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Fuels Price Structuring; A Tool for Integration of Environmental Concerns into Energy Sector

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ABSTRACT: In Iran the mainstreaming tool for integrating environmental concerns into energy sector is an Energy-Environment Review (EER-Iran). This paper comprises: (i) an analysis of the current situation with regards to energy production and consumption; (ii) an evaluation of the growth prospects with regard to energy production and consumption; (iii) the identification of environmental issues induced by the generation and use of energy and estimation of the costs of damages; (iv) the evaluation of the extent of contribution to the climate-change phenomenon through emission of greenhouse gases; (v) the evaluation of the proposed mitigation measures for the previously identified environmental problems; and (vi) conclusions and recommendations. The EER-Iran assessed the total health damage from air pollution in 2001 at about US $ 7 billion; equivalent to 8.4% of nominal GDP. In the absence of the price reform and control policies, the EER estimated that the damage in Iran will grow to US $ 9 billion by 2019, in the money of 2001. This is equivalent to 10.9% of nominal GDP, i.e. a large percentage of a larger GDP. Of this total, US $ 8.4 billion come from transport sector. The damage cost to the global environment from the flaring of natural gas assessed on the basis of a carbon price of US $ 10/ton CO_2 and found to be approximately US $ 600 million per year.

Key words: Environmental Energy Planning, Energy Production-Consumption Pattern

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INTRODUCTION

The energy sector of Iran is dominated by oil and gas. Iran is OPEC's second largest oil producer and holds 8.6% (12.3 billion tons) of the world's oil reserves and 17% (26.6 trillion m^3) of its gas reserves. Oil production in 2000 amounted to 186.6 million tons or to 3.8 million barrels per day (mbd). Figure 1 illustrates the development of crude oil production, export and consumption over the last 30 years.

The production of gas is now around 300 million cubic meters per day (mcmd). Of the total production 30 mcmd is flared and 85 mcmd is re-injected into oil fields to boost oil production, leaving 185 mcmd for marketing to consumers. 274 towns have been covered by the gas grid and 48 more are being connected (Iran Statistical Yearbook, 2001). The crude oil meant for domestic use is refined in nine refineries, whose combined nominal capacity is 1.35 mbd. There are plans to increase this capacity to 2 mbd. Environmental hazards, mainly in the form of water and soil contamination, are least for pipelines and maximum for road transport. Accordingly, it is desirable to move oil and oil products as much as possible through pipelines. In Iran, two-thirds of the total movement takes place in this way. The export of 2.6 mbd of crude oil takes place mostly from the offshore facility at Khark Island in the Persian Gulf, by means of tankers with capacities upward of 70000 tons (ROPME, 2000). The tankers have to de-ballast at the time of loading and consequently, nearly 2.6 mbd of water mixed with oil is discharged into the sea. This has an implication for marine life and coral reefs (Iran Statistical Yearbook, 2002). Compared to oil and gas, other forms of primary energy are limited importance and play only a minor role in the economy of the country. Coal has been produced since the early sixties. Coal reserves in Iran are estimated at 12.3% Gig tons. 90% of the reserves are in the Alborz Mountains and in North-East Khorasan. 45% of these reserves are of coking coal which is used in the steel industry.

The theoretical potential for hydropower in Iran is estimated to be about 42000 MW. 13 hydropower schemes are now in operation in Iran with a total power generation capacity of 2000 MW. These projects generated 6908 GWh in 2000, accounting for 7.4% of total electricity; more than 60% of this power energy is obtained from the two dams Dez and Shahid Abbaspour (Karun 1), both in Khuzestan province. Nine large hydropower projects are now under construction. A 1000 MW nuclear power plant is under construction in Blusher, and is expected to be commissioned in 2006. Tehran and Fars have photovoltaic generators of 32 MW capacities.

The wind energy potential in Iran is estimated to be around 6.5 GW. There is a wind farm in Manuel with an installed capacity of 9.7 MW. The largest project for development of wind energy is the 90 MW plant under construction in Gilan. There are a number of geothermal prospects in Iran. The most promising of these prospects is at Mt. Sabula in Ardebil province in NW Iran. The greater Sabula area may have a geothermal power potential of up to 500 MW (Energy Balance, 2002).

Iran has an installed electricity generation capacity of 34000 MW of which 93% is thermal and the rest hydroelectric. Presently, production of electricity in Iran is achieved by 19 steam power plants (fueled with oil or gas), 4 combined cycle plants, 30 gas plants, 13 hydropower plants and one wind farm. The total annual production amounts to 130083 GWh. This capacity is being expanded to meet the growing demand. Thermal plants are run on both on natural gas (70.8%) and fuel oil.

In the period 1980-2001, consumption of petroleum products rose from 172 to 393 mboe, gas from 13 to 242 mboe. The per capita consumption of oil and gas was 9.48 boe per year in 2001. in the last 10 years, gasoline consumption has increased faster than any other oil product, it has almost doubled.

Increasing the consumption of natural gas is one of the objectives of the government. Gas is now used by 32 power plants, 2863 industrial units and 6 million domestic consumers. Of the urban population of 42 million, 30 million were covered by 2000. The long term plan aims to increase gas consumption to 260 bcm by 2020. Natural gas being a clean fuel, its increased use is desirable on environmental grounds. However, in Iran, it's desirable purely on economic grounds alone as the cost of supply is very low (IRI, 1999).

Electricity consumption has increased from 59102 GWh/an in 1990 to 121332 GWh/an in 2000. This corresponds to an average annual growth rate of 7.7%. Per capita consumption grew at an average rate of about 5.8% per year.

Traffic (transportation) is one of the main consumers of energy and one of the main sources of air pollution. The Iranian vehicle fleet in 2005 comprised roughly 7 million vehicles (5.5 million excluding motorcycles), of which 5 million passenger cars (TERP, 1997). A very substantial part of this fleet is concentrated in Tehran, where in 2005, without motorcycles, amounted 10 2.4 million vehicles. The main fuels are still gasoline and gas oil. The fast rising vehicle population and the low fuel efficiency have given rise to increasing fuel consumption by vehicles in Tehran. Fuel efficiency in cars is far below standards achieved in other countries. It is estimated that fuel efficiency could improve by 40% for gasoline vehicles at little additional cost ($500 per vehicle). A number of initiatives have been taken to reduce vehicular emission in Tehran. Compressed Natural Gas (CNG) has been introduced. The consumption of natural gas by taxis and passenger cars reached 6000 million m^3 in 2005. It is expected that further switch from gasoline or gas oil to CNG will help in reducing air contamination in this heavily polluted metropolitan area (APT 2002).

Energy in the domestic market is heavily subsidized. Heavy oil is subsidized at 85%, gas oil at 79% and gasoline at 68%. Electricity subsidies for domestic use vary from -10 to 100% (55% on average). The subsidies not only put a heavy burden on Iran's economy, they also lead to

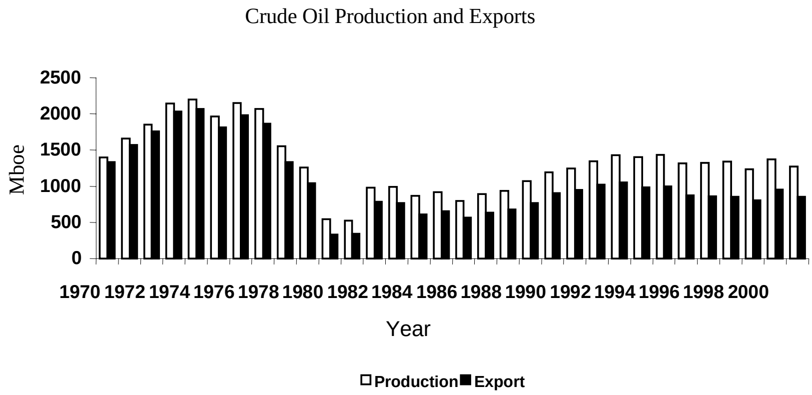

Fig. 1. Development of crude oil production and exports

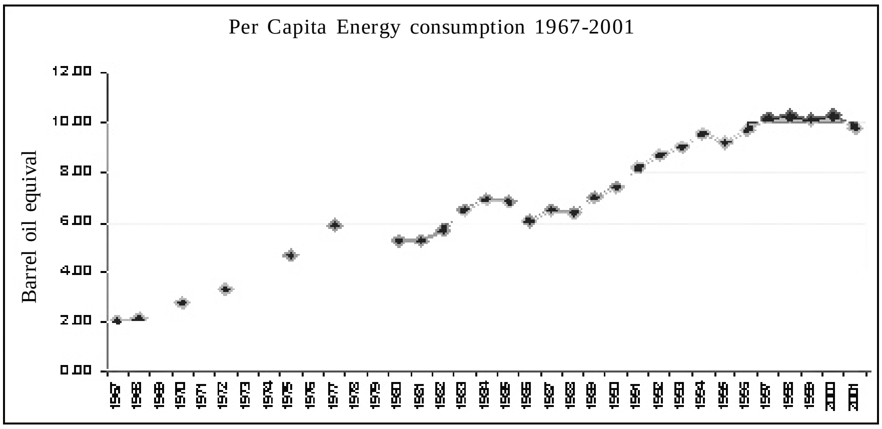

Fig. 2. Per capita energy consumption (in barrels of oil equivalent)

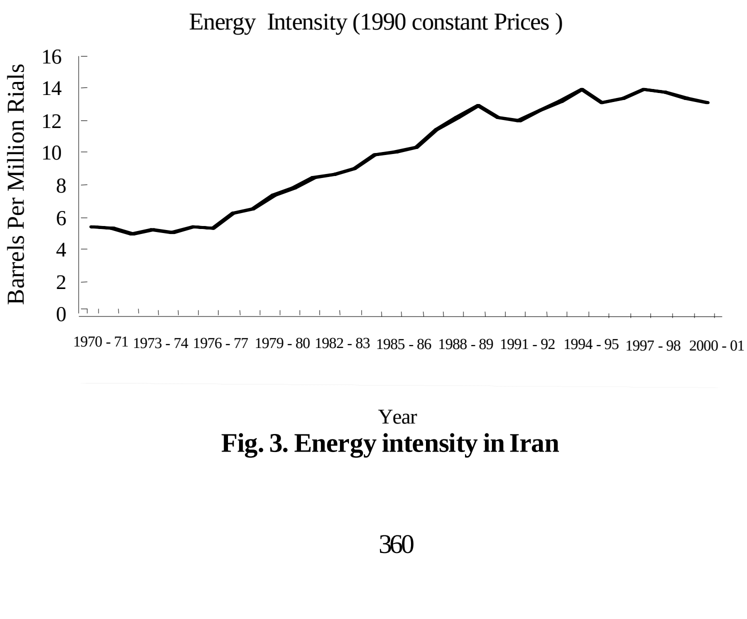

Fig. 3. Energy intensity in Iran

wasteful energy consumption, since the low energy prices do not present any incentive for efficient use of energy. Energy intensity has risen over the last 30 years, as is evidenced by the following Figure, and it is very high in an international comparison. Wasteful use of energy, in turn, also increases the negative effects on the environment.

Development Perspectives

The total population of Iran, one of the main parameters for the increase in energy consumption, has been growing from 10 million in 1900 to 25.8 million in 1965 and to 60.2 million in 1995 (latest census). It was 64.9 million in 2000 and is supposed to reach 70.3 in 2007. The population would reach 75.6 million in 2010 and 86.3 million in 2021.Fertility has dropped considerably, actually to below replacement level in larger cities and the economically more developed provinces.

Development of energy consumption in the future will be influenced, among other factors, by the following parameters: Population Increase, Increasing Urbanization, Increasing per capita Consumption, Better Energy Efficiency, Lower Energy Subsidies, Industrialization (IRI, 2001-2003).

Environmental Issues

Elements of an environmental policy are stated in a number of legal documents. The most important one is in Article 50 of the constitution. The development plans place priority on reducing pollution, and preserving the country's natural and cultural resources. There are also requirements in the Air Pollution Act (1995) and its executive by-law of 1997, for reducing pollution from motor vehicles, factories, power plants and residential sectors.

Air pollution, especially in mega cities, figures prominently among the main environmental causes which affect human health. A study on air quality in Tehran revealed the morality risk associated with particulates (PM 10) as being at 4000 deaths per year due to this pollutant. To this, an about equal number of cancer cases caused annually by exposure to NOx has to be added. The marine environment is affected by oil pollution. About 1.2 million barrels (roughly 160,000 tons) of oil are spilt into the Persian Gulf Area annually. The bulk of this oil stems from tanker transport accidents (49.5%), from offshore production facilities (19.4%) and from urban runoff (14.8%), while almost 10% stem from natural sources (oil seeping out from natural deposits).

Greenhouse Gas Emissions

The Islamic Republic of Iran signed the United Nations Framework Convention on Climate Change at the Rio de Janeiro Earth Summit in 1992 and ratified the Convention in 2005 as a Non-Annex1-Party. It has submitted its First National Communication to the COP of UNFCCC recently. The National Greenhouse Gases Inventory for 1994/95 can be characterized as follows:

- 84% of total CO_2 emissions are resulting from the energy sector (fuel combustion and 'hot flaring'). Energy Transformation (refineries and Power Plants), Industry, Transport, and Building each have a share of 20 to 25% of the CO_2 emissions from fuel combustion.
- 62% of total CH_4 (methane) emissions are resulting from the energy sector (fugitive emissions from natural gas production and 'cold flaring'). Agriculture with 25% (livestock and rice production) and waste with 13% are the other two important contributors. Fuel combustion is of minor importance for the CH_4 emissions.
- Only 13% of total N_2O emissions are attributed to the energy sector. Agriculture with a share of about 77% is responsible for the bulk of the N_2O emissions

All Iranian GHG emission together sum up to a CO_2 (equiv.) of 405000 Gg (=6.7 tons per capita) in 1994, rising to 8.7 tons per capita in 2000 (JICA 1997). The contribution of Iran to the global CO_2 emissions is about 2%.

Proposed Measures for Environmental Protection

Different sources, have proposed a high number of measures of a very diverse nature (from national policy to very specific technical interventions) to be adopted for reducing impacts in the energy environment interface. Many of these have not gone beyond the stage of idea or concept, others have been elaborated to some detail, and some are being implemented.

The single most important measure for a reduction of energy consumption and in this way for a reduction of emissions is the reduction, and finally elimination, of energy subsidies. Subsidizing fuel for cars and other forms of energy puts a very heavy burden on the economy of the country. Furthermore, cheap energy (as low as 10% of world market prices for some energy carriers) leads to a wasteful use of energy and very effectively prevents any measures for increasing energy efficiency from being taken. The total costs for energy subsidies correspond to 25% (1999) and 27% (2000) of GDP. The effects of phasing out subsidies have been calculated for a number of scenarios (see below).

In addition to the subsidy issue, a list of sectoral measures or policies has been compiled, based on the multitude of already proposed measures and on the insight gained from the work carried out. These have then carefully analyzed in order to verify which ones should be recommended for implementation, and under what conditions. The criteria for the selection of such measures and their recommendation for implementation were the following:

- Measures in the interface of energy and environment, i.e. suitable for reducing pressure on the environment stemming from the energy sector.
- Applicability and relevance in the context of the conditions prevailing in Iran.
- Substantial beneficial effects for the environment.
- Favorable cost-benefit ratio (least cost alternatives, win-win types of projects, considerable reduction of external costs).

The measures established for detailed analysis are listed in Table 7.

The Proposed Action Plan

The Action Plan which was developed as the main outcome of the EER-Iran seeks to explore the possibilities of reducing the damage through price reform, sectoral measures aimed directly at polluting activities or a mixture of the two. The damage done by air pollution from the energy sector in Iran in 2001 was about US$7 billion; this is equivalent to 8.4% of GDP. Subsidies paid to the consumers of energy in 2001 were US$14.7 billion or about 18% of GDP in Iran. The most damaging forms of energy are among those with the highest subsidies.

Environmental damage costs will increase even faster than energy use because as incomes rise the willingness of the population to pay for a better environment will also increase. In the absence of price reform and policy intervention the damage will grow to US$20 billion by 2019, in the money of 2001. This is equivalent to 10.9% of GDP, i.e. a larger percentage of a much larger GDP. Of this total US$8.4 billion arises from the transport sector.

Table 1. Benefit values proposed for Iran

Pollutant	Value ($/ton)
PM10	4300
SO_2	1825
CO	188
NOx	600
CO_2 Low	3
CO_2 Medium	10
CO_2 High	80

Using these damage costs one can estimate the total local damage from the energy sector in 2001. The results are shown in Table 2.

Damage costs from the air pollution caused by the energy sector can be estimated as before by multiplying emissions by a unit damage cost. It must be remembered that the transfer of the damage costs from the EU basis was calculated in proportion to the GDP per capita of Iran. As GDP in Iran will increase in the period we must allow for the increased willingness to pay for environmental values and the consequent higher damage costs.

According to demographic forecast (WB, 1999 & WB, 2003) the rate of increase of population from 2005 to 2010 will be 1.46% per annum and from 2010 to 2021 will be 1.21% per annum. Coupled with the GDP growth estimates noted earlier this indicates a per capita GDP growth rate of 4.5% under the 3rd Plan, 2.5% under the 4th Plan and 2.8% under the 5th and 6th Plans. The local damage costs have been adjusted accordingly.

Table 2. Damage caused by the sector in 2001(and 2019) bn US$

	Natural Gas	Crude Oil	Gasoline	Kero	Gasoil	Fuel Oil	LPG	Total
Oil refining		0.37 (1.06)						0.37 (1.06)
Power Generation	0.086 (0.43)					0.84		0.92 (0.43)
Agriculture				0.0013 (0.0053)	0.21 (0.65)	0.0076 (0.018)		0.22 (0.67)
Res. Comm.	0.033 (0.134)			0.044 (0.19)	0.084 (0.26)	0.097 (0.22)	0.0046 (0.020)	0.26 (0.83)
Industry	0.018 (0.073)			0.00025 (0.0011)	0.09 (0.28)	0.81 (1.86)	0.0006 (0.0026)	0.92 (2.22)
Transport	0 (0)		1.13 (3.84)		0.74 (2.33)	0.046 (0.11)	0.0051 (0.023)	1.93 (6.30)
Others	0.0053 (0.021)		0.00025 (0.001)	0.0013 (0.0054)	0.068 (0.21)	0.014 (0.031)	0.00038 (0.0028)	0.088 (0.27)

Table 3. Future damage costs (US$ /ton)

Pollutant	2001	2004	2009	2014	2019
PM10	4,300	4,900	5,551	6,373	7,317
SO_2	1,825	2,082	2,356	2,705	3,105
CO	1,870	1,712	1,937	2,223	2,553
NOx	600	684	774	889	1,021

The total of $19.38 billion of damage is equivalent to 10.9% of GDP in 2019, compared to 8.4% in 2001. Damage will grow not only in absolute terms, but also as a percentage of GDP. The evolution of damage over the period compared to GDP growth is summarized in Table 4. The fall in unadjusted damage costs (i.e. not adjusted to reflect increased income and therefore higher valuation of the benefits of reducing pollution) between 2001 and 2004 is a consequence of the penetration of natural gas that becomes less rapid in subsequent years as the best targets are converted. The adjusted values, i.e. revised for increased income, are the most reliable guide to damage. It can be seen that under the conditions of the Reference Scenario the per capita damage costs rise steadily over the period and by 2019 are more than double the value in 2001. This essentially means that individuals will perceive damages at twice the existing level. The impact on environmental damage and the national economy of policies to make energy prices cost-reflective was examined. The only clear target for price reform is the opportunity cost. Opportunity costs are an attempt to take out all the distorting and superfluous components of market prices and to estimate the true value to the country of inputs and outputs into the measures induced by policy. The following Table 5 provides a comparison of market prices with opportunity costs based on the analysis presented in EER-Iran. A big effort is needed to bring prices in line with costs. Three scenarios for price reform have been analyzed, namely, elimination of subsidies by

- 2009 (end of 4th Plan; fast price reform);
- 2014 (end of 5th Plan); and
- 2019 (end of 6th Plan; slow price reform).

The effect of price reform on the energy sector would be dramatic. If prices are brought to the level of opportunity costs by the end of the 5th Plan in 2014 then the Total Primary Energy Requirement in 2019 will be 1030 mn bbloe, compared to 878 mn bbloe in 2001 and to 1947 mn bbloe in 2019 if there is no price reform. The emissions of CO_2 in 2019 in this scenario will be 358 million tonnes compared to 708 without price reform and to the 325 million ton emitted in 2001.

Table 4. Damage costs and GDP development

	2001	2004	2009	2014	2019
GDP in 2001 (billion $)	82.7	98.5	119.8	145.8	177.5
Population (million)	65.9	69.3	74.6	79.7	84.5
GDP/capita ($/capita)	1,280	1,430	1,600	1,840	2,110
Damage costs adjusted billion $	4.71	5.2	6.58	8.53	11.77
Damage costs unadjusted billion $	4.71	4.56	5.1	5.76	6.9
Damage as % GDP adjusted	5.7%	5.3%	5.5%	5.9%	6.6%
Damage as % GDP unadjusted	5.7%	4.6%	4.3%	4.0%	3.9%
Adjusted damage per capita (US$/capita)	71.5	75	88.1	107.1	139.4
Unadjusted damage per capita (US$/cap)	71.5	65.8	71.75	72.3	82

Table 5. Comparison of market prices and opportunity costs

Energy form	Opportunity cost ($/bbloe)	MarketPrice ($/bbloe)	Subsidy (% of OC)	Annual increase to 2009 (%)	Annual increase to 2014 (%)	Annual increase to 2019 (%)
Gasoline	32.5	10.5	68%	25%	12%	8%
Kerosene	27.1	2.38	91%	63%	28%	18%
Gasoil	27.1	2.75	90%	58%	26%	16%
Furnace Oil	13.5	2.12	85%	45%	20%	13%
NatGas (Industry)	8.5	2.88	67%	25%	12%	8%
Gasoil (Industry)	26.1	5.5	79%	36%	17%	11%
NatGas(ResComm)	9.7	2.38	75%	32%	15%	10%
CNG (Trans)	15.4	2.12	86%	48%	22%	14%
Elec(Agric)	121.9	2.25	98%	122%	49%	31%
Elec (ResComm)	121.9	14.75	88%	52%	23%	15%
Elec (Industry)	30.5	27.1	11%	2%	1%	1%
Elec (Others)	91.4	20.3	78%	35%	16%	10%

The increase in GDP over the period will be 124%. So with price reform the economy can meet growth targets with little increase in energy requirement or emissions of CO_2.

The costs of the energy sector by 2019 are halved by price reform. The total opportunity cost of the sector in 2019 under a 2014 price reform scenario is about $21.75 billion compared to an estimated $44.5 billion in the absence of price reform.

There are equally dramatic impacts on environmental damage. With price reform the total damage cost in 2019 is $10.13 billion compared to $19.38 billion under the reference scenario. This is still higher than in 2001.

Price reform in the energy sector will increase the level of prices to consumers directly through the energy bill and indirectly through the impact on other goods and services. The likely upper level of impacts is shown in the Table 6.

Table 6. Effect on consumer price index (CPI) of price reform

Price Reform	Increase in CPI (% per year)
2009	12.6
2014	6.1
2019	4.0

This analysis shows that there are some advantages in a slower introduction of reform.Price reform will boost economic growth. The value of the extra income from the sale of the energy products released for export by the reform program is equivalent to an extra 12.8% of GDP by 2019. In the slowest price reform scenario (by 2019) the extra growth is added over the whole period.If comprehensive price reform is not politically feasible then price increases should be targeted to transport fuels because these give the largest environmental benefit per unit of subsidy avoided. A 5% annual rise in the real prices of gasoline and diesel would produce by 2019 annual subsidy savings of $3.8 and $2.3 billion respectively and damage cost savings of 13 and $1.7 and $2.1 billion.

Some sectoral measures such as reduction of flaring, reduction of transmission and distribution losses in electricity, reduction of losses from or land gas network, promotion of the switch from oil to natural gas in industries and transportation and residential demand side management, have been modeled to determine their impact under current pricing and when implemented concurrently with price reform. Figure 4 shows the cumulative benefits of the measures to the national economy in the case when price reform is fully achieved by 2014. The cumulative benefits to the economy are measured by the value in export of energy products released reduced by the investments required to implement the measures. The cumulative benefit including the damage cost is also shown. The damage is a real cost to the economy and reduction in damage is a real economic benefit. It can be seen that the policy package pays back in economic terms in six years if damage costs are not included, but in three years if damage costs are included. The cumulative net value of the policy package by 2019 is about US$6.25 billion.

Figure 5 shows the net financial flow to the state budget. This is important information because it reveals the ability of the state to finance the measures.

Also, Fig. 5 shows the net financial flow to the state budget, i.e. the avoided subsidies to the energy sector net of the costs of financing part of the investments in renewable energy, energy efficiency and fuel conversion required by the package. The cumulative financial flows become positive after 2010 and reach a maximum in 2012, after that year prices are so close to opportunity costs that there is no longer any significant flow of avoided subsidies to set against the costs of the measures.

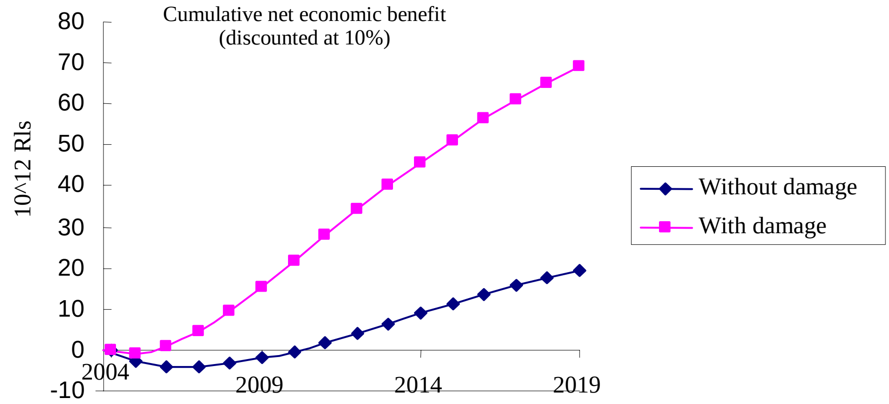

Fig. 4. Cumulative net benefits to the country (10^{12}Rials, 1$=800Rials)

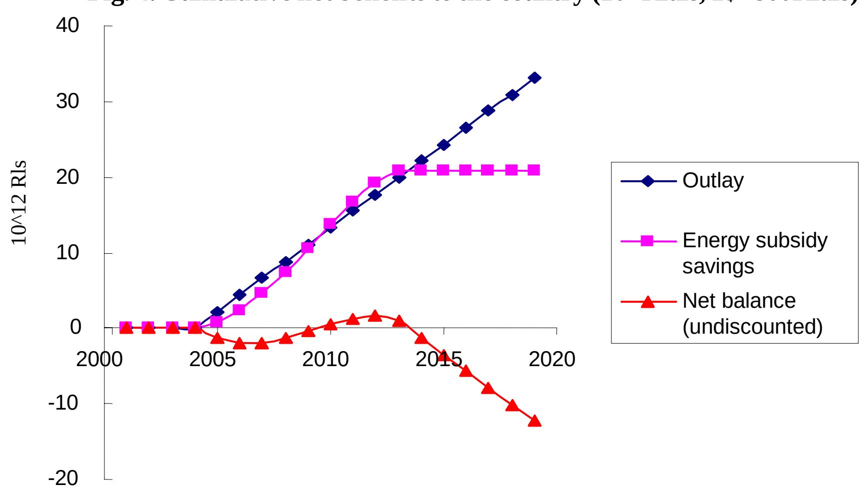

Fig. 5. Net financial flows to the state (1$=800Rials)

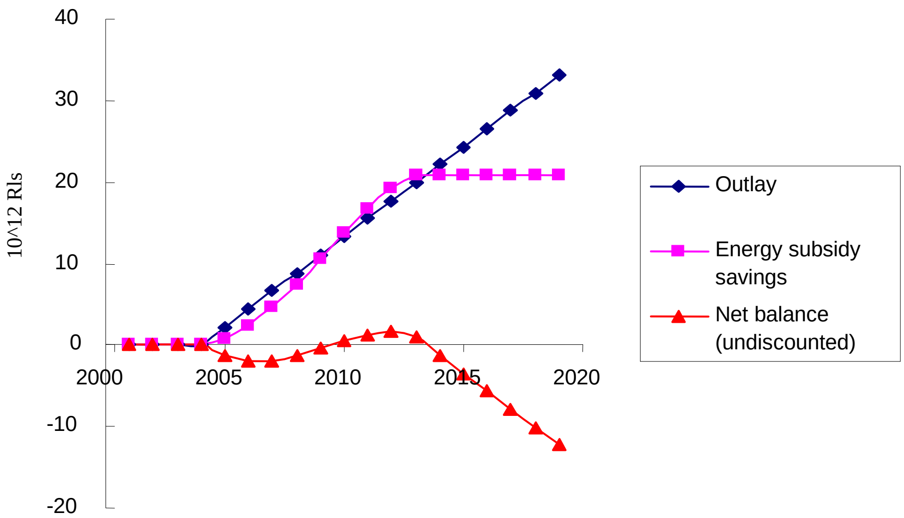

Fig. 6. Net financial flows to the state without class C measures

Table 7. Main effects of price reform and sectoral measures

Year	**2001**	**2019**			
Scenario		**1**	**2**	**7**	**9**
Primary energy requ. (m bbloe)	878	1,947	1,835	1,030	962
Domestic energy cons. (m bbloe)	720	1,556	1,460	789	737
out of which					
- Nat. gas	242	575	588	300	310
- Gasoline	99	198	160	117	94
- Gasoil	160	294	294	92	92
- Fuel oil	73	98	41	66	31
- Electricity	60	197	183	120	114
Emissions (kt)					
- CO_2	352,000	708,000	649,000	358,000	332,000
- SO_2	1,349	1,436	812	753	530
- NOx	1,106	2,161	1,578	1076	747
- CO	5,435	10,790	7,678	5967	4135
- PM 10	131	228	214	80	72
Subsidies bn US$	15	36	33	0	0
Subsidies in % of GDP	17.8	20.3	18.8	0	0
Damage Costs bn US$	4.7	11.8	8.2	5.9	3.9
DC in % of GDP	5.7	6.6	4.6	3.3	2.2

Scenarios.
1: Business as usual (no price reform, no sectoral measures)
2: No price reform, all sectoral measures
7: Price reform by 2014, no sectoral measures
9: Price Reform by 2014, sectoral measures (preferred scenario for the Action Plan)

If the measures are to be continued after this date then they need to be financed from other sources. The support measures for renewable energies are expensive to the state because they are justified in terms of climate change benefits that do not appear in the state budget. Figure 6 shows the cumulative net cash flow to the state in the absence of these class C measures. In this case it can be seen that the measures induce a positive cash flow from the outset. After the year 2012 when there are few benefits to the state from avoided subsidies the revenues fall away. The policy package should be reconsidered at this point (Table 7).

CONCLUSION

The following conclusion has been drawn and a few recommendations are made:

- The Government of Iran should consider a policy to bring energy prices to the level of opportunity costs by 2014 or 2019. If comprehensive price reform is not politically feasible then price increases should be targeted to transport fuels.

- In association with this price reform policy there should be a set of sectoral polices known as the Energy-Environment Action Plan.
- A mechanism should be developed to return a portion of avoided subsidies to an Energy Action Plan Fund to finance activities under the Action Plan. The initial resources of this fund should be of the order of $100 million.
- The focus of activities within the Action Plan should be on energy efficiency, substitution of natural gas and cleaner technology for transport.
- Renewable energy projects should be conducted only in the context of international schemes that make payments available for avoided emissions of greenhouse gases.
- Detailed examination should be made of the volumes, composition and location of vented and flared gas and the options for cost-effective reduction of flaring should be determined and implemented.

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