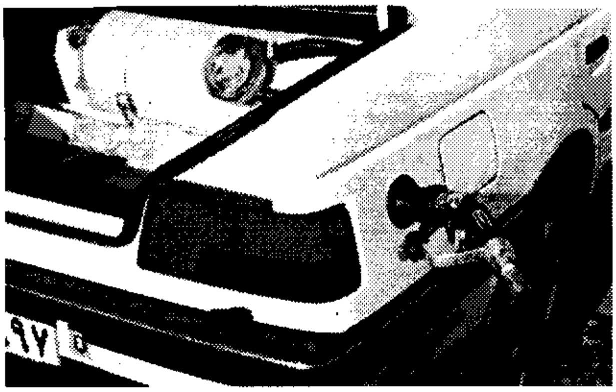
a representative fossil power plant, respectively.

For achieving an optimal allocation of resources one has to propose amethod in which bureaucratic costs are minimized. Setting up a market for tradable emission allowances is a good solution in this regard. On the basis ofsuch a market, the emissions as well as energy conservation is managed on the platform of sustainable development. The emission tradable tariffs might provide the financial resources for investment in sustainable energy projects as well.

An alternative way to take social costs into account is the internalizing externalities, in sense of making the power companies to produce a specific portion of their production from sustainable energies, on the base of approved act. In this way, power companies would automatically develop the sustainable energies. Taking in to account of all efforts, the contribution of sustainable energies would be least among others up to 2020.

More studies on emission markets, initial price of tariffs, levels of emission allowance for each plant, evaluation of the impacts of such markets on electricity production costs, etc are recommended.



Internalization of the externalities is another proposal for which the energy ministry should impose a mandatory level of renewable energies

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electricity will increase and the gap between costs of fossil electricity and sustainable energies will decrease.

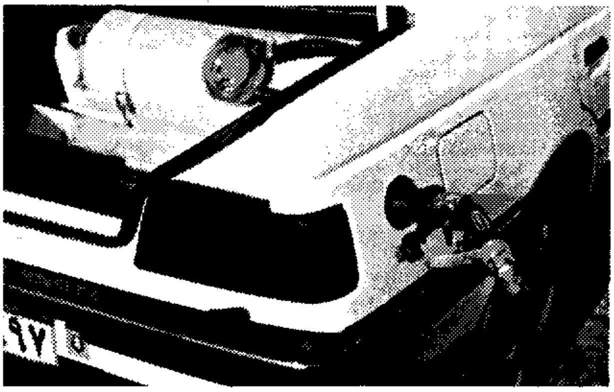
Considering the above-mentioned discussion, The U.S. congress approvedthe CAAA act and practically set up a market for pollution allowances. The data shows that SO2 emission was about 20 million tons per year in USA in 1980, which decreased to the level of13.8 million tons per year in 1997. Decreasing this figure to 8.95 million tons per year has been approved by the congress for the year 2010. According to the act, power plants are allowed to store or sell their emission allowances to others. At the end of each financial year each plant must offer an amount of emission allowance to the government. In 1997 the price of each allowance was $ US 110. Each allowances permits one ton emission of one ton of So2 (Swinton, 1998).

If emitting of 30% of pollutants is not allowed in US, then the power plants should buy 4 million tons of allowances, which is an income of about 445 million dollars. Such significant revenues can be used for development of sustainable energies.

For Iran to move towards an optimal social allocation of energy resources following recommendations are presented.

Setting up a market for tradable emission allowances:

At first, the price of tariffs should be kept at low levels, and a portion increases in the production costs, which occurring as a result of buying tradable emission allowances, should be eligible to be imposed to commercial and residential prices of electricity. Analyzing



The proposed suggestion for Iran is on the basis of a general procedure in which economic agents pay for social costs

the performance of the first period of this market would provide useful information for determination of the rates for the next periods. This information reflects economic situation including inflation rate, currency rate, and the growth of energy carrier prices. Selling emission allowances by government (or provincial authorities) provide some useful financial resources, which could be allocated for promoting sustainable development of Iran. These financial resources should be invested for sustainable (renewable) energy projects, whether by government or private sectors. Allocation of low-interest-rate loans, paying subsidy to renewable electricity power plants, buying the green electricity with guaranteed prices from their producers, or selling green electricity to regional distribution companies on a subsidized prices are some useful practical policies.

Internalizing the externalities:

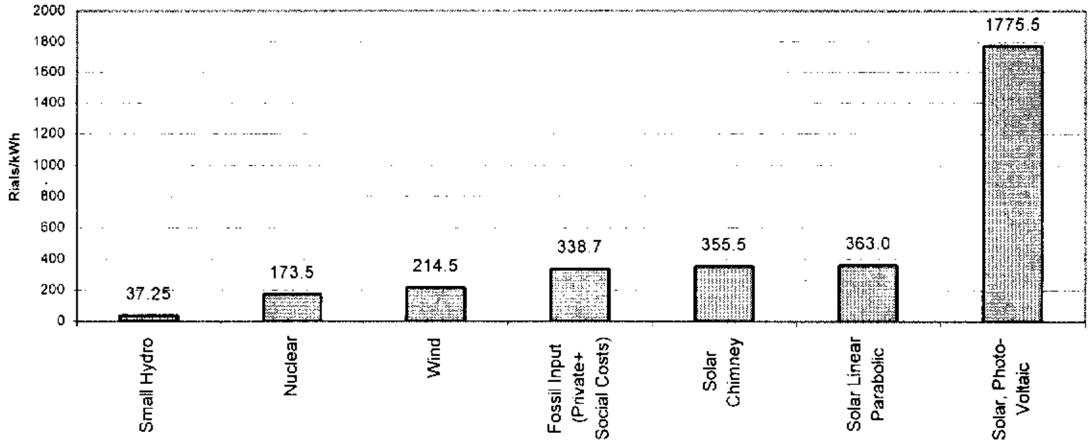
If power plants, legally, have no right to impose externality costs to the society and there is non-cost possibility for negotiation between two parties, the optimal social allocation of resources automatically occurs (Coase, 1960). However, negotiation with all people, who face with losses of negative externalities (e.g. air pollution) is very expensive and sometimes is impossible (due to free riding problem). In such a circumstance, a practical solution might be internalizing the externalities. This means that power companies, on the base of a law, should invest in sustainable energies each year. The amounts of investments might be equal to a percentage of imposed social costs that are determined by energy policy makers. In this case the power companies should not buy allowances or pay for their pollution. Then the given mandatory investment on sustainable energies or production of a part of electricity from sustainable energies would practically internalize the externality problem with least executive cost.

CONCLUSION

The literature of externalities of economic activities shows that the negative impacts of externalities disturb the social allocation of resources. Researchers have shown that creating a market to reflect the social cost of bad by-products of production process (e.g. air pollution) could be an efficient way for figuring the problem out.

Calculations show that on the base of private cost-benefit analysis (without considering the social costs of externalities), only small hydro power plants are economical and can compete with fossil power plants. On the other hand, using a social cost-benefit analysis, small hydro, nuclear, and wind power plants have lower production costs than

Figure 3. Average production cost of electricity in fossil and sustainable plants, considering social costs



simultaneous upward increases in both electricity and fuel prices, the marginal profits remain unchanged. Therefore, the emission taxation system or trading mechanism for emission tradable tariffs would be executable for Iran. If such a design is to be executed as a law, the new capacities of electricity production would promote sustainable energies, so it can be interpreted as going toward optimal social allocation (maximum electricity production with minimum environmental effects). This policy can be considered as a positive step toward a clean development mechanism (CDM).

In fact, this market can peruse three main goals, i.e. decreasing theenvironmental pollution in national level, optimization of energy consumption, providing a permanent financial resource for developing sustainable energies.

U.S. congress based on economist recommendations, regarding the ability of market for efficient allocation of pollution cost, approved Clean Air Act Amendments (CAAA) in 1990. This act provides a market for trading for coal power plants. The emitted So2 causes acidic-rain and impose a large amount of social cost on society (Swintion, 1988).

The idea of using a market for reducing the effects of negative externalities has been initially proposed by Pigou (1932). He stated that emission tax would provide a large potential for reducing emissions. Coase (1960) also expressed that if the two parties (injurious and damaged) could

market had enough power to remove the externality without any failure. Therefore, using the market abilities to reduce externalities has a rich and long literature.

The applied method at CAAA is taken from Dales studies (Dales, 1968). He stated that providing an ownership for public resources like clean air and clean water could develop a market for these resources. With such a market, the prices simply allocate efficiently the resources among users. Montgomery (1972) has proved that in a competitive situation with full awareness, there is not any other way better than emission allowances.

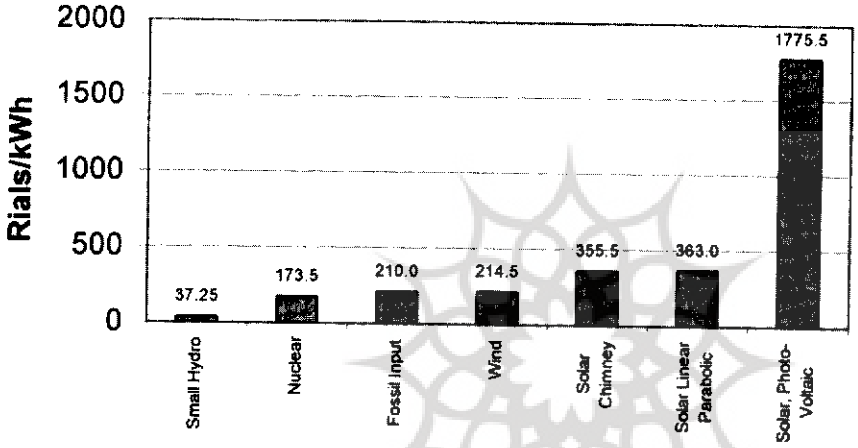
When there is a market for trading emission allowances, pollutants compare the cost of purchasing the allowances with the price of decreasing the pollutants. If plants owners be able to change their fuel with a small expense or install absorbers to research the appropriate level, they do it and sell their excess allowances in the market and vice versa. As a result, the emission of pollutants will decrease to the level determined in the act and provide a large amount of money to allocate for development of sustainable energies and protection of clean air. Consequently, final and average costs of fossil

Table 2. Index of Pollution and environmental costs for fossil power plants in Iran in 1998.

Power Plant	Electricity Production (%)	Pollution Index C (g/kWh)	Environmental costs (Rials/kWh)	Environmental costs* (US Cent/kWh)
Steam	63988 (65.4)	162	88.9	5.08
Combined cycle	20580 (21)	174.8	82.8	4.73
Gas turbine	5906 (6)	233.1	110.4	6.3
Diesel	373 (0.4)	214.1	128.7	7.3
Hydro	7015 (7.2)	1.8	0.5	0.03
Average	**97862 (100)**	**157.6**	**82.7**	**4.7**

Source: Ministry of Energy, 1999 * US$ 1=1750 Rials

Figure 2. Average private cost of electricity generation



costs are practically difficult, but via some innovative methods, they are evaluated and estimated. The environmental costs from fossil power plants related to emissions of 1997 are shown in Table 2. The maximum carbon emission is from gas-turbine power plants with 233.1Gram carbon per one kWh. The second largest emitting is diesel power plants with 214.1 g/kWh. The maximum share of electricity production is belonging to steam power plants (65.4%).

The environmental costs of electricity production in diesel power plants are 128.7 Rials/kWh, which is the highest value among the different kinds of power plants. Average environmental cost was about 82.7 Rials/kWh. Considering the average environmental costs (4.7 US Cents) per one kWh, a considerable amount of financial resources from social costs could be allocated for developing sustainable energies.

Total average expense (private plus social) of electricity production, using fossil fuels is about 338 Rials/kWh, which in comparison with hydro, nuclear and wind energy is high. Figure 3 shows that if the government intervenes and imposes emission tax, then small hydro, nuclear, and wind electricity would be economically viable.

Moving to Optimal Social Allocation, Promoting Sustainable Energies

Social costs of electricity production can be reduced by government intervention or any other policy making authority. Since it is impossible to produce electricity without any danger of pollutant practically, therefore one can operate on the basis of market mechanism and replace sustainable energies with fossil energies to increase capacity of electricity production.

Constructing an emission tax system or creating a market for emission tradable tariffs can be suitable instruments for controlling emissions and/or providing required financial resources to develop renewable energy projects. Determining allowance limits for pollutants and regulating the mechanism for trading the emissions can create such a possibility by policy-making institutions. If the price of tariffs increases, then the management of power plants would trade tariffs on the base of an economic cost-benefit analysis. In addition, power plants may substitute energy inputs (e.g. natural gas or sustainable energies) or may install some equipment to control the emissions (e.g. installation of filters or absorbers).

Assuming a market for emission tradable tariffs, if a power plant holds a high tech system with minimum emission, then it can sell extra share of allowed emission to other plants and/or other factories. Therefore, the market would determine the price of the tariffs. In spite of governmental management of power plants in Iran, this process could be executable and such a mechanism could be easily regulated for Iran.

In Iran, fuel prices for power plants are highly subsidized, therefore the price of electricity will provide a suitable marginal profit for them. Because of

Rials (22.28 US Cents) per kWh.

Another application of wind energy is for extraction of water (A water pool is usually installed for storage of water beside a wind water pump). It is believed that usage of wind pumps with low velocity or paddle pumps in the windy areas with an average wind velocity of more than 3 m/s is suitable. The price of a paddle wind pump in 15m height, 4.75 meter diameter for water extraction of 100m3 per day from 30m depth is about 15,986,190 Rials in Ardebil city, located in the north west of Iran, (Sheikhan, 1997). Comparisons show that the water extraction cost per one cubic meter, using an electric pump in a 25 kilometers distance from a low-pressure network, is 114.5 Rials. While the extraction cost by using a five hp domestic-made diesel pump or an Iranian made wind pump with an storage pool of 100 cubic meter, are 190.9 and 1200.7 Rials respectively (Sheikhan, 1997).

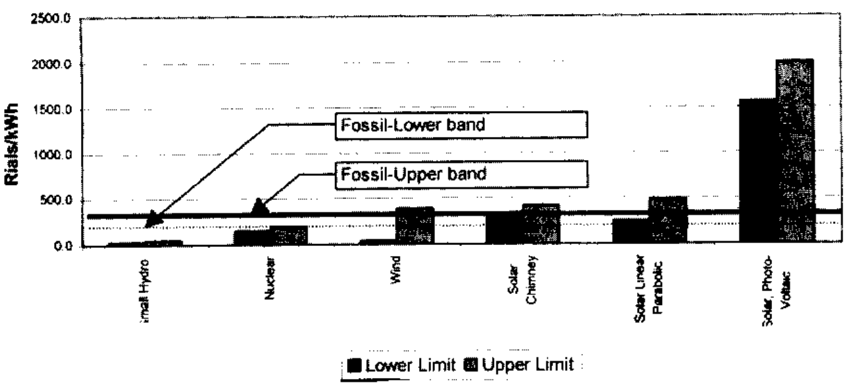
Therefore, on the base of the data, production cost of electricity, using wind energy is 10 times more than using other sources, which makes it uneconomic (given the current subsidized electricity prices and cost-benefit analysis). Calculations show that the present value of benefits of using different types of water pumps for 1 hectare within 20 years is about 8 million Rials. The net present value (NPV) of electrical and diesel pumps are positive while it is negative for Iranian made wind pumps. The NPVs for electric, diesel, and wind electricity are calculated 4.6, 2.8 and - 30.8 million Rials,respectively.Of course taking other kinds of social benefits (e.g. employment rise, opportunity costs of fossil energies, foreign revenues, and environmental benefits) into account would decrease the gap of the benefits and costs. In another study the ratio of production cost of water extraction using wind pump over diesel pump (without fuel subsidies), in different areas in Iran, is calculated between 1.3 in Manjil to 3.7 in Shahrood (Sheikhan, 1997).

Comparison of Electricity Generation from Fossil and Sustainable Energies

Considering the information given in the previous section, it is possible to compare the private costs of fossil and sustainable energies. Before any comparison, it should be noted that estimated costs might vary due to different level of internal/international interest rates, inflation and exchange rates for fossil/sustainable power plants. This situation weakens the confidence level of calculations, so that one has to consider them with precautions. These economic factors affect on the estimated private costs and benefits, while the methods of quantifying or moneitizing environmental effects, efficiencies, congestion, and etc influence the amount of estimated social costs or benefits. Therefore, it could not be a totally convincing comparison. In this way, upper and lower bounds will give the estimations, which is called interval estimations. Figure 1 shows that production cost of a fossil power plant is laid down between 150-270 Rials/kWh. Only small hydro and nuclear electricity are comparable with fossil plants. Meanwhile the average price of electricity was 49.5 Rials/kWh and the maximum price from commercial section 99.6 Rials in 1997 (Ministry of Energy, 1997).

The results of private cost-benefit analysis on the base of average figures show that sustainable energies could not compete with fossil energies in Iran, yet (see Figure 2). Fossil fuels have some social costs due to by-product emissions. The pollution has local or global impacts. Such impacts vary depending on situation of site and type of fuel. The local impacts may reach to its maximum level, when the local climate conditions of site help for stabilizing of pollution. In this case the calculation of average social expense per kWh electricity will be difficult, because in addition of calculation of the extent of pollution, their effects on people heath and physical capitals (acidic sediments) is very difficult. Social costs, are also ascribed to the wind electrically power plants. Such costs do not usually take into account. According to wind farms, it is necessary to pay attention to some cases, which produce interference on electronic equipment, making noise, injuring immigrant birds and congestion costs. In the following section the social cost of electricity generation is discussed.

Figure 1. Comparison of Electricity Production Costs by type in Iran



Social Costs of Electricity Generation

Although, the estimation of social

inflation rate etc. With due attention to the points mentioned above it is impossible to reach a unique result.

Electricity Generation Cost, Sustainable and Fossil Fuels

The wind potentials of Iran is estimated at 6500 MW, which is equal to 28% of current installed generating (Ministry of energy of Iran, 1997). In order to protect and manage pastures, around 54 wind water pumps have been installed from 1991 to 2000 (Iran Statistics Center, 1997). About 11 wind turbines with nominal production capacity of 300-500 kW, which adds up to 4 MW have been installed in Manjil (in northwest of Tehran province) during 1994 to 1997 (Taleghani et al, 1997). Electricity production from solar and wind power plants, which have been installed by Atomic Energy Organization of Iran (AEOI) up to the year 1998, were more than 42000 MWh.

Table 1 compares the private costs of electricity production for fossil, nuclear, wind and solar power plants, which is reported in different research works. As the data shows the average production cost of electricity, have a wide range. For example, the production cost of electricity, using wind, varies from 83 Rials (4.7 US Cents) to 390

Table 1. The average production cost ofelectricity using wind, solar, or small hydro plant (Lower and upper bands)

Source of Research (Energy Type)	Rials-kWh	Assumptions and Descriptions
Abbasspour et el, 1997 (Wind Energy)	83.52–78.39	Internal rate of return 5-6.5 percent, capital return period 10-12.5 years, number of turbines 5-50 units, Inflation rate %18, domestic interest rate %16, and foreign currency interest rate %8.
Ministry of Energy, 1997 (Wind energy)	144.6-219.3	Iranian made wind power plant: for one 600 kW wind turbine the capital investment was equal to 1300 $/kW and average production cost equal to 7.31 Cents; and for fifty turbines, capital investment was equal to 990 $/kW and average production cost equal to 4.82 cents.
Fasaghandis, 1999 (Wind Energy)	163.2	Production Capacity 300KW, exchange rate: 1US$=3000 Rials
Fasaghandis, 1999 (Wind Energy)	177.1	Production Capacity 500KW, exchange rate: 1US$=3000 Rials
Ministry of Energy, 1997 (wind energy)	310–390	On the base of valid international sources the production cost of wind electricity is in the range of 7-13 ¢/kWh.
Enayati, 1997 (Small Hydro electricity)	30–44.5	Average production cost of Yassooj power plant with an installed capacity of 2500 kW was equal to 44.5 Rials/kWh. This factor for the Jannat Roodbar plant with an installed capacity of 1000 kW was equal to 30 Rials/kWh. The base year was 1994.
Koochari, 1997 (Solar Energy-PV)	1560–1991	The study shows that Photo Voltaic (PV) system are economical in Iran's five solar areas for villages in which holds less than 7 households and are more than 10 Km far from Electricity Networks.
Khademi, 1997 (Solar–linear Prabolic)	390–480	At the time being, this technology is in the commercial -industrial phase. For installing 1 kW capacity about 2500-3000 U.S. Dollars is needed.
Khademi, 1997 (Solar- chimney)	291–420	Production cost for 30 kW capacity is about 13.6 – 14.3 cent per one kWh. It is about 9.7 – 9.9 Cents per 1 kWh for 100 kW capacity.
Khademi, 1997 (Solar– Prabolic) for Iran	246–258	International prices has adjusted in accordance with domestic prices
Abbasspoor et al, 1997 (Fossil Power Plant)	129–160.8	In 30 years old, 1 barrel of crud oil 16, 20'$respectively, for 1 kWh electricity 4.3 and 5.36 cents respectively.
Khademi, 1997 (Fossil Power Plant)	150–270	Capital expenses for peak, average and basic load are 340, 625 and 1525 U.S. Dollars per 1 kW capacity respectively. Average costs of electricity generation per one kWh is estimated to be 5.9, 6, and5.6 Cents.
Fesaghandis, 1999 (Fossil Power Plant)	133.7–180.5	Including social cost of electricity generation: Lower limit is based on the social cost calculated by Iran's ministry of energy. Upper limit is based on the social cost calculated by EPA.
Fesaghandis, 1999 (Fossil Power Plant), Madhaj- steam power plant	168.2–215.2	Including social cost of electricity generation: Lower limit is based on the social cost calculated by Iran's ministry of energy. Upper limit is based on the social cost calculated by EPA.
Abbaspoor et al, 1997 (nuclear Power Plant)	154 – 192.9	The average cost of electricity generation is in the range of 5.16 - 6.43 Cents for 1kWh.

Introduction

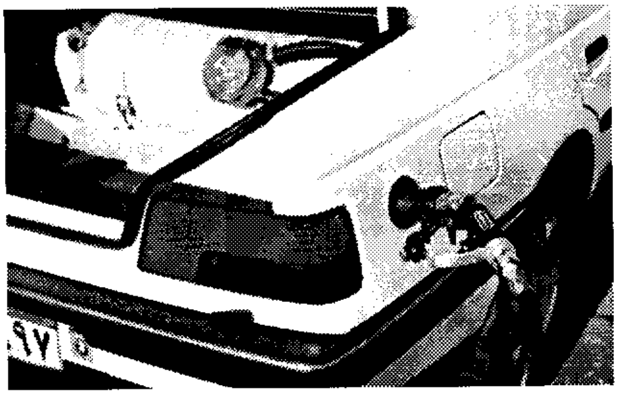
Social costs of economic activities have always been under consideration of economist although ignored in the free market mechanism. At first, these considerations were analytical and theoretical but gradually they have converted to some serious social/legal practical issues. Considering the social costs keeps the economy from the problem of market failure in the process of optimal allocation of resources. In fact, externalities in the process of production and economic activities interpret that market mechanism does not correctly operate in the real world. Consequently, society may suffer from the lack of optimal allocation of resources imposed by market failure.

In the discussion of externalities of fossil fuels, energy policy makers emphasize to achieve two main goals including a) social optimization in allocation of energy resources and b) moving toward optimal allocation of resources by promoting the application of sustainable energies.

Monetizing externalities is not perfect yet. In addition, calculation of costs for different energy carriers is heavily influenced by factors such as exchange, interest, and inflation rates. In order to minimize uncertainties we have used the most reliable data from several sources.

To achieve an optimal allocation, it is not enough to generally know that the social cost of fossil fuel is higher than sustainable energies. It is necessary to find a pragmatic solution for considering the social costs of electricity generation by fossil-based power plants.

The paper is organized as follows: section two discuses moneitizing positive and negative externalities. Section three explains the cost of electricity generation, using sustainable and fossil fuels. Section four compares the private cost of electricity generation from fossil and sustainable energies. Section five contains social costs of electricity production from fossil fuels. Section six endeavors to identify some pragmatic solutions towards social optimal allocation of energy resources, promoting application of sustainable energies. The last section sums up the paper.



Monetizing the value of negative and positive externalities is one of the most important discussions in the calculation of social costs or benefits

Monetizing Externalities

Monetizing the value of negative and positive externalities is one of the most important discussions in the calculation of social costs or benefits. However approximation of social costs or benefits is not an exact science. For example, in evaluating the costs of pollution from fossil fuels in an electricity generation plant, all of the areas come in to account. While only the plotted area near the site should be taken into account. Also in the case of windy area the pollution effect on local health would be negligible. In addition taking into account the parameters like global warming will change the evaluation. It is a very complex task to find out how the pollution affects people's health, and the number of affected people, is beyond our knowledge. Calculation of the value of life for a person is very difficult and debatable. It is not comparable with the value an insurance company pays for death, with the value of his/her earning power when he/she is alive. Insurance companies may consider the same value of life for a simple worker or a doctor. While a doctor can earn much more money than a simple worker can. As another example, the calculation of wasting time in traffic jam in Tehran is a difficult job or even if you know the number of wasted hours for each person in detail, it is still very difficult to quantify the cost of leisure to people.

Prevention of pollution in a fossil power plant can be executed by changing the fuel, from e.g. gas oil or coal to natural gas. So the social cost of pollution for a fossil power plant can be considered as the required investment to switch the input fuel. It may also consider as the price of supplementary devices for controlling/reducing the emission via installing filters or absorbers in exhausts. The price for installing fitters in a 700 MW power plants with heavy fuel oil is about 0.5 US cents per kWh (Fasghandis, 1999). Therefore it is impossible to evaluate a standard level of social cost from an environmental pollutant. But different methods of evaluation give a range of social costs, which can be considered in a useful sensitivity analysis. In addition, in such a calculations, there may be different assumptions for economic factors e.g. interest, currency, and

Externality and Social Costs of Fossil Fuels in IRAN Opportunities for Sustainable Energy

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Externalities of fossil-based electricity generation impose social costs that usually do not appear in the market mechanism. This paper considers monetized environmental impacts of electricity generation from fossil fuels in Iran. Comparison of full social costs of electricity generation by fossil fuels with those of the renewables shows that in Iran the latter is socially viable. In order to achieve this and therefore attain optimal allocation of resources setting up some practical ways and means rather than relying on market mechanism is essential. The proposed suggestion for Iran is on the basis of a general procedure in which economic agents pay for social costs (e.g. through emission allowances). Such payments should be allocated for promotion and development of renewable energy resources. Internalization of the externalities is another proposal for which the energy ministry should impose a mandatory level of renewable energies.

Key words: electricity generation, renewables, externality, social cost, emission allowances, Iran