodities and services traded in market and base the values on the observed prices. The cost(value) of increased air pollution, for example, can be estimated by the value of damage on ordinary buildings, loss of crops, loss of working day by affected people, increased demand for health care and medicines etc. This approach is however, inadequate as an approximation of the values if the environment is appreciated in itself. Therefore, in many cases, it may be better to figure out people's preferences for improved environmental qualities, rather than to estimate the cost of environmental damage. Different approaches have been applied, but the Contingent Valuation Method(CVM) has received most attention. A CVM-study is a survey over people's willingness to pay (WTP) for environmental problems with large impacts, such as climate change, the CVM also fail to reflect changes in market equilibrium as consequences of measures taken to change the environmental state. Reduction in emissions of greenhouse gases in order to mitigate climate change will have vast impacts on the energy markets. It is impossible to foresee these changes in an interview situation; it is hard enough for experts with huge models.

Krupnic et al (1996) suggest that assessments of damage costs and demand for improved environment differ with a ratio of 1:2 – 1:3 . This is often explained by the fact that demand-side assessments include appreciation of non-market values.

In a strictly economic sense, the value of a cleaner environment is defined only when the marginal willingness to pay equals the marginal cost of environmental improvements that is, when the demand for improvement equals the supply. An appropriate assessment of environmental values requires that both the damage costs and the demand factors are examined.

Pearce et al (1996) summarized attempts to assess and monetize the benefits of reducing greenhouse gas emissions. They found the marginal cost to be US$ 5 to US$ 25 per tC; most values seem to lie in the rang 5-20 $ though higher values are obtained if the discount rate is 2% or less (Aaheim,Aunan,Seip, 1997).

5.4. Assessing the Cost of CO_2 – Abatement

There continue to be a great deal of disagreement among studies that focus on the cost of reducing carbon dioxide (CO_2) emissions from fossil fuel production and use.

Technical-economic (B-U) models identify substantial cost effective emission reduction potential in most countries, under the assumption that existing barriers to energy efficiency can be reduced. The total emission reduction potential in most industrialized countries over the next decade is estimated at 10 to 30%, at no or low cost to society, and larger if increasing cost are accepted (Swisher, 1996).

Studies based on macroeconomic (T-D) models, on the other hand, generally conclude that significant macroeconomic losses would result from the imposition of carbon emission limits. The energy-policy measures that the macroeconomic models evaluate are energy-price changes through for example carbon taxes. As modeled in top-down analyses, such measures result in a transfer of input to other sectors, revenue increases to governments, and an economic efficiency loss to society. Other policy interventions (e.g. regulations and other measures aimed to overcoming barriers to energy efficiency improvements) are assumed to be expensive and sub-optimal, because they are not part of the assumed economically efficient baseline (Climate Change 1995). T-D models suggest that a direct (Pigovian) tax on carbon emissions, channeled through general government spending and large enough to constrain emissions, would be an expensive strategy. Many bottom-up analysts would probably agree, recognizing that market barriers to energy-efficiency improvements would inhibit an optimal response. Both groups would likely agree that a tax, perhaps revenue neutral or channeled to investment, to slowly increase the price of energy would capture the many environmental and other externalities from energy use. The B-U models, however, identify additional emission reduction potential under the assumption that the barriers to energy efficiency can be reduced.

Most cost estimates for a 20% reduction in U.S. CO_2 emissions by the year 2010, rang between -0.6% and +0.5% of GDP. This difference is explained at least in part by nature and level of detailed of the input assumptions used in the specific bottom-up analysis. There are many studies for Europe that have been carried out using neo-Keynesian models. In these studies, carbon taxes were generally used to maintain a given level of CO_2emissions, assuming lump-sum recycling. The result shows that the loss in GDP is relatively low for reductions of up to 10-20% from the baseline (below 0.2% of GDP) but rises dramatically as the target is increased. The reason for this is that these studies are pessimistic about the tax level required to achieve a 25-30% reduction from baseline emissions in 2000-2005 (e.g. 380 US$/t in Belgium, 100US$/t in Sweden).

Most macroeconomic studies of the national costs of CO_2emissions control estimates the cost of moderate reduction in CO_2emissions up to year 2020, to be between 0.025 and 0.075 percent of the world's GDP per percent reduction in emissions (Aaheim,1997).

Greenhouse gas abatement studies for developing countries are not numerous, the relatively few that do exist are based on methodologies designed for use in developed nations. The models are market-driven and assume the existence of future markets, perfect information, competitive economic dynamics on the demand and supply side, and optimizing behavior on the part of producers, consumers and government. These assumptions are often found to be invalid in developing countries (Climate Change 1995). Of the developing countries, China has received the greatest attention from T-D modelers, since it is currently the third largest emitter of CO_2. In a recent study, the OECD used the Green-model to analyze the impact of subsidy removed in China and India (OECD, 1994). This study assumes facing out of subsidies on the sail price of oil by 2000 and on coal and gas by year 2010. The study finds that the removal of energy subsidies has a major impact in reducing energy consumption and carbon emission. The reductions are nearly 40% and 60% respectively in 2050. The reductions are due to higher energy efficiency and use of backstops promoted by higher market prices for carbon-based fuels. The OPEC Secretariat used a macroeconomic model to investigate the impacts of OECD-type carbon taxes on developing countries (Waker&Birol, 1992 – Climate Change 1995), and explicitly considered the impact of income and price level on the consumption of non-commercial energies (NCE). The study finds that the income elasticity of NCE is negative, meaning that consumers shift from NCE to commercial energy as income rises. But more important, the study also reports an inverse relationship between non-commercial and commercial energy demand in response to price change. That is, consumers switch from commercial to NCE in the case of price hikes. Both these results point to behavior that is obvious and well known in the developing nations and yet is most often forgotten or ignored in top-down analyses.

Most bottom-up studies of developing countries on the national level and typically cover scenario periods from 1988/90 to 2020/30. These studies typically formulate reduction targets, either as percentage change from a baseline (or reference case) reflecting the reference case’s economic development and energy requirements (UNEP, 1994) or as percentage changes related to a high emission case for the energy sector.

The United Nations Environment Program (UNEP) country studies include an estimation of cost for emission reduction of between 12.5% and 25% from the baseline scenario in the short term (2005/10) and between 25-50% in the long term (2020/30).

Cost is defined as financial cost at the energy sector level including investment, operation and maintenance and fuel costs. The short-term marginal cost fall within a relatively narrow range between -$10 and +$30 per ton of CO_2 reduced, and the long – term marginal cost for most countries fall within an interval of -$10 to +$25 per ton of CO_2 for emission reductions of about 5-25%.

All studies generally conclude that: the emission reduction potential includes low-or negative cost options relating to end use and conventional supply technologies in the short to medium term. In the 30-40 year time frame, the UNEP country study have estimated average emission reduction costs to be below $14 per ton of CO_2.

5.5. Iranian Case Study

I did not find any study which attempts to estimate CO_2-abatement cost for Iran. However, there are several studies for estimating the potential of saving energy in country. In this report study I'm going to present some of these studies.

5.5.1. End-Use Energy Efficiency Strategy in Iran

In a study of "An End-Use Efficiency Strategy in Iran", done by experts from Iran and World Bank in January 1994, focuses on those energy saving options that appear most promising, from an economic point of view. Due to financial constraints, the transport sector is not dealt with in this report. Table 5.1 shows the result of this study and the measures which contribute to energy saving. Although there remains much uncertainty in estimates, the potential economic energy savings during the period of 1994-2005 are estimated to be at least 2 Mill. toe for fuels and 7300 GWH of electricity (or about 2000MW), most of which will be realized after year2000. To achieve these savings over ten-year period an investment of US$ 200 million are required supported by a government dedicated to implement the proposed end-use energy efficiency program.

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TABLE 5.1

ECONOMIC ELEMENTS / SECTORAL ACTIONS	Current consumpti % total	Recoverable potential, 2005: Fuels 10^{3} toe	electricity GWh	MW	Feasible Targets Annual energy saving at end of the program: Fuels 10^{3} toe	Electricity GWh	MW
A. Residential, comercial, public services							
1- Development of nat.gas, LPG		0	800	100	0	150	40
2. Househs appliances standards, labelling		200	1000	200	10	80	30
3. DSM, equipment substitution							
comercial & services		# 0	700	280	0	200	70
residential		# 0	600	250	0	100	40
4. Information campaigns		100	300	140	10	130	50
5. New buildings, building code		70	1500	500	8	100	40
6. Public lighting		0	75	30	0	40	15
Subtotal resid, comercial and services							
- conservation		370	4175	1400	28	650	245
- substitution		0	800	100	0	150	40
- total		370	4975	1500	28	800	285
B. Industry							
1. Emergency measures (load shedding)			200	50		30	10
2. Technical assistance, energy service		400	350	80	100	20	5
3. Training of managers and technicians		200	100	25	30		
4. Development of natural gas		100			10		
Subtotal							
- conservation		600	650	155	130	50	15
- substitution		100	0	0	10	0	0
- total		700	650	155	140	50	15
C. Transport							
1. Organization, intercity goods transport		180			30		
2. Organization, Urban traffic		220			50		
3. Audits and projects in enterprises		170			15		
4. Substitution, LPG, GNC		300			50		
5. Support actions		150			10		
Subtotal							
- conservation		720	0	0	105	0	0
- substitution		300	0	0	50	0	0
- total							
D. Load Management, cogeneration							
1. Load management, large consumers			1000	280		200	50
2. Independent generation, cogeneration			700	150		120	30
Subtotal (conservation)			1700	430			
Total							
- conservation		1690	6525	1985	263	700	260
- substitution		400	800	100	60	150	40

Source: Technical Report , World Bank, jan. 1994.

Skelton Budget (estimate)

-energy audit	$ 600,000
-equipment	$ 400,000
Demonstration pilot project:	
-consulting and local personal	$ 300,000
- equipment for pilot projects	$ 600,000
-energy monitoring instruments	$ 100,000
Total	$ 2,000,000

The unit (investment) cost of energy saved by measures in this program range from 4-20 CUS/kwh (except for information campaigns which cost 1.05 CUS/kwh) for electricity and 250-350 US$/toe for petroleum products. Environmental implications of this energy saving program are not discussed in general, except for measureA.6,"public lighting". This study assumes replacement of 100,000 MV-lamps in service in Tehran over a period of 3 years would result in annual energy saving of 22GWH. The cumulative CO_2 reduction during the span of program is estimated around 360,000 tons. This CO_2 reduction assumes 50% diesel and 50% gas generation; coefficient of 800 ton/GWH was provided as an estimate by Tehran Regional Electric Company(TREC). The estimated cost of this measure consist of three components: HPS lamps and ballasts, labor cost and management overheads, and will add up to 6300Mill.Rls. So the unit cost of reduction in CO_2 emission for this measure will be approximately 17500 Rls/ton CO_2.

To estimate total CO_2 reductions by this program we must take some assumptions.

- We assume that the total electricity saved by this program are generated in the same way. Then the CO_2 reduction from electricity saved is:

  7300 GWH * 800 ton/GWH = 5,840,000 ton CO_2

  We assume further that, 2 Mtoe fuel saved consist of following fuel types:

  Gasoline, gas oil, crude oil, fuel oil and gas. Each with a share as follows:

  0.5 Mtoe, 0.5 Mtoe, 0.3 Mtoe, 0.3 Mtoe, O.4 Mtoe respectively.

By using unit conversion factors and emission factors after the Japanese Science and Technology Agency, which are shown below, we can estimate CO_2reduction from 2Mtoe energy saving by implementing this program.

U	Unit	toe	GJ	toe/ton	CO_2 Emission Factor	
		Unit Convertion Factors				
Crudeoil	KL	0.890	37.179	1.000	3.165	ton/ton
Gasolin	KL	0.780	32.657	1.070	3.132	ton/ton
Gasoil	KL	0.870	36.593	1.035	3.187	ton CO_2
Fueloil	KL	0.920	38.435	0.960	3.219	ton CO_2
Gas	1000m^3	0.880	36.635		2.31 E-04	grCO_2/cal

(1) Gasoline: 500,000 / 1.070 * 3.132 = 1,463,551.4 ton CO_2

(2) Gas Oil : 500,000 / 1.035 * 3.187 = 1,539,613.5 ton CO_2

(3) Crud Oil : 300,000 / 1.000 * 3.165 = 949,500 ton CO_2

(4) Fuel Oil : 300,000 / 0.960 * 3.219 = 1,005,937.5 ton CO_2

(5) Gas : $4 * 10^{15}$ cal * $2.31 * 10^{-4}$ = $9.24 * 10^{11}$ gr CO_2= 924,000 tonCO_2

Sub Total = 1+2+3+4+5 = 5,882,602 ton CO_2

Total = 5,882,602 + 5,840,000= 11,722,602 tonCO_2

A rough estimating give us about 11.7 Mill.ton CO_2 emission reduction resulting by this energy saving program.

In assessing the marginal cost of CO2-reduction from this savings program over the ten years period we must make some assumption about how investment cost are distribute within each sector. We assume that US$ 200 million are divided equal within the sectors:

Measures	investment cost US$ Mill.	Annual energysaving Fuel 1000TOE	– electricityGWH
A- residential,commercial, public services			
- conservation	40	28	650
- substitution	10	0	150
B- Industry			
-conservation	45	130	50
- substitution	5	10	0
C- Transport			
-conservation	25	105	0
-substitution	25	50	0
D- Load Management			
- load management	15	0	200
-cogeneration	35	0	120

We find the marginal cost of CO2-reduction by using following equation:

$$ci = \frac{Ci - \sum \frac{Si}{(1+r)t}}{\sum \frac{xi}{(1+r)t}}$$

C= Investment cost

c= marginal cost of CO2-reduction

S= saved energy US$

x= emission reduction

r= rent

T=period of program

i=measure

By using the unit cost of energy we find how much S will be, and by using unit conversion factors and emission factors we get the value of x. For example, substitution in sector A (residential, commercial,…)give us an annual energy saving equal to 150GWH. By using coefficient of 800 ton CO_2/GWH and unit cost of 3.2 USc/KWH for electricity,(assume %5 interest rate), we will have:

S= 150000000(kwh) * 0.032 = 4800000 US$

X= 150 * 800 = 120000 ton CO_2

r = 0.05

t = 10

C = 10000000 US$

Put these values in the equation and find marginal cost of CO_2 reduction(c = - 30.45 US$/ton CO_2) .

The marginal cost of CO_2-reduction for all measures in this program rang from -68.4 US$/ton CO_2 for conservation in transport sector into +1.8 US$/ton CO_2 for cogeneration.

Transport – conservation =-68.4 US$/$CO_2$

_ substitution = -58.67 "

Residential , commercial,…_conservation = -38.66 "

_substitution = -30.45 "

Load Management = -29.25 "

Industry _ conservation =-9.75 "

_ substitution = -2.19 "

Load management _cogeneration =+1.8 "

This study shows us that the emission reduction potential includes low or negative cost options relating to end use and conventional supply technologies in the short term and larger reduction achieve if increasing cost are accepted.

The Barriers to Implimentation of this Program

There are several barriers which make this program not to be carried out:

*Institutional problem

*Decision making

*total cost of implementation

Energy market is subject to substantial market imperfection. There is lack of information and experience among both energy users and equipment suppliers. Asymmetric information lead to market imperfection and ignorance lead to investment on inefficient technology. This is especially the case for the industrial sector where the financing of large energy efficient schemes would not be a priority despite their prospective large impact.

The economy suffers from state intervenation. Iranian government provide subsidies to both industry and to consumers. Fuel and electricity prices do not reflect the full social cost due to subsidies and/or the emission of environmental externalities.

The longstanding subsidization of domestic energy consumption has led to excessive , low priority consumption to a habit of energy waste and to a situation where the energy sector-companies can not even cover operating costs. The situation has further led to financial limitation for investment in energy efficient technology and programs.

There is separation between those who receive the benefits and those who pay the cost of efficiency improvements. In the building sector, private developers have little intensive to construct efficient, often more expensive housing schemes and buildings, since they will not be the ones to benefit from energy savings achieved ultimately.

The government can choose those measures which is less expensive to implement . For example conservation in residential sector is cheaper to implement than conservation in transport sector, however, the second one have “lower” marginal reduction cost.

The government can also use non-price policies, like:

- information policies, such as energy labeling, creation of energy centers that provide energy-saving advice and information, and advice on technology procurement.

- Regulation that limit consumers' choice or require changes in their behavior, including building regulations, energy efficiency standards.
- Voluntary agreements with industrial and commercial establishments to meet agreed targets.

*

In assessing the total benefit of accumulated energy saving over the period assumes that some investment will achieve results before 1998. There are further assumed that as an average the total savings of the period would be equal to three years of the annual savings obtained at the end of the period . The result indicate that the standardization and labeling of household appliances, as well as information campaigns will generate substantial benefits for the Iranian economy and for the power sector, even at current power tariff: The pay back period of investment is less than two years and the total benefits spent over that period. The result of the tertiary and other sectors in terms of avoided costs for the power sector, rate of return of investments and benefits over the period compared to investment indicate a good profitably for actions related to building code and public lighting. Direct investments in existing buildings of the commerce and services sector have rather long pay back periods. But there are not any assessments for benefits of environmental improvements.

5.5.2. Comprehensive Energy Development Plan in Iran

The main objective of a consistent and comprehensive energy policy for improving efficiency of the economy is to provide a means of establishing an efficient, economical and reliable energy supply system which will be compatible with social development and environment. To achieve this objective the Plan & Budget Organization (PBO) in the Islamic Republic of Iran has organized a study of "Comprehensive Energy Development Plan",(CEDP). This study has been taken jointly by the (PBO) of Iran and Japan International Cooperation Agency (JICA), based on the division of undertaking of each side. The Japanese' expert team were responsible for conducting energy studies in energy conservation and energy-environmental interaction areas, and Iranians' expert were responsible to analyze energy demand and supply system and review of energy market.

The analyzing for promoting energy conservation in this study, three sectors are selected:industry-,energy conversion-, and transport-sectors. The study is very industry-specified, because of both data availabling and substantial energy savings potential in those fields. The investment cost is also assessed for some of them.

The main objectives of the study on environmental protection are to clarify the necessity and targets of improving environmental pollution (air pollution in particular) and to identify policy issues for realizing the targets. The issues related to air pollution have mainly arisen in many of large cities in Iran. Therefore in the short term plan, government gave priority to local air pollution. In medium and longer term, for improving air quality the Department of Environment have the following targets:

- reduction of pollution resulting from traffic
- reduction of pollution resulting from industries
- reduction of household produced pollution
- rules and regulation

The capital cost requirements for environmental abatement is shown in table 5.2. The results of evaluation is displayed by classifying the magnitude of the costs as “large”, ”Medium”, “small” and “Negligible”.

Tabel 5.2: Pollution Abatement Cost Impact on Prouduction Investment

Table 6-30 **Pollution Abatement Cost Impact on Production Investment**

	Pollutant	Source	Countermeasure	Industries								
				Steel	Power	PetRef	PetChem	Gas	Paper	Cement	Sugar	Glass
Air	SOx	Process	Reduce sulfur content in feed	-	-	-	-	M & P	-	-	-	-
		Boiler, Furnace, Reactor	Fuel conversion to gas	N	S	-	S	L & P	S	S	S	S
			Reduce sulfur content in fuel	N	N	L & P	N	-	N	N	N	N
			Flue gas de-sulfurization	S	S	S	M	-	M	-	L	L
			Integrated high stack	S	S	S	S	-	M	M	M	M
			Sulfur recovery	M & P	-	M & P	-	M & P	-	-	-	-
	NOx	Process, Heater	Fuel conversion (CoalÂ®Heavy oilÂ®Natural gas)	S	S	M & P	S	M & P	S	S	S	S
		Boiler, Furnace, Gas turbine	Low-NOx burner	N	N	N	N	N	N	N	S	S
			Modified burning	N	N	N	S	-	S	S	M	M
			Flue gas de-nitrification	S	S	S	M	-	M	M	L	L
	CO2	Boiler, Furnace, Gas turbine	Energy saving	M & P	S & P	M & P	M & P	S & P	S & P	M & P	S & P	M & P
	Dust	Various places	Closed space dust collecting	S & P	S	-	S & P	-	S	M & P	-	S & P
	Smoke	Flare stack	Smokeless burning	N	-	N	N	N	-	-	-	-
			Waste gas recovery	S & P	-	S & P	S & P	S & P	-	-	-	-
Water	BOD/COD	Process	Biochemical treatment, Coagulation precipitation	N	N	S	M	N	M	-	M	-
	SS, Color	Process	Coagulation precipitation, Filtration	N	-	-	S	-	M	S	S	-
	Oil	Process, Ballast, Seal	Oil separater	-	-	S & P	S	S	-	-	-	-
	Heat	Condenser, Cooler	Cooling tower	S & P	S & P	S & P	S & P	-	-	-	-	S & P
	Subsidence	Well	Decrease well water use	-	-	-	-	-	-	-	-	-
Waste	Dust	After collection	Recycle to applicable feed	S & P	-	-	-	-	-	S & P	-	S & P
	Slag	Furnace	Re-utilization (for Cement, Civil materials)	S & P	-	-	-	-	-	S & P	-	-
	-	Oil separater	Dewatering and incineration	-	-	S	S	-	-	-	-	-
			Recycle to feed, or fuel	-	-	S & P	S & P	-	-	-	-	-
	Sludge	Water treater	Dewatering and incineration	-	-	S	S	-	S	-	S	-
			Dewatering and utilization as cement feed, etc.	S & P	-	-	-	-	-	S & P	-	-
Noise		Various places	Curtailing at sources, Shelter, Enclosure	N	N	N	N	N	N	N	-	-
Others			Plantation on premises, Telemetering system	S	S	S	S	S	S	S	N	N

Note : "L", "M", "S" and "N" indicates magnitude of cost impact on total investment of an ordinary production unit of the industry.
(L = Large : 1 - 10 %, M = Medium : 0.3 - 3 %, S = Small : 0.1 - 1 %, N = Negligible : Less than 0.1 %)
"-" denotes "not applicable".
"P" means "productive", by saving or producing products or by-products.

The study estimates the potential of CO_2reduction and there is not estimating for abatement cost for CO_2. According to the factor analysis for CO_2 emission in the country, the main factors contributing to emission of CO_2 are energy intensity and fuel conversion. Supposing that all the requirement of fuel oil is provided with natural gas, the effect on CO_2 reduction is estimated to be 6%. The potential improvements of energy intensity are estimated to be 35% and will realize 39% of CO_2reduction.

Study done by Iranian Experts:

To study the optimal utilization of energy resources, a macroeconomic model has been developed. The model is based on optimal control methods and it helps to identify the optimal path of the development of the main economic indicators.

To achieve the objective of this study, a reference scenario (RS) has been defined. It presents a scale for comparing trend of economic growth in different conditions.

Comparison of the results of the model in different cases will provide information on the extent of the impact of various energy-policies on the economic development. There are however, other scenarios which are defined to see the implication of different policies on different variables. In Energy-Savings Scenario (ESS), four energy-savings technology are thought: public lighting, efficiency improvement in household's utilities (both cooling-and heating systems) and finally improve energy management in buildings, in three sectors: Residential, Commercial and Service sector.

Third scenario, is called for Energy-Management Scenario (EMS), which consist of several measures, like:

a- use of renewable energy

b- reduce energy intensity and improvement of efficiency

c- structure change in transport sector

d- fuel switching and load-management in power sector

e- reduce loss and improve efficiency in energy sector

In RS (business as usual case) the final energy demand in the country is about 704Mboe, and 1414.5 Mboe per year in 1378(1998) and 1400(2021) respectively. These values in ESS are about 663.9 and 1170.1 Mboe in respective years, but in EM scenario, these values reduce to 592 Mboe and 1008 Mboe for respective years.

The annual CO_2 emisson in R-scenario increase from 154 Mill. ton CO_2 to 337 Mill.ton CO_2 in 2021. But in ES-scenario CO_2emissions will increase to 221Mill.tonCO_2 in2021. The annual CO_2emission in EM-scenario will be about 213 Mill.tonCO_2 in 2021.(i.e.116 and 124.Mill.ton reduction per year compared with R-scenario). There are also two other scenario in this study, one for emission control, where per capita CO_2emission in year 2009 will be equal or less than per capita emission in Japan in year 1991, and in the other one, there is thought 100US$ carbon tax for each ton of CO_2 emission.

In the first case, total annual CO_2emission will be 321 Mill.ton CO_2 in 2021, while carbon tax have no impact on CO_2emissions.

Unfortunately, there is no information about the total cost of implementing the energy saving program or/and the investment or operating costs of each measure. If the total cost in ES-scenario was clear, then we could find the unit cost per unit reduction in the emissions of a particular gas, or per unit energy saved by using equation (1):

$$c_t = \frac{\sum_{t=0}^{T} \frac{C_t}{(1+r)^t}}{\sum_{t=0}^{T} \frac{x_t}{(1+r)^t}} \qquad (1)$$

(C_t) is total costs at (t), (x_t) is reduction in emission or energy consumption at (t), (r) is the discount rate and (T) is the life time of the measure.

The unit cost differs usually between the measures. If the unit cost of energy saving is lower than alternative price of energy for a measure , then that measure is socially beneficial, even without including environmental benefits. If the unit cost of a measure exceeds the alternative price of energy, environmental impacts of energy saving may contribute to turn the measure socially beneficial. Then a valuation of environmental benefits is required, and this value must be at least as high as the cost not covered by the alternative price of energy (excess cost). The excess unit costs correspond to the minimum required environmental benefit of reducing the emissions of one gas if the respective measure is to be regarded as socially beneficial.

Unfortunately, there is not found any study for assessing the damage cost of pollutant in Iran. In estimating the damage cost, EPA's estimated values are usually be used. This method do not give real picture of damage, because different principles may apply for an assessment of, for example: the loss of labor or the value of a statistical life(the amount of money to spend or reducing the probability of dying from air pollution by one unit). The direct and indirect costs of illness depend on several variables, which are different in different countries (f.exp. hospitalization, consulting doctors in open health care and medicines,etc).

The social cost of pollution control is usually calculated as the deviation from the initial equilibrium with no restrictions on the emission. Clearly, an emission target implies a positive, social cost if no improvement in health and environment is represented in the calculation.

To pointing out the so-called no-regret options, the benefits of less pollution must be estimated, to show which measure yield net social benefits. Estimates of such benefits can be based either on the economic consequences of less damage associated with pollution or on estimates of the willingness to pay for less pollution. The problems of assigning reliable economic estimates to policy proposals are common, and they are especially pronounced in developing countries, which are subject to substantial market imperfections. This applies especially in the energy markets, which are subject to strong regulation in many countries, and in Iran. Whether it pays to invest in measures to save energy is as even more difficult question than to assess the costs, since the social benefit of reduced pollution levels will have to be assessed.

There is need for many detailed information and reliable date, for example, effects of the energy saving programs (or other measure) on human, material and crops, for evaluation of different program/measures, and to carry out a study relevant for policy making.

Possibilities of trading quatos or opportunities for joint implementation make information of the unit cost of CO_2 emission reduction vital, even if the country has not any commitment to do so.

5.5.3. Renewable Energy Development Program in Iran

Solar energy, including hydro, wind, biomass, geothermal and ocean energy are environmentally clean and non-problematic source of energy and due to their technical simplicity are certainly one of interesting options left for man.

The amount of solar energy received by the earth surface in a year is estimated to be about $5.48*10^{34}$ jouls, or 15000 times of the current world annual consumption.

Iran has great potential for large-scale application of solar energy system. In short, thought the utilization of solar energy received by 15510 $km^{2,}$ or less than 1% of its land, Iran can produce enough hydrogen to meet its present annual energy demand of 3.6EJ, and export 6.77 EJ of clean energy, at the same level of 1992. Other source of renewable energy including wind, hydro, biomass, geothermal and ocean, to a less extent, are also important options in Iran.

*Elements of a National Program

The introduction of solar energy into our energy system will take place over decades, that is, extensive penetration of solar energy and solar hydrogen into energy markets will not happen quickly for several reasons, such as the time lag for technology development and the development of large manufacturing industry, and a limitation on total investment capital available.

At present time, Iran's energy consumption is calculated at rate of 120,000 MW. Recent energy study shows that even with implementation of reasonable energy conservation measures and policies, rate of energy consumption reaches some 200,000MW in the year 2020. Results of a project concerning the" possible renewable energy consumption In Iran" shows that a target of 20,000MW is feasible in year 2020(Department of renewable Energy,1996).

Of course,10 percent renewable energy contribution in 25 years need determination, data acquisition, technology achievements and planning. For this purpose crucial elements of national program were defined. These elements are in the form of three different types of projects:

- Fundamental projects leading to detailed analyses of renewable energy data, techno-economical analyses and feasibility studies concerning the availability and difficulties of renewable energy conversion technologies.

- R&D programs and proto type projects for better understanding, technical achievements of and efficiency improvement. These projects were defined regarding the state of art technology, national bodies' recommendations.

  Joint venture cooperation and research programs at regional and international level intended to reach further technical improvements and technology transfer.

5.6. Political Acceptability

What might be most economic may not be achievable

Corrective measures to internalize externalities are not always easily implemented, nor are they universally effective. Whatever the level of adjustment developing countries adopt, non will be cost-free. The various actions they will have to take in their own interests and in the interest of the international community involve substantial costs. It is not a matter of funds being redirected from one set of development objectives to another but of genuine additional costs. For example, inclusion of the environmental aspect in project and other lending would require additional staff time and increase the cost associated with each project loan, both on the part of the lender and on the part of the borrower responsible for preparing environmental assessments.

Evaluation measures of the environmental impacts arising from energy investment and of the economic and consequences, both short-term and long-term, may take various names and different steps. In the final analyses, however, each rational decision making procedure is a careful consideration of the advantages and disadvantages of an action, whether this be a policy action or an investment. This applies whether this be cost-benefit analyses, cost-effectiveness analyses, environmental impact assessment, or economic models incorporating environmental parameters.

Coverage may differ in scope and specifics, but a comprehensive evaluative analysis would include variables such as political acceptability, income distribution, macroeconomics socioeconomic effect, in addition to the purely technical aspects of environmental damage or benefit.

In many countries, the least-cost strategies for reducing emissions, including no-net-cost measures, may be politically difficult. For example, significantly higher taxes on energy, balanced by tax reductions elsewhere in the economy, or removed of subsidies, have small economic cost or zero in certain cases. Political difficulties may be even greater in developing countries, where it is harder to demonstrate benefits and where such policies may have seriously adverse implication for the poorest section of society.

Moreover, the pressure from electorates to act on climate change is generally lower. In general, governments will prefer policies involving low economic cost and low political difficulty- assuming they are able to assess the cost and difficulty of implementing each measure.

Most of the economic literature has focused in the costs and benefits of specific emission-reducing actions rather than in the political difficulties associated with policies to induce individuals, firms, and institutions to take those actions.

In spite of political difficulty, however, government in Iran, with their reform policy from SFYP(1994-99), intended to increase efficiency through the introduction of more market oriented pricing policy. They have scarcely started to reduce and gradually eliminate the energy subsidies. In the Third Five Year Plan 1379-83 (2000-20004) all fuel types' prices will increase gradually, with exception for gasoline price which will increase about 4 times during this period.

In the SFYP, government allocated total Rls. 246.4 billion credits, to prevention of air pollution problem in Tehran and other large cities.

There are several energy-efficiency measures which are already implemented or will be implemented in near future. But implementation of all potential energy savings measures needs a huge amount of money.

Dr.A.Sedighi, an Iranian expert in energy management and conservation, means that Iran has annual savings potential in energy for about 2000Mill. US$ per year (Hamshahri, Aug,1999).

The marginal cost of energy saving or CO_2emission reduction may probably be low, but the total cost is high, and with the prevailing problems of Iranian economy in mind, it is unlikely that implementation of all feasible measures will be given a high priority. From 1995, just 0.02 percent of oil-revenue is used for energy savings purpose.

5.7. Final Remarks

The potential in developing countries for large percentage increase in emission of greenhouse gases(GHG) over the next decades has resulted in suggestion that control over such emission should be considered as part of near-term developing planning. It is unrealistic and unreasonable, however, to expect the developing countries to restrain their energy use for development purposes because of concerns in the international community over the trend toward global warming, especially in light of the many uncertainties that surround the nature of the risks themselves and of the accuracy of projections. The rate of increase in fossil fuels use in developing countries may be large but the actual increase for individual countries will, in general, still be small compared to the absolute increase that accompany consumption in high energized industrialized nations. The potential damage to the environment may not be comparable to those arising from the accumulated energy-using capital stock in these advanced countries, given the already existing sources of emissions and patterns of industrial emissions of carbon dioxide. As Smith(1989) puts it, just as economies take on a financial debt in order to grow faster, they take on a “natural debt” as they barrow the assimilative capacity of the environment by releasing waste gases faster than they can be removed naturally. In this respect, developed countries are at this point holders of the largest ”natural debt”.

Developing countries receive advice from many quarters not to replicate the environmentally unsound policies and practices of the industrialized countries. But unless such advice is accompanied by viable alternatives it is not acceptable, if it implies that developing countries should stagnate in the interest of overall environmental protection, in the immediate future they may not have access to the technology that will allow to shift to processes in the power and transport sector as well as industries that are less energy intensive or that are relatively more environmentally benign.

Although accepting, for example, that the threat of large percentage increase from developing countries in the emission of GHGs is important enough to warrant changes in present development pathways, Smith(1989) notes that, on the contrary:

(i) the best way to protects the poorest group is to bring them as soon as possible to a minimum level of development at which they can expected to adequately handle environmental stress, and

(ii) the extra GHG emissions necessary to accomplish this task are minuscule in the global GHG picture and thus will not be critical in determining climate change.

Smith further recommends that the best approach for a developing country planner worried about climate change may be to accelerate those aspects of development that will assist the poorest and most vulnerable populations in attaining the levels of health, flexibility, education, and resilience that will allow them to cope with environmental stress of all sorts, including climate change. This may offer a much more effective least-risk development pathway than would one attempting to rank development projects on the basis of greenhouse gases.

In spite of “natural debt” of industrialized countries and many suggestions from many experts about massive resource transfers to poor countries to bring them to a minimum level of development, I wonder, why still some “environmental”-economists speaks about exempting certain energy-intensive industries from paying tax (carbon tax) in developing countries which co-operate, for example, to abate CO_2emissions, or suggest the use of trade restriction(via imports/exports tariff) on non-cooperating countries. There are many literature about “ Leakage” and “free-riding”. Free-riding arises when countries do not contribute to global abatement, from which they themselves benefit. Leakage arises when a unilateral policy to abate CO_2 alter world prices in a way which makes other countries emit more CO_2 than they would in the absence of the unilateral policy. Leakage is transmitted through international trade; free-riding is not.

When we concern about global warming, then every thing should be seen in a global perspective. Then comparative advantage becomes less important.

Suppose that, because of imposing carbon tax in industrial countries with large natural debt, some energy-intensive industry with a large involvement in international trade (such as steel, chemicals, non-ferrous, etc) moves to a developing country, like Iran which has not imposed any carbon tax and has a huge amount of energy resources which produces at a very low cost in international standards. The outcome should be Pareto optimal. Because, from an economic point of view:

(i) The firms will maximize their profits

(ii) Products will be produce at a lower costs

(iii) Employment and economic activity in Iran will increase, so will GDP increase too.

This can help country to follow a development path which is more sustainable if the country committed itself to practice more environment-friendly policy.

From an environmental point of view:

(i) the CO_2emission will increase in Iran as a result of leakage. But:

firstly, Iran has a little" natural debt" and a little per capita CO_2emission, though huge amount of energy resources. Secondly, with so many uncertainty around global warming, it may be better to distribute the risks,(that is what we have learned from economic theory) even if it is the total of CO_2emissions from all countries which are relevant for climate change.

(ii) some of increased amount of GDP can be used for implementing measures which increase energy efficiency and save more energy. By saving energy, Iran can contribute to reduce GHG emissions in another country by exporting less carbon-content energy to countries like China and India, which emits large amount of CO_2.

(ii) there can also be one side-effect. By decreasing economy activity in developed country, not only CO_2emissions from industry sector will be reduced, but also emission from other sectors will decrease too.

Thus as long as environmental-economists in developed countries are afraid about lose competitiveness in international markets, and are repairing the "optimum" tariff (the optimum tariff element included in the measure is derived from optimization of cooperative groups interest rather than from global optimization,(Amano,1994)), so I will say that, statements such as , massive transfer to poor countries, or sustainable development or environmental concerns will just be some words and good rhetoric. Joint implementation is not a complete "answer" to the problem.

Developing countries are already being encouraged and are attempting to practice conservation and to use energy more efficiently. This approach is both economically efficient and would help reduce the generation of environmental “bads” into the atmosphere. At the same time, by reducing the demand for fossil fuels, efficient energy use would, in the process, reduce the risk associated with environmentally harmful accidents.

Environmental risks cannot be completely avoided. Difficult choices must be made about how best to control particular risks using the limited resources available. These choices involve trade-offs. Economics can help with these decisions by providing information on the pros and cons of particular courses of action. Although some may reduce economy to the science of scarcity, it is in fact the science of choice, given scarcity.ڤ

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