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Climate Policy and Sustainable Development: Opportunities for Iranian – German Cooperation

Case Study: Solar Thermal Energy in Iran

Saving energy, realising net economic benefits and protecting the environment by investing in energy efficiency and renewable energies

- Executive Summary -

May 2005

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Foreword

Iran has considerable human and material resources to modernize its energy supply and to co-ordinate the transition to a sustainable energy system. Moreover, Iran has a high amount of renewable energy sources: there are favourable conditions for the profitable use of wind energy, very good opportunities for the extension of water power use as well as an ideal setting for the use of solar energy. However, a change of the energy system requires that current shortcomings and barriers will be worked out and discussed in a clear, frank and reliable manner. The present high level of subsidisation of energy prices prevents a market development in favour of energy efficiency technologies and renewable energy sources.

Against this background, the present study provides recommendations – derived from a case study on the use of solar thermal energy – to adjust domestic prices for fossil fuels and electricity to world market prices, to reduce current subsidies during a longer time period and in defined steps and to financially support the expansion of the use of solar thermal energy as long as the subsidies for fossil fuels and electricity are not yet fully removed. While recommending the reduction of energy price subsidies, compensation measures are suggested to avoid overloading low-income households with higher energy prices. Combined with further measures to promote the use of solar energy (such as information and training campaigns, initial assistance for the extension of agencies and contractors that open up solar energy use as their business field and the implementation of CDM model projects) decisive impulses can be given for a fast and broad-ranging extension of solar thermal energy in Iran.

The interesting finding of this study is that the expansion of renewable energy sources would not result in an economic burden but would favour the Iranian economy, save costs and create new domestic jobs and new business sectors. To conclude, this important step towards a sustainable energy supply would not mean an economic disadvantage but would induce an increase in welfare.

I. Energy supply of Iran: problems and chances

Iran has considerable human and material resources to modernize its energy supply and to co-ordinate the transition to a sustainable energy system. However, a change of the energy system requires that current shortcomings and barriers will be worked out and discussed in a clear, frank and reliable manner. Starting with outlining key objectives for a sustainable energy policy this chapter first identifies the main problems of the energy supply of Iran. Subsequently, chances and opportunities of a modified energy policy in Iran will be outlined, focussing on the use of solar thermal energy.

1. Key objectives of sustainable energy policy

Taking into account the current state of international research on sustainable energy policy one can name four strategic sustainability objectives that can also form the basis of a future Iranian energy policy: social acceptability, resource efficiency, ecological effectiveness and economic efficiency.

The objective “social acceptability” means that electricity for households and industry, fuels for transport and industry as well as energy for hot-water, heating and cooling in the building sector are provided to socially equitable prices.

The objective “resource efficiency” means avoidance of losses and best possible use of energy saving potentials to maximize the energy output of non-renewable fossil energy sources as well as renewable energy sources. Increased energy efficiency reduces the energy bills of the customers. The energy costs saved can be invested to accelerate the market introduction of renewable energies.

The objective “ecological effectiveness” means minimization of pollutants (CO_2, NO_x, SO_x) that endanger the healthiness of human beings living today and minimization of greenhouse gases such as CO_2 and CH_4 that cause instability of the climate system and affect basic living conditions of mankind (present and future generations).

The objective “economic efficiency” requires the internalisation of all costs of the energy supply that are expected in the long-term in order to decide on specific technologies and technology paths that are profitable from a business management perspective, that result in the lowest level of long-term economic and ecological costs and that lead to highest welfare gains.

2. The current dilemma of Iranian energy supply

Compared to the key objectives for sustainable energy systems the Iranian energy system has a couple of structural deficits that block the required modernisation and yield considerable economic, social and ecological costs for the present and future of Iran. In detail, these are:

- the rapidly expanding transport sector in conurbations with an excessive share of energy intensive personal transport in urban transport as well as in long-distance transport that result in the globally highest levels of pollution and death tolls on the roads;
- the disproportionately high share of the household sector in total electricity and heat energy consumption;
- the growing share of domestic demand in the oil and gas supply that have weighty consequences for export capacity and revenue of foreign currencies;
- the subsidisation and artificial reduction of energy prices for electricity, gasoline and oil with the consequences that consumers with already high rates of energy consumption are encouraged with financial support of public budgets to further increase their energy consumption. Besides, this obstructs the modernisation of the energy supply system through the implementation of efficient combined heat and power technologies and the expansion of renewable energies and leads to a misallocation of resources;
- the high energy intensity which is a result of the above mentioned deficits and which is well above averages in industrialised and emerging countries.[1]

3. Promising signals for a change

These quite serious problems require a public debate to sensitize the Iranian people and the political representatives in order to look for solutions. Fortunately, a public debate on these issues was initiated in 2004, for the first time, in the parliament as well as in the media. Numerous experts and politicians criticized the energy subsidisation policy of the government and plead for more targeted subsidies for low-income households and parts of the industry instead of a general

[1] For a more detailed discussion of the structural deficits of the Iranian energy system refer to several articles in: World Energy Council/National Energy Committee of Islamic Republic of Iran (ed.), 2004: The Forth National Energy Congress, May 2003, Key Contributions, Teheran, Iran. Further information is contained in Massarrat, Mohssen, 2004: Iran’s Energy Policy: Current Dilemmas and Perspectives for a Sustainable Energy Policy, in: International Journal of Environmental Science and Technology, Vol. 1, Number 3, pp. 241-252.

subsidization of energy prices. The Iranian Energy Efficiency Organisation (SABA) developed a programme that aimed at increasing energy efficiency. Other institutions in the energy sector such as the energy ministry discussed alternatives to the current form of energy consumption. The municipality of Tehran developed ambitious plans to legally stop the growth of inefficient car fleet in Tehran. These and other steps are positive signals that indicate a growing awareness for a structural change in the energy system in Iran.

Actually, Iran has considerable human and material resources that enable it to manage the change towards sustainable energy productions and consumption patterns thereby improving the living conditions of the Iranian people through the reduction of pollutants but also yielding economic benefits. This study on solar thermal energy in Iran by CEERS and the German Wuppertal Institute for Climate, Environment and Energy in co-operation with the German “Büro Ö-quadrat” shows exemplarily that such a change is possible. The study is a result of a joint German-Iranian project that was funded by the German Heinrich Böll Foundation.

II. Case study: Solar thermal energy in Iran

1. Favourable natural conditions for the use of solar energy

Iran has a high amount of renewable energy sources: there are favourable conditions for the profitable use of wind energy, very good opportunities for the extension of water power use as well as an ideal setting for the use of solar energy. The average global radiation for Iran is about 19.23 $MJ/m^2/day$ (= 5.3 $kWh/m^2/day$) and it is even higher in the central region of Iran, with more than 7.7 hours per day (more than 2,800 hours per year).

The level of incoming global radiation (~2,000 kWh/m^2 per year) in Iran is globally one of the highest. In Germany, for example, the annual incoming global radiation (~800-1,000 kWh/m^2) is less than half of the Iranian average. Taking into account the size of the Iranian territory (~1,648,000 km^2) the total amount of radiation in Iran is about 3.3 million TWh per year – this is thirteen times higher than the total energy consumption in Iran.

Despite these favourable natural radiative conditions there is hardly any use of solar energy in Iran. In the past couple of years only about 4,000 solar thermal installations per year were constructed.

2. The current situation

In urban areas in Iran, heating and hot-water installations vary substantially. The most popular systems are central gas burning boilers that are placed in cellars of residential, commercial and office buildings. These boilers provide both hot-water and heat through radiators.

The situation in the Southern parts of Iran is totally different as gas pipelines are absent in these areas. Thus, electrical water heaters (cylinder type of 60, 80, 100 and 120 liters) are commonly used for the supply of hot-water. In general, this hot-water is used for washing purposes. In Southern Iran there are hardly any space-heating installations as they are not needed throughout the year due to climatic conditions.

It should also be pointed out that there is not any district heating and cooling system in Iran. Thus, required hot-water is being produced within each household either by central gas burning boilers (*see above*) or by using gas fired heaters placed at kitchen walls. Quite often both methods are used simultaneously to warm water for both heating and washing purposes.

Almost all residential and office buildings in district No. 22 of Tehran (and other districts of Tehran) are equipped with various heating systems. Solar energy can therefore be used for pre-heating of incoming water so that fuel and electricity use can be minimized.

3. How does the use of solar thermal energy work?

Only few components are needed for a solar thermal energy system which basically consists of a collector, a heat carrier, a heat exchanger, a storage and controls. Actually, for some more simplistic systems there are not even exchanger, storage or controls needed.

In its modern form, the solar water heating system consists of a flat plate collector and an insulated storage tank (*see Figure 1*). The collector is commonly a black colored metal sheet with a metal tube attached to it and is usually provided with a glass cover and a layer of insulation below the metal sheet. A piping connects the collector tube with a tank that stores hot water for non-sunny periods. Once installed on a roof or another suitable location the collector starts absorbing solar radiation. The absorbed heat is transmitted to the water circulating in the tube and the heated water is finally further transferred to the storage tank. In the most common designs, the storage tank is located above the top of the collector. The elevated position of the tank leads to natural convection: water circulates from the collector to the tank and no pump is required.

If an electric pump is installed in the return circuit between the bottom of the storage tank and the lower header of the collector, the tank can be placed at a more convenient level (e.g. in the basement). This is now an active system. A control unit steers the pump to operate only when the temperature of the water at the bottom of the tank is below that of the water in the upper header. A check valve is needed to prevent reverse circulation and thermal losses during nighttime. If the water does not warm up enough on cloudy days, an electrical heating rod (12 immersion heater) heats the water to the desired temperature.

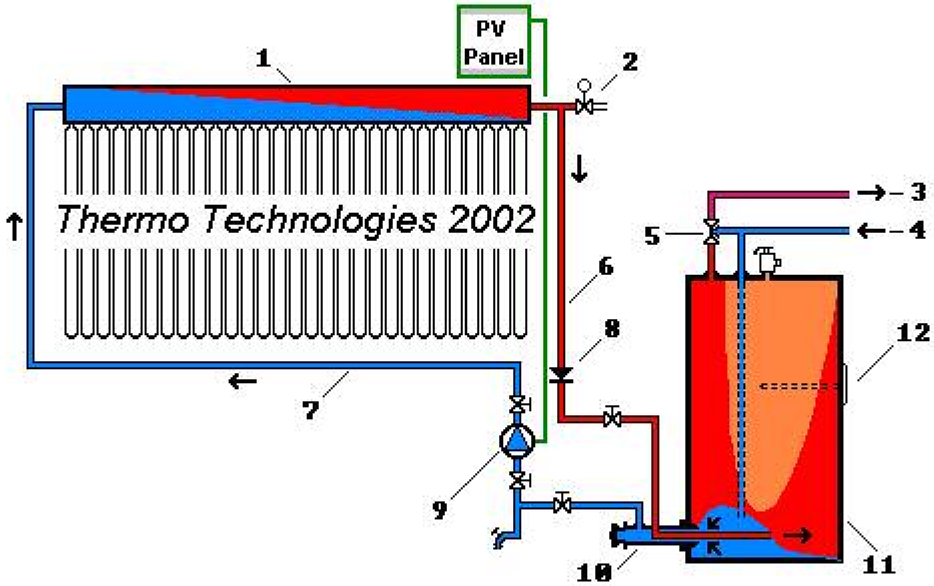

***Figure 1**: Open Loop Solar Water Heating System*

1 Solar Collector	5 Tempering Valve	9 Circulating Pump
2 Manual Air Valve	6 Collector Return	10 Roma Valve
3 Hot Water to Taps	7 Collector Supply	11 DHW Tank
4 Cold Water Feed	8 Non Return Valve	12 Immersion Heater

In the study we have examined different systems and technological variations of solar thermal collectors. In this executive summary, however, we only outline a system with open circuit (Open Loop Solar Water Heating System; *see Figure 1*).

A solar collector surface of 3 to 4 m^2 (~30-40 ft^2) combined with an insulated tank with the volume of 200 to 400 liters (~50-100 gallons) can provide 200 to 300 liters (~50-80 gallons) of hot water at about 60°C (~140°F) per average sunny day in a favorable climate.

The solar collector technology is not new. In Australia, solar thermal energy systems were introduced and further improved in the 1950s and 1960s. Several manufacturers expanded their business to the production of solar water heaters. Meanwhile, Australia has an established industry that produces about 1.5 million units per year. In some districts, particularly in Northern Australia, domestic water is heated almost exclusively by solar energy.

Countries like Australia and China show how renewable energies can gain more and more importance in the energy supply systems, thereby achieving net economic benefits and benefits for the environment. China has been the world's biggest producer and user of solar water heating for many years, with an annual growth rate of 27% in installed area over the previous five years. While the business was initially developed in smaller towns and villages, solar thermal systems are currently used in cities, too.

4. Energy saving and reduction of greenhouse gases by solar thermal systems

In the "Solar Thermal Energy" study by CEERS, Wuppertal Institute and Ö-quadrat different examples of solar water heating projects have been calculated. For a typical two-floor flat with 10 residents the assumptions and results are presented here:

The average consumption of hot water was assumed with 500 liter per day. To heat up this amount of water an energy input of 9.13 MWh per year is needed (with considering the efficiency factor of the heating system).

Installing a solar thermal energy system with three collectors, a collector surface of nine square meters in total and a storage capacity of 400 liters can deliver 69 percent (or 6.31 MWh/year) of the required energy to heat up the water.

Apart from the saving of energy costs the reduced use of fossil fuel results in an annual greenhouse gas reduction of 2.5 tons CO_2 equivalent.

5. No profitability for private investors at current fuel prices

According to the study the investment cost of the solar water heating plant for a typical two-floor flat is about 1,588 US $. Assuming a lifetime of 25 years and a nominal interest rate of 22 percent the annual fixed cost of the solar thermal plant would be 352 US $ (annuity; *see Figure 2*). The annual cost for maintenance and servicing will be 0.5-1.0 percent of the investment costs or, as assumed here, 13 US $ in the first year.

The savings by the solar plant through the substitution of fossil fuels are about 14.4 US $ in the first year, assuming a diesel-oil price of 0.016 US $/liter or 0.0016 US $/kWh. It is quite easy to see that under these conditions there will not be any payback of the investment. Assuming constant prices, the annual savings would be less than 2 US-$. Since general inflation currently rises faster than energy prices, these cost savings would even decrease in the following years, and average operation and maintenance costs would exceed the energy cost savings.

The preliminary conclusion is simple: Solar thermal systems are far away from being profitable with current energy prices for private investors. Even if 50 percent of the investment costs would be subsidised, there would be no profitability for private investors. The main reason for that is the extremely low price for fossil fuels that are highly subsidised and belongs to the lowest in the world.

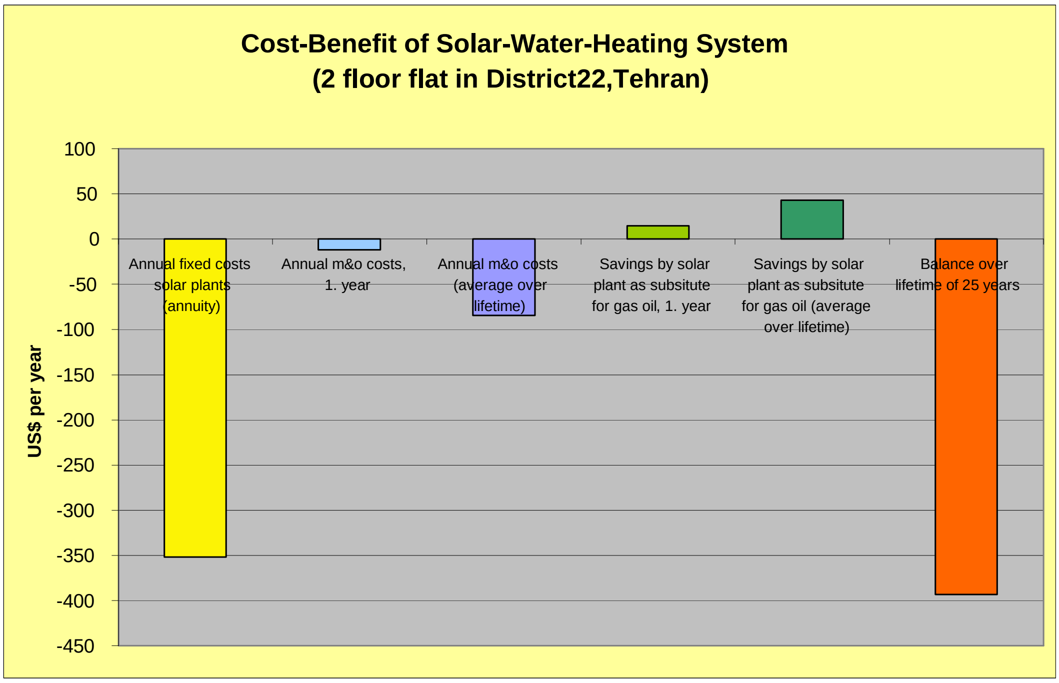

Figure 2: *Cost-Benefit of SWH for a 2 floor flat in Tehran, with 22% nominal interest rate, at current residential prices for diesel oil, a growth of oil-price by 8.3% and general inflation rate of 14 %.*

6. Profitability at export-prices under specific assumptions for inflation, energy price development and interest rates

The current level of energy prices in Iran leads to an energy intensive consumption as these prices do not trigger any incentive for energy saving and prevent investments in energy saving measures from becoming profitable. However, assuming that due to energy saving measures additional fossil fuels could be exported at prices that are at the level of world oil market, this would yield a growing welfare of the Iranian economy (*see Figure 3*).

Assuming oil prices being at about 38 US $ per barrel (the price in early April 2005 was more than 50 US $) the value of a substituted kWh of diesel oil would be 0.024 US $. For the solar thermal plant this would mean that the energy savings would amount to about 216 US $ per year at the beginning of its lifetime. Assuming rising prices for fossil fuels the value of the energy saving due to the installation of the solar thermal system would increase from year to year.

The cost-benefit ratio for a private investor would be about 0.4. That means that the benefit from the energy saving would be nearly three times higher than the cost (with an assumed nominal interest rate of 22 percent and an annual increase in diesel oil prices by 8.3% and of maintenance and servicing costs by 14%).

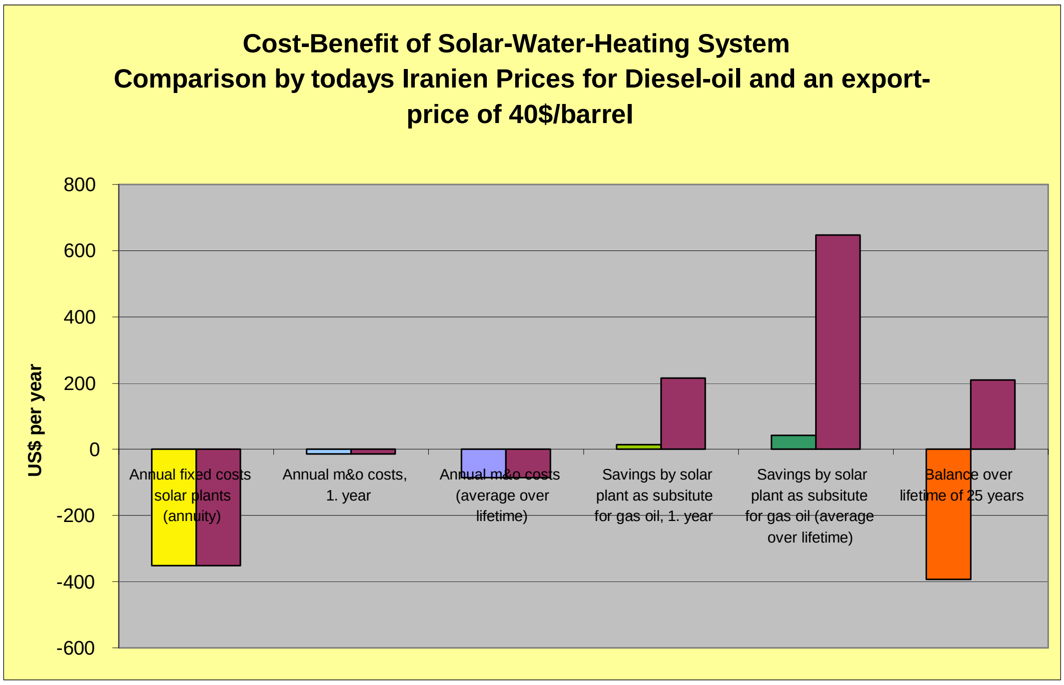

Figure 3: *Comparison of Cost-Benefit of SWH for a 2 floor flat in Tehran, at current residential prices for diesel oil in relation to an export-price of about 38 US$/barrel (22% nominal interest rate; growth of oil-price by 8.3% and general inflation rate of 14 %).*

7. Net benefits for the Iranian economy: Investing in solar energy and selling saved fossil fuels to the world market

Assuming the Iranian government would pay for the investment (1,588 US $), the operation and maintenance of the solar thermal system the saved oil could be sold to the world market. This would be in line with OPEC regulations as Iran has a production quota and not an export quota. The net benefit for the country would be about 4.200 US $ over the lifetime of the solar water heating system (25 years) assuming that the initial investment could be financed by a foreign loan with 3 percent nominal interest rate. (with an assumed annual increase in world energy market prices by 2.0% and of maintenance and servicing costs by 2.0%).

8. Further benefits: Investing in solar energy, thereby substituting electricity

In south part of Iran, solar water heating would substitute electricity consumption. In this case, solar heating systems may be sometimes profitable despite today's low energy prices.

The profitability would be even higher if the price of the electricity substituted would be close to the actual cost of producing and distributing a kWh. However, in the present Iranian tariff system this is not the case. Actually, electricity tariffs are strongly subsidised. If this would not be the case the tariffs would be at least five times higher than today. As shown above, a solar thermal system would be highly profitable with avoided cost of 0.025 US $. However, the current electricity tariff for the residential sector in Iran is about 0.012 US $/kWh. Such a low electricity price is a main obstacle for private investments into energy efficiency and renewable energy measures.

9. Potential of solar water heating in Tehran

According to the used computer model (RETScreen) about 0.6 MWh per year and person could be supplied by solar water heating systems. Assuming that 25 percent of the total population in Tehran (~8,734,000 inhabitants) would use solar water heating systems the overall energy production from such systems would be equal to about 1,310,000 MWh per year. In addition, there is a potential for solar air heating systems that is similar to the potential for solar water heating systems.

Taking only into account the benefits of the use of solar water heating systems the saved fuel oil from 1,310,000 MWh would reduce greenhouse gas emissions by 503,078 tones CO_2 equivalent.

III. Results

Within the present economic and political conditions solar heating systems for hot water are not profitable from the perspective of a private investor.

- With fuel oil prices corresponding to those of the year 2004 (0.016 US $/liter), none of the examined solar plants will work economically. This result would even be valid if very low maintenance costs and a given investment incentive of 50 percent are assumed. This is due to the highly subsidised energy prices for all consumer groups. The oil price for Iranian households is about one twentieth of prices at the world market for crude oil (as of April 2005). The same is true for electricity tariffs that are subsidised up to a level of 80 percent.
- If fuel oil prices would correspond to current prices at the world market, and under specific assumptions for inflation, energy price development and interest rates, all examined cases would be cost-effective and some of them would be very profitable. This is also valid if no capital investment bonus would be paid.

The Iranian economy would gain net benefits from investments in solar thermal energy systems.

- From a budgetary point of view investments in solar plants would be of high interest for Iran. The costs of producing heat by solar plants are well below prices for fuel oil at the world market. Therefore, subsidizing the investment costs of solar thermal plants by the Iranian government would yield economic benefits.
- Investments in solar energy are investments without risks and with high revenues for the Iranian economy. If we assume that the Iranian government borrows loans at the international capital markets with an interest rate of 3 percent and finances with this capital solar installations that result in a reduction of fuel use for heating in households. If we further assume an oil price of 38 US $ per barrel (the average oil price was about 50 US $/barrel in March 2005) and an annual increase in oil prices of 2 percent, every solar thermal installation in a two-floor flat would yield a revenue of about 168 US $ per year. Assuming a lifetime of 25 years every solar thermal plant would yield economic net benefits (additional oil revenues minus capital and maintenance costs) of 4,200 US $. Assuming that solar heating systems would be installed in about one quarter of all households in Tehran, the total net revenue would sum up to 1,800 million US $ for the Iranian economy.
- Iranian energy problems cannot be solved by solar heating systems alone. However, these systems could be an important step towards a sustainable

restructuring of the energy supply. The changes of conditions at the energy market required for the use of solar thermal energy would also be of advantage to other renewable energy sources such as wind and geothermal energy and, in particular, to energy efficiency technologies such as efficient cooling appliances and lighting systems.

- The current Iranian price policy in the energy sector has expensive effects on the Iranian economy (*see Figure 4*). The high level of subsidies for heating and transport fuels as well as for electricity results in an inefficient use of energy and prevent the use of solar energy and other renewable energies. By this Iran looses valuable energy resources that could otherwise be sold at high prices at the world market. The domestic use of fossil fuels furthermore, causes pollution of the environment that result in negative impacts for human health, damages of buildings and reduced agricultural harvests. Those external costs are to be paid by all members of the society. Apart from these social costs caused by the subsidies of energy prices further disadvantages are created for the Iranian economy as the development of specific business sectors such as in the area of solar thermal energy and efficiency technologies does not take place.

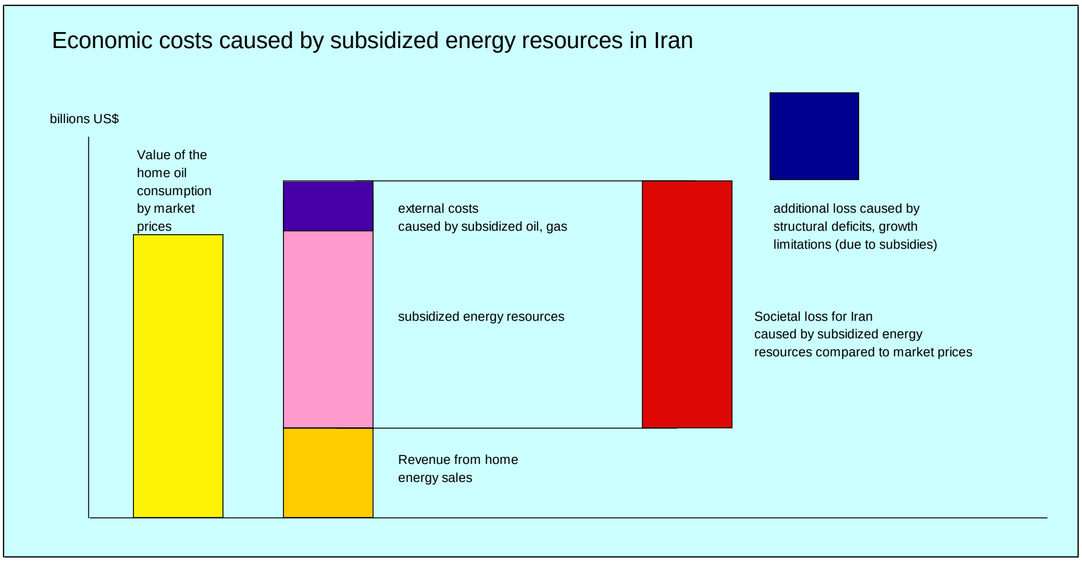

Figure 4: *Social costs of subsidised energy prices*

Apart from the described economic benefits for the Iranian budget a strategy to support the broad implementation of solar water heater systems would have additional advantages:

- Solar water heaters could be used in various ways in Iran. The technical prerequisites exist. Assuming that about 25 percent of households in Tehran would install such systems a total amount of 1,310,000 MWh of solar energy could be used that correspond to a reduction of 503,000 tones CO_2 equivalent. Besides, solar energy can also be used for air heating in many residential and office buildings.

- An increased share of solar systems in the energy sector would lead to a decrease in emissions of conventional polluting substances (NO_x, SO_2, smut). These emission reductions result in reduced external costs of the energy system.
- Estimated Iranian oil reserves account for more than 130 billion barrels – only Saudi Arabia has more reserves. Used in an economic and efficient way, these resources would last for a longer time period thereby giving income to future generations of Iranian people.
- The growth rate of electricity consumption in Iran is projected to be around 6-8 percent per year for the next 10 years. This would induce enormous costs for the building of new power plants and the expansion of the transportation and distribution grid. These costs could be partly avoided if solar water heating systems would substitute part of the electricity consumption.
- If the trend in energy consumption will be the same like the past ten years, the consumption of primary energy in Iran will amount to 1,270 million barrels of crude oil in 2006 – compared to 803 million barrels in 1997. Growing domestic oil consumption means that there is less oil to export. This would result in decreasing revenues from oil and natural gas exports.
- Investments in solar energy systems would create additional jobs. The growth of employment could even be more stimulated if there is a priority on setting up domestic production plants for the technical equipment.
- The sooner the Iranian government starts going this way towards a sustainable energy future the more benefits Iran will gain. At a global level, the competitiveness of renewable energies increases steadily and is expected to do so in the next years and decades. The sooner the conditions for the use of solar energy are created in Iran and the sooner mass production of plants takes place, the more Iran will benefit: on the one hand, as the difference between the costs of a kWh solar energy and a kWh energy from oil will increase in the future, on the other hand, as the number of installed plants and with that the amount of saved energy will increase earlier.
- After a successful domestic introduction of solar systems by taking away the present obstacles in Iran, a strategy to export these systems in the surrounding countries might be promising.

IV. Recommendations

Taking into account the outlined advantages of solar thermal energy for Iran our recommendations are as follows:

- Subsidies for fuels and electricity should be reduced step by step until market prices are reached. To avoid negative social effects of higher energy prices there should be a compensation for low-income households through a direct payment. Similar compensation models are in place, for example, in Switzerland. The most immediate impact of the proposed higher energy prices would be an increase in cost of living for private households. To avoid negative reactions the cutting of subsidies need to be accompanied by an effective "public education" campaign. If households and workers are aware of the compensation mechanism and the overall objective to improve long-term growth rates of the economy and of the income of people higher energy prices may be more easily accepted.
- Until the price level facilitates profitable investments in solar plants, the Iranian government should provide financial support for private investors who plan to build up solar thermal installations.
- Apart from investments by private investors, the Iranian government should also invest in the extension of solar energy by setting up a specialized agency or contracting firms. Those should target the installation of solar water heating systems in public buildings but could also address private residential buildings.
- If market conditions for solar energy are implemented as outlined above, solar energy could also be a new business area for public utilities. Those could deliver the heat generated by solar energy at the same price as heat from oil- or gas-fired or electric water heaters and take on the maintenance and servicing. The same business model could also be taken over by manufacturers of solar energy facilities and craftsmen who could develop an economic sound "all inclusive" service (installation, maintenance, measurement, settlement of accounts).
- The fast, countrywide expansion of solar thermal energy in Iran requires an information and training campaign at different levels. Apart from spreading information to the consumers and potential investors training strategies for craftsmen need to be developed and implemented. By doing this, taking into account the experiences made in Germany might be useful. Besides, this area provides opportunities for co-operation with German organisations (e.g. InWent, GTZ) as well as receiving financial assistance.
- Apart from the reduction of the use of fossil fuels through solar thermal energy the increase in energy efficiency as well as the efficiency of water use is of

importance: by installing water saving armatures, saving of hot-water use can be reached. Besides, the electricity consumption of solar plants can be reduced through highly efficient pumps. Increased energy efficiency reduces the energy bills of the customers, even if there might be a slight increase in price per kWh in order to finance actor- and technology-specific programmes, which are needed to be implemented to take advantage of the enormous energy savings potentials available. The energy costs saved can be invested to accelerate the market introduction of renewable energies.

- To extend the use of solar energy co-operations with investors from Annex I Parties to the Kyoto Protocol could provide additional opportunities. Using the Clean Development Mechanism (CDM) of the Kyoto Protocol investors from industrialised countries can get CO_2 certificates generated through the implementation of solar energy projects. Those certificates can improve the profitability of a project.
- The net cost savings by intensified solar thermal energy use could be used to finance at least partly the electrification of those 20,000 rural villages (about 1 million households) in Iran without electrification. Although photovoltaic is currently one of the most expensive ways of producing electricity, it is more cost-effective for the electrification of small, remote settlements than the extension of the grid.
- Private investments in technologies with long lifetimes and mid-term payback periods require stable economic conditions, clear objectives for the design of energy policies and the implementation of corresponding policy instruments. Paving the way towards a sustainable energy supply will not be successful without these prerequisites.