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An Environmental & Economic Analysis for Reducing Energy Subsidies

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ABSTRACT: This paper estimates the trend of total energy subsidies from year 2003 (that is 16.68 % of GDP) and running a model, predicts that energy subsidies will reach to 20% of GDP by 2019 if subsidies continue. Also environmental damage costs of energy consumption have been entered the model (Environmental Cost-Benefit Analysis Model: ECBA Model) in addition to the vast amounts of subsidies. So damages caused by energy consumption as air pollution and Green House Gases have been considered as an attempt to internalize energy cycle externalities. Using an ECBA Model which considers changes in level of social welfare and environmental quality as probable benefits, the Benefit/Cost ratio for running price reform policy under two scenarios has been analyzed and calculated. The analysis shows that reducing energy subsidies for each energy form is considerably beneficial. Apart from the environmental benefits, the increase in prices can be a base for a re-distribution of income within the poor deciles of economy and this policy would increase the government revenue and economic growth in long-term.

Key words: Energy, Subsidies, Price Reform, Environmental Quality

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INTRODUCTION

Energy in Iran domestic market is heavily subsidised; this paper estimates the total subsidy by running a model for year 2019. Also for the first time in Iran, environmental damage costs caused by air pollution -which were transferred from Western European practice adopted by the conditions of the country by scaling according to GDP per capita measured in PPP terms- has been assessed and entered the Cost-Benefit Analysis (CBA) in addition to the vast amount of subsidies. So the amount of pollution (which was derived from an end use model) has been used to estimate the future situation of environment and economy in different scenarios.

Subsidies in the Iran energy sector are very widespread. According to an estimate, the total subsidies to the energy sector in Iran amounted to 126,441 billion Rials in the year 2003 equivalent 15.794 US$/ Billion (Ex. Rate of 1 US$= 8000 Rials), which is 16.68 % of GDP in 2003 (IEA, 2003) (Table 1). Given that Iran is a large energy exporter, the ample earnings from crude oil have perhaps contributed to the liberal largeness from the government.

However, subsidies work against efficiency of resource allocation and by placing a huge financial burden on the government; they cause inadequate investments in the social and infrastructure sectors. But at the same time, subsidies are a political issue and it is hard to eliminate them. A thorough cost-benefit analysis of subsidies can go a long way in reducing the political resistance to reducing subsidies.

Figure 1 gives the trend in prices of gasoline, gas oil, kerosene and fuel oil in Iran along with the international crude oil prices (BP and IRI, 2003) since 1974. This graph shows the wide disparity that exists between the domestic prices in Iran and the international prices. To the extent that the graph compares the international prices of crude oil with the Iranian domestic prices of the petroleum products, it understates the extent of subsidy somewhat. Yet, the wide gap separating the international and domestic prices underscores the potential need for rationalizing domestic prices.Ideally, the subsidies should be targeted and limited to the more deserving segments of the population.

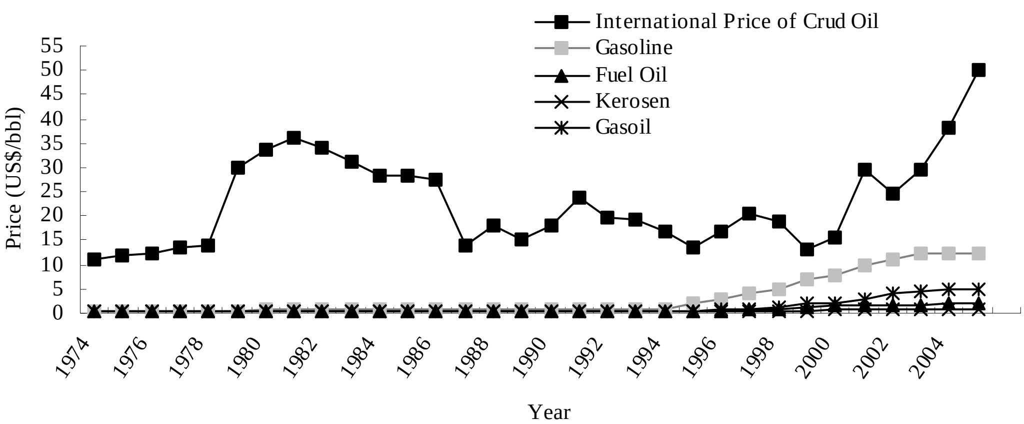
However, the subsidies in Iran are not specifically targeted but are more like blanket subsidies since the general price level in the economy is held below the international parity. In such a case, each consumer gets the same amount of per unit subsidy and the total quantity of subsidy paid to the consumer depends on the quantity of fuel consumed. Such an approach to subsidization is necessarily regressive as the larger consumers, who are typically least deserving of the subsidy, receive the larger amount of subsidy. For the purpose of this analysis, it would be useful to examine how the subsidies are distributed across different income segments. It has been considered wise to deploy Lorenz Curve analysis and Gini coefficients in a somewhat modified form to address this issue.

In the traditional approach, the Gini coefficient of zero means perfect equality in the sense that each decile of population gets equal share of income in the economy. However, the objective of subsidies is not to make uniform impact on every income class but to pay more to the deserving classes. Thus, the Gini coefficient for subsidies should ideally be as close to minus 1 as possible. Figures 2 and 3 show the differences in approach. Figure 2 shows the curve for the Gini coefficient as calculated for the subsidies given for gas oil consumption in Iran, while Figure 3 shows the desirable curve for subsidies.

Table 1. Level of subsidies in Iran (Billion Rials)

	Product/ Sector	House-hold	Indu-strial	Agri-culture	Trans-port	Comm-ercial	General	Total
	Gasoline	-	52	15	22,003	3	129	22,202
	White Kerosene	10,855	40	117	-	167	301	11,480
	Gas Oil	2,018	2,809	5219	21,569	904	1,724	34,243
	Furnace Oil		8,208	0	788	1903	31	10,930
	Liquid Gas	3,222	263	-	529	290	-	4,304
	Electricity	17,416	5,943	4,621	-	1370	4,127	33,477
	Natural Gas	6,408	2,560	-	2	701	48	9,719
Total	**Billion Rials**	40,006	19,874	9973	44,891	5337	126,355	126,441
	Billion US$ *	5.001	2.484	1.247	5.611	0.667	0.795	15.794

Source: Iran Energy Balance, 2003
* 1 US$= 8000 Rials (2003)



Source: International prices from BP Statistical Review of World Energy, 2003; Domestic prices from Ministry of Energy, Iran

Fig. 1. Trend in domestic and international prices ($/bbl)

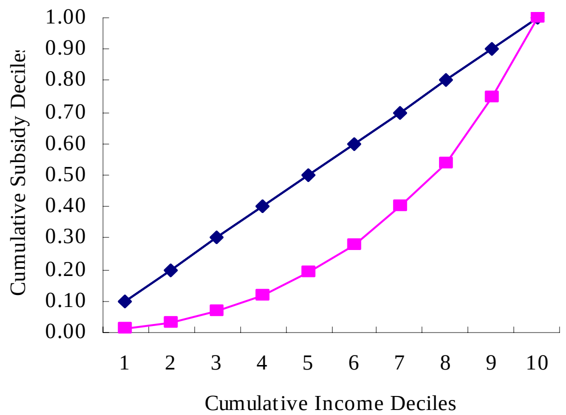
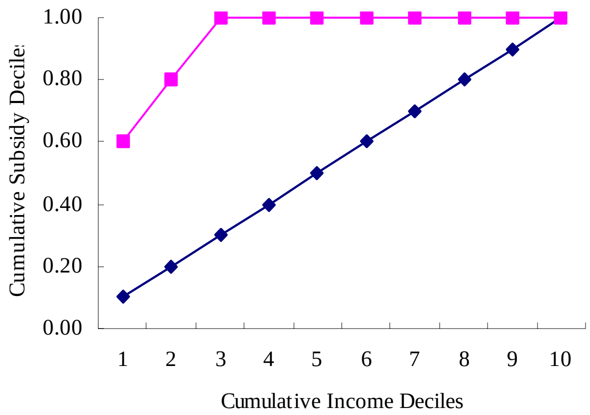


Fig. 2. Lorenz curve for gas oil subsidies



Source: Authors estimates

Fig. 3. Ideal distribution of subsidies

Fig. 3 shows a pattern of Lorenz Curve for an ideal subsidy distribution scheme. The poorest deciles of the population are getting the maximum percentage of subsidies (60%). The next two deciles, which can also be classified as poor, are also getting 20% of total subsidies each. The rest of the income deciles are not eligible for any subsidy. Such a curve would make the Gini coefficient negative. In fact, the most desirable Gini coefficient for a subsidy scheme would be as close to –1 as possible. While the percentage of population falling under each income deciles is not available, it is expected that such a scheme will benefit a large percentage of the population.

The following Table shows the Gini coefficient for subsidy given out by the government for each decile of population.

Table 2. Gini coefficient of subsidy

Fuel	Urban	Rural
Gasoil	0.548	0.432
Gasoline	0.433	0.352
Electricity	0.315	0.035
Natural Gas	0.255	-
Kerosene	0.069	0.188

Viewed in this light, distribution of subsidies in Iran is quite uneven.

MATERIALS & METHODS

Using a Comprehensive Cost Benefit Analysis Model which considers changes in level of social welfare and environmental quality as probable benefits (or costs), the B/C ratio for implementing price reform policy under two scenarios has been analyzed and calculated considering $25/bbl as the reference value for domestic prices of energy forms. Distributional effects of freed resources and inflation caused by price reform are the main concerns of policy makers for the case of eliminating (or reducing) subsidies. The model used to calculate society deadweight lost and also environmental improvement (which is run by MARKAL Software) shows that social benefit - at the end of policy time frame- can efficiently cover any distributional negative effects of running the policy when necessary social institutions are carefully arranged before. The following assumptions/scenarios are considered in the present investigation:

1. The opportunity cost of liquid and gaseous fuels is taken as ½ of the price that the producer will realize by exporting the fuel.
2. International prices of crude oil are assumed to average around $50/bbl ex-AG for the time frame under study.
3. The opportunity cost of electricity is taken as the cost of delivering electricity at the consumer premises.
4. Two scenarios are built for reducing subsidies: Scenario 1 takes the domestic prices to target prices (50% of International prices) by 2010/11 and scenario 2 achieves the same objective by 2015/16.

RESULTS & DISCUSSIONS

Subsidies are a political issue. Hence, it will be very difficult to eliminate the subsidies at once. Therefore feasible policy options on reduction of subsidies would involve gradual increase in prices, to reach international prices over time.

There are two critical variables that this policy option involves:

- Deciding on the opportunity cost of various fuels over the policy time frame.
- Deciding on the time frame of the policy.

The opportunity cost of any good or service is the benefit foregone by not putting that good or service to the best available alternative. Thus, the opportunity cost of capital is the price that it could command if used in next best alternative.

Similarly, the opportunity cost of various fuels considered in this paper, except electricity, is the price that the country would realize if these fuels were sold in the international market. But the international prices of petroleum products are themselves volatile. Thus, targeting to take domestic prices to international parity would mean aiming at a base which it is itself shifting, apart from the uncertainty regarding the future prices of these fuels.

Many international organizations regularly forecast crude oil prices for various purposes. OPEC (Organization of Petroleum Exporting Countries) had set a target band of US$22 - US$28/bbl for prices of crude oil before recent increase in oil prices. The International Energy Agency (IEA) regularly forecasts the crude oil prices in order to understand the demand and supply of petroleum in the market. The agency [ExternE, 2000] has assumed a crude oil price of US$21/bbl by the year 2010, which rises to US$25/bbl by the year 2020. However, for the pursuance of the current objective of reducing subsidy, the year on year volatility in the international prices should not pose a constraint since the policy options being reviewed take a long-term view. Although the oil market has shown different signs during last decade, recent increase in the level of crude oil prices (2004 & 2006); causes any attempt to set international prices of crude oil as a reasonable target for domestic prices in the long-term be politically impossible. Hence, for the purpose of this study reaching to %50 of the predicted international crude oil price has set as the target (US$25/bbl Persian Gulf (Ex-AG)).

Table 3. Target prices of petroleum products (US$/bbl)

Product	Price
Gasoline	28.02
Gasoil	27.92
Kerosene	27.99
Fuel Oil	22.38

The associated target prices of petroleum products are given below (Table 3). So the opportunity cost of each fuel (Gas oil, Gasoline, Kerosene and Fuel Oil) has been calculated as difference between target price and internal price. The opportunity cost of natural gas deserves special attention. There are no global prices of natural gas. Each region has its specific methodology for price discovery that has evolved over time as per the needs of the stakeholders in the region and the competitive scenario. In the USA, for example, in Asia-Pacific, the prices are linked to crude oil, primarily due to the easy substitutability of gas and crude oil in Japanese power plants. Given the existing formula for the LNG pricing in Asia-Pacific, the net target price of LNG is estimated at as US$2.7/MMBtu (Assuming that subtracting the liquefaction costs of US$1/MMBtu). This is taken as the part of long-term opportunity cost of natural gas in Iran, which should be covered.

In the case of electricity because exports do not constitute a major market for Iran, the aim of reducing subsidies is to recover the full cost of delivering electricity at the consumer's premises. Thus, it should include cost of generation, including variable cost and fixed costs of generating power, and the cost of transmission and distribution of electricity.

It is a policy decision in Iran that all increments in electricity generating capacity will be based on natural gas. Thus, the fuel cost of generating power will be derived from the opportunity cost of natural gas. The critical variable is the efficiency of natural gas turbines. Given the long time frame under consideration, the turbine efficiency of 56% is assumed, which is now normally achieved in many countries. Thus, the natural gas requirement translates into 0.18 m^3/kWh and the associated fuel cost comes at Rials 131.63/kWh, valuing natural gas at its opportunity cost.

The next major cost of power generation is the capital costs and the operation and maintenance costs. The capital costs of a typical CCGT averages at Rials 5120 Million per MW. Assuming a PLF of 75%, auxiliary consumption of 3%, life of the plant as 20 years, and a discount rate of 8% gives the annualized capital cost as Rials 91.2/kWh.

Adding the operation and maintenance expenditure of 2.5% of capital cost gives the Total Fixed + O&M cost per unit of power sent out as Rials 111.63/Kwh.

No figures are available on the transmission and distribution costs in Iran. It is assumed that high voltage and low voltage transmission investments of US$15/kW would be required. This capital cost is annualized using the assumptions given above. The capital cost per unit of such network comes at 2.16 Rials/kWh. The level of Transmission and Distribution (T&D) losses in the economy is also an important factor in determining opportunity cost of electricity. The current T&D losses are about 20% while the desirable level is 8%, which the policy should aim at. Reducing T&D losses to this level is not expected to occur overnight. Hence it is assumed that the average T&D losses over the time period of this policy will be 12%.

Thus, the total opportunity cost of electricity in Iran comes at 278.6 Rials/kWh. One important constraint on the time frame for this policy option is the social and political effects which do not permit the prices of goods and services sold by any public enterprise to be raised at once. However, given the existing difference between domestic prices prevalent in Iran and international prices, taking domestic prices to international parity at least at 10% per year would take a long time. For example, in the case of Gas oil, it would take more than 40 years if prices are allowed to rise only by 10% per year to reach international parity price of Gas oil corresponding to the crude oil price of $50/bbl. Policy options with this long a time frame are not feasible as the costs and benefits will be very uncertain and so will be the net benefits expected from the policy. Yet there would be obvious difficulties in amending these social and political limitations. Thus, a middle path has to be found out that meets the social as well as economic objectives.

Table 4. Compounded Annual Growth Rate (CAGR) for prices under two scenarios (%)

Product	Scenario 1	Scenario 2
Gasoline	16	9
Gasoil	39	21
Kerosene	39	21
Fuel Oil	52	28
Natural Gas	45	24
Electricity	18	10

Ideally, the corrections in prices should be completed at least by the end of the Fourth Plan (year 2010-11). However, given the large gap between the domestic and international prices and the constraint on the rate of price increase, this may not be possible as the annual price increases during the Fourth Plan period becomes very high. Therefore the end of the Fifth Plan period (2015/16) is considered as the target horizon in that case. In the alternative, the prices for the products may be increased at a faster rate during the Forth Plan by the year 2010/11.

Accordingly, two scenarios are considered for implementing this policy option. Scenario 1 increases the price with the objective of achieving target prices by the year 2010/11, coinciding with the end of Fourth Plan whereas Scenario 2 has the objective of achieving the same result by the year 2015/16, coinciding with the end of the Fifth Plan. The annual compounded growth rates required under these two scenarios is as follows (Table 4).

The traditional microeconomic theory suggests that there are efficiency gains that accrue to the economy when it moves to the market determined prices. The prices determined in a competitive market promote maximum allocative efficiency in the sense that any movement away from that level is accompanied by reduction in consumer welfare. This gain in efficiency is most clearly evident in reduction of consumption to the efficient level, given a certain price elasticity of demand. Decline in consumption due to increase in prices is the primary mechanism that generates other costs and benefits (The World Bank, June 2000).

The first benefit is the reduction in emissions, both local and global. Burning petroleum fuels gives rise to emissions of harmful gases like CO2, CH4, SO2, N2O, CO and NMVOCs (MOH, 1997). Out of these, some like CO2 and CH4 are green house gases (GHGs) and hence represent global common “bad” (JICA, 1997). Reduction in consumption thus generates benefit for the global community by reducing CO2 emissions. Other gases, like NMVOCs, SO2, N2O and CO are local pollutants and hence reduction in consumption generates benefits primarily the local economy. The damage costs of these gases, as proposed for the Iranian economy (JICA, 1997) are used within the model. This approach - Benefit Transfer - is commonly used to transfer benefit values of reducing pollutants from the source country to study site. All data in source country is achieved by a long term Dose-Response study. The results of main study would be adopted comparing ratio of real income in source country to study country. The income used in the transfer function is calculated by Purchase Power Parity (PPP), which represents different purchase powers in real term (Pearce, 2000). Iran GDP per capita used through analysis has been more than PPP$ 6000 in 2004 (UNDP, 2004).

The second benefit is the increased producer surplus. Increase in prices of various fuels generates producer's surplus from two sources. One is the increased indigenous expenditure on the fuel in question since the elasticity of demand is low. The Office of Energy Planning in the Ministry of Energy estimated the following elasticity of demand for various fuels under consideration [Ministry of Energy, October 2002]. The Table also shows the percentage increase in expenditure on the fuel in question if the prices rise by 1%.

However, this increase in consumer expenditure, which contributes to the producer's surplus is a mere re-distribution of income within the economy and is therefore ignored for the purpose of cost benefit analysis at the economy wide level.

But another source of producer's surplus, which is not generated from within the economy is the additional earnings from exports. If the domestic consumption is progressively checked due to increase in prices and if the production capacity already exists to take care of the unconstrained demand, then the producer will have the opportunity to export the surplus product at international prices [IRI & the World Bank, 1999]. This additional export earning will add to the national surplus. Thus, the second benefit of reducing subsidy is the additional producer surplus due to extra export earnings.

Reduction in demand has a cost in terms of reduced consumer's welfare. However, some percentage of the reduction in the consumer surplus goes to the producer as producer surplus and hence constitutes a redistribution of income. But not all reduction in consumer surplus goes to the producer (Fig. 4).

As shown in Figure 4, the total loss of consumer welfare in moving from consumption point A to consumption point B is P1ABP2. However, the area P1CBP2 represents gain to producer and hence just a redistribution of resources in the economy. Thus, the "deadweight" loss in the economy is represented by the area ABC.

The following are taken as benefits of reduced subsidy under the traditional cost benefit analysis as applied to the current objective:

a. Reduction in CO_2 pollution
b. Reduction in other forms of pollution
c. Additional export earnings

The deadweight loss portion of the reduction in consumer surplus is taken as a cost of reduced subsidy. Since the reduction in demand generates all other costs and benefits, the first step is to determine the base case demand against which the reduced demand will be juxtaposed.

The CAGRs (compounded annual growth rates) of demand for each over the period 1991-92 to 2000-01 are given in Table 6 (The Ministry of Power, 2000 & 2001). One approach would be to project the demand based on these historical CAGRs.

Table 5. Elasticity of demand and increase in expenditure

Fuel	Elasticity	% in exp.
Gasoline	-0.47	0.52
Gasoil	-0.51	0.78
Kerosene	-0.27	0.72
Fuel Oil	-0.21	0.788
Natural Gas	-0.29	0.70
Electricity	-0.34	0.65

Table 6. CAGRs of growth in demand for various fuels (%)

Fuel	CAGR
Gasoline	6.48
Gasoil	2.68
Kerosene	1.31
Fuel Oil	1.51
Natural Gas	8.45
Electricity	5.82

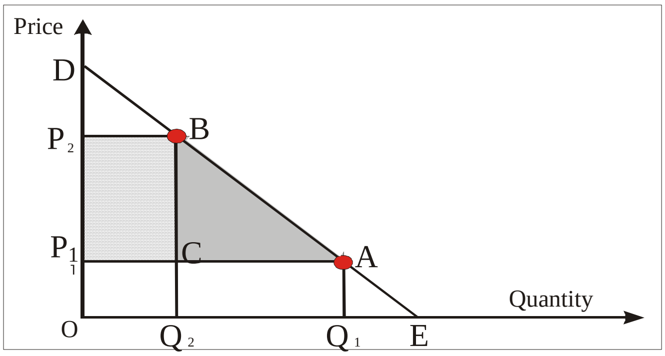


Fig. 4. Reduction in consumer welfare ( ) and deadweight loss ( )

However, this approach implicitly assumes that the major determinants of demand such as the growth rate of GDP will also remain unchanged for the time period under consideration. This is not a realistic, but a rather restrictive assumption to make. The Office of Energy Planning under the Ministry of Energy has assumed the following growth rates for various sectors for the period up to 2005 and beyond [Ministry of Power, October 2002].

- Rate of growth of domestic production - 6% on the average for the third plan and 4% annually for 2005-2021
- Rate of growth of real value added in the industries and the mining sector – 8% on the average for the period 2000-2005 and for the period 2005-2021, it would be proportional to its share in the gross domestic product in 2004
- Rate of growth of value added for the transportation sector – 7% on the average for the period 2000-2004 and for the period 2004-2021, it would be proportional to its share in gross domestic product in 2004.

The GDP elasticity for the demand of fuels under consideration can be gauged from the following demand functions estimated by the Office of Energy Planning.

- Demand function for Gasoline:

LGA = 5.51 + 0.97 LVAT – 0.47 LPGA

o Where, LGA is the logarithm of Gasoline demand, LVAT is the logarithm of value added for transport and storage and communications at fixed prices of the year 1982 and LPGA is the logarithm of real sales price of Gasoline.

- Demand function for Gas oil:

LGO = 3.11 + 0.95 LGDP – 0.51 LPGO

o Where, LGO is the logarithm of demand for Gas oil, LGDP is the real GDP and LPGO is the logarithm of the true sales price of the Gas oil.

- Demand function for Kerosene:

LKE = 1.74 + 0.98 LGDP – 0.27 LPKE

o Where, LKE is the logarithm of demand for kerosene, LGDP is the logarithm of the GDP to the fixed prices of 1982 (real GDP) and LPKE is the real logarithm of the true prices of the sales of kerosene

- Demand function for Fuel Oil:

LFO = 7.08 + 0.49 LVIM – 0.21 LPFO

o Where, LFO is the logarithm of the demand for furnace oil, LVIM is the logarithm of the value added of the industries and mines sector in fixed 1982 prices and LPFO is the logarithm of the real fuel oil prices.

- Demand function for Natural Gas:

LNG = 1.11 LGDP – 0.29 LPNG + 1.40 D68

o Where, LNG is the logarithm of the demand for natural gas, LGDP is the real gross domestic product, LPNG is the real sales price of natural gas and D69 is the figurative variable that explains the expansion of the natural gas network for 1968 onwards

- Demand function for electricity:

LEL = 1.23 GDP – 0.34 LPEL

o Where, LEL is the logarithm of the consumption of the electricity, LGDP is the logarithm of the real gross domestic product and LPEL is the logarithm of the real price of the sales of electricity.

Thus, in this analysis, the base case demand is projected using the demand curves as estimated by the Office of Energy Planning. However, this is also broadly supported by the fact that such projections are not very different from those based on historical CAGRs.

Using these demand functions and the assumptions regarding the growth rates of various components of GDP, as listed above, the following Base Case demand for the various fuels is estimated (Table 7).

Price increase for the years 2003 and 2004 is assumed to be at 10% annually, based on the Third Plan law constraint (IRI, 2001).

The next step is to factor in the two scenarios of price increase in this base case demand to arrive at Modified Demand under the two scenarios.

This is done using the compounded annual average growth rate in prices estimated under the two scenarios and the price elasticity of demands as given above. However, the price increase assumed under Scenario 1 lasts only till the year 2010/11 but the time frame of the policy option is till 2015/16 since the time price increase under Scenario 2 goes up to that year. Thus, for the period 2011/12 to 2015/16 under Scenario 1, the price increase is nil, which effectively raises the demand at the normal growth rate linked to GDP (or its sub-sector as the case may be). The Modified Demand under two scenarios for all the fuels, along with the difference with Base Case demand is given in the following Tables.

Table 7. Base case demand for various fuels

Fuel **Year**	**Gasoline** (bn Bbls)	**Gasoil** (bn Bbls)	**Kerosene** (bn Bbls)	**Fuel Oil** (bn Bbls)	**Natural Gas** (BBOE)	**Electricity** (BBOE)
2003/04	0.117	0.166	0.061	0.095	0.281	0.067
2004/05	0.125	0.175	0.065	0.099	0.300	0.072
2005/06	0.130	0.182	0.067	0.101	0.313	0.075
2006/07	0.135	0.189	0.070	0.103	0.327	0.079
2007/08	0.141	0.196	0.073	0.105	0.342	0.083
2008/09	0.146	0.203	0.075	0.107	0.357	0.087
2009/10	0.152	0.211	0.078	0.109	0.373	0.091
2010/11	0.158	0.219	0.082	0.111	0.389	0.096
2011/12	0.164	0.227	0.085	0.113	0.407	0.010
2012/13	0.170	0.236	0.088	0.115	0.425	0.010
2013/14	0.177	0.245	0.091	0.118	0.443	0.011
2014/15	0.183	0.254	0.095	0.120	0.463	0.011
2015/16	0.191	0.264	0.099	0.122	0.484	0.012

Table 8. Modified demand for gasoline (billion barrels)

Year\Scenarios	**Scenario 1**	**Scenario 2**	**Base**	**Difference 1**	**Difference 2**
2003/04	0.117	0.117	0.117	0.000	0.000
2007/08	0.102	0.117	0.141	0.038	0.024
2011/12	0.094	0.115	0.164	0.070	0.049
2015/16	0.110	0.112	0.191	0.080	0.078

Table 9. Modified demand for gas oil (billion barrels)

Year	**Scenario 1**	**Scenario 2**	**Base**	**Difference 1**	**Difference 2**
2003/04	0.166	0.166	0.166	0.000	0.000
2007/08	0.081	0.137	0.196	0.115	0.059
2011/12	0.048	0.095	0.227	0.179	0.132
2015/16	0.056	0.066	0.264	0.208	0.198

Table 10. Modified demand for kerosene (billion barrels)

Year	Scenario 1	Scenario 2	Base	Difference 1	Difference 2
2003/04	0.061	0.061	0.061	0.000	0.000
2007/08	0.047	0.060	0.073	0.026	0.012
2011/12	0.039	0.054	0.085	0.046	0.031
2015/16	0.046	0.048	0.099	0.053	0.050

Table 11. Modified demand for fuel oil (billion barrels)

Year	Scenario 1	Scenario 2	Base	Difference 1	Difference 2
2003/04	0.095	0.095	0.095	0.000	0.000
2007/08	0.066	0.088	0.105	0.039	0.017
2011/12	0.051	0.072	0.113	0.063	0.041
2015/16	0.055	0.059	0.122	0.067	0.063

Table 12. Modified demand for natural gas (million barrels of oil equivalent)

Year	Scenario 1	Scenario 2	Base	Difference Sc1	Difference Sc2
2003/04	281	281	281	0	0
2007/08	196	282	342	145	59
2011/12	154	258	407	252	149
2015/16	185	235	484	299	248

Table 13. Modified demand for electricity (million barrels of oil equivalent)

Year	Scenario 1	Scenario 2	Base	Difference Sc1	Difference Sc2
2003/04	67	67	67	0.00	0.00
2007/08	78	80	83	5.02	2.83
2011/12	95	97	101	5.91	3.43
2015/16	116	118	122	6.27	4.16

The approach towards valuing the various benefits and costs is detailed in Table 14. Difference between base case Scenario and Modified demands includes export; deadweight losses and reduction in environmental damage costs are calculated by running MARKAL software using transferred values of pollutants.

The future benefits and costs are discounted at an 8% rate to arrive at the Net Present Value (NPV) of each policy option. The Benefit-Cost ratio (BCR) is also estimated to facilitate decision-making. The NPV and BCR of each scenario for each fuel are given below.

Table 14. Present Values (billion Rials) and Benefit-Cost Ratios under Scenario 1

Fuel BC Components	Gasoline	Gas oil	SKO	FO	Natural gas	Electricity
Export earnings	126,626	401,626	97,674	111,676	143,590	11,711
CO_2 benefits	2,907	7,741	1,889	2,629	10,163	829
Local pollution	27,765	74,016	18,056	43,812	13,389	1,067
Deadweight loss	20,748	70,914	17,872	19,776	52,445	7,031
Total Benefits	157,298	483,383	117,619	158,117	167,141	13,607
Total Costs	20,748	70,914	17,872	19,776	52,445	7,031
Net Benefit	136,550	412,469	99,747	138,341	114,697	6,577
B/C	**7.58**	**6.82**	**6.58**	**8.00**	**3.19**	**1.94**

Table 15. Present Values (billion Rials) and Benefit-Cost Ratios (BCRs) under Scenario 2

Fuel BC Components	Gasoline	Gas oil	SKO	FO	Natural gas	Electricity
Export earnings	92,022	269,121	62,354	67,405	80,327	8,483
CO_2 benefits	2,111	5,188	1,205	1,593	5,685	600
Local pollution	20,158	49,605	11,518	26,534	7,490	773
Deadweight loss	9,559	31,466	7,606	7,587	19,166	3,688
Total Benefits	114,291	323,914	75,077	95,532	93,502	9,857
Total Costs	9,559	31,466	7,606	7,587	19,166	3,688
Net Benefit	104,732	292,448	67,471	87,945	74,336	6,169
B/C	**11.96**	**10.29**	**9.87**	**12.59**	**4.88**	**2.67**

As is evident, under Scenario 2, the Benefit-Cost ratios have increased, when compared with Scenario 1, due to the fact that costs are now spread over a longer time horizon and hence have lower present weight-age. At the same time, however, the net benefit from the policy option has reduced when compared with Scenario 1. Figure 5 combines these two measures into one to facilitate the comparison among the policy options.

While the benefits of undertaking all the policies simultaneously will be huge, it is not likely that the government will increase the prices for all products at one go. Thus, decision has to be made regarding which fuel should be targeted first. Table 16 shows the ranking of the policies for price reforms in subsidies as per the BCR.

As is evident, the BCR's are higher under Scenario 2 than under Scenario 1. At the same time, the NPV is higher under Scenario 1 than under Scenario 2. This is because of the fact that though the benefits under Scenario 2 are on an average around 65% of those under Scenario 1, the costs are about 42%.

Table 16. Ranking the benefits for different fuels under two scenarios as per BCR

Policy	NPV (Billion Rials)	BCR
Reducing subsidy on Fuel Oil Scenario 2	87,945	12.59
Reducing subsidy on Gasoline Scenario 2	104,732	11.96
Reducing subsidy on Gas oil Scenario 2	292,448	10.29
Reducing subsidy on Kerosene Scenario 2	67,471	9.87
Reducing subsidy on Fuel Oil Scenario 1	138,341	8.00
Reducing subsidy on Gasoline Scenario 1	136,550	7.58
Reducing subsidy on Gas oil Scenario 1	412,469	6.82
Reducing subsidy on Kerosene Scenario 1	99,747	6.58
Reducing subsidy on Natural gas Scenario 2	74,336	4.88
Reducing subsidy on Natural gas Scenario 1	114,697	3.19
Reducing subsidy on Electricity Scenario 2	6,169	2.67
Reducing subsidy on Electricity Scenario 1	6,577	1.94

As a result, the BCR has risen. And as far as the fall in net benefits under Scenario 2 is concerned, this is because of the discounting applied to arrive at the present value of such benefits. Under Scenario 1, the benefits rise at a faster rate because the reduction in demand is faster. As a result, the benefits achieved under Scenario 2 till the year 2011/12 are lower than what is achieved under Scenario 1. Thus, though the total benefits over the time period remain the same, discounting them means that benefits accruing in the earlier period are given more weight and hence the benefits under Scenario 1 are higher. Coming to the choice of the fuel on which the subsidy should be reduced first, Fuel Oil presents a clear option. Not only is the BCR higher than the rest, the fact that it is not consumed by the households directly means that its direct social cost will be low. Though the net benefit under the option is low, it definitely represents a good choice to start with. Along with the FO, subsidies on Gas oil should also be reduced, which confirms results of other researches (APT,2002).

The choice between Scenario 1 and Scenario 2 not withstanding, reducing subsidies on Gas oil give high net benefit and yield high BCRs. This is also linked to the fact that price increase required in these two fuels to match half of the opportunity cost is also the highest. Gasoline, Kerosene and Natural Gas are next candidates and the period over which price increase will be undertaken for these has to be decided by the executing agency, keeping in mind the above costs and benefits.

Electricity gives surprisingly low benefits but this is due to the relatively less increase in prices required for the fuel to match the unit production cost.

Table 17 ranks the subsidy schemes as per the NPV. The ranking of fuels in this case has changed. The absolute benefits are highest in the case of Gas oil followed by Fuel Oil and then Gasoline, Natural Gas, Kerosene and Electricity in that order. As far as choice between scenario 1 and scenario 2 is concerned, scenario 1 gives higher benefit in case of all the fuels.

Table 17. Ranking the benefits for different fuels under two scenarios as per NPV

Policy	NPV (bn Rials)	BCR
Reducing subsidy on Gas oil Scenario 1	412,469	6.82
Reducing subsidy on Gas oil Scenario 2	292,448	10.29
Reducing subsidy on Fuel Oil Scenario 1	138,341	8.00
Reducing subsidy on Gasoline Scenario 1	136,550	7.58
Reducing subsidy on Natural gas Scenario 1	114,697	3.19
Reducing subsidy on Gasoline Scenario 2	104,732	11.96
Reducing subsidy on Kerosene Scenario 1	99,747	6.58
Reducing subsidy on Fuel Oil Scenario 2	87,945	12.59
Reducing subsidy on Natural gas Scenario 2	74,336	4.88
Reducing subsidy on Kerosene Scenario 2	67,471	9.87
Reducing subsidy on Electricity Scenario 1	6,577	1.94
Reducing subsidy on Electricity Scenario 2	6,169	2.67

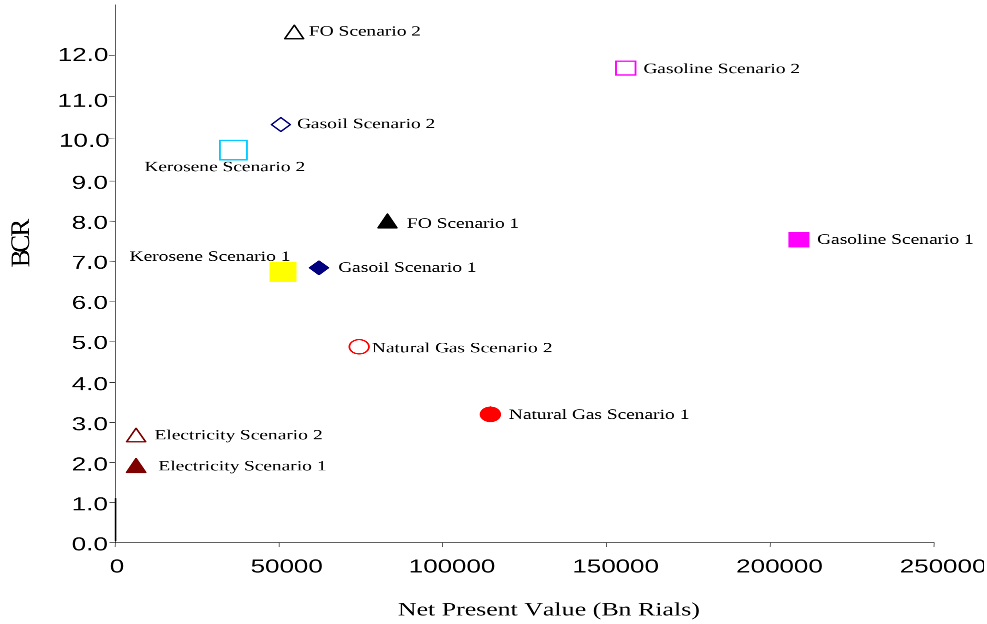


Fig. 5. Comparing the two scenarios

Apart from the benefits evaluated above, the increase in prices will also lead to extra income for the government. However, these represent a re-distribution of income within the economy and they will definitely contribute to the government revenue.

It is not possible with the data available to design a compensation scheme that would give some idea about the net flow of revenue to the government. But the above figures do suggest the range of revenues released for the compensation scheme.

CONCLUSION

This paper estimates the total subsidy to the energy sector in Iran amounted to 126,441 billion Rials in the year 2003, which is 16.68 % of GDP (Table 1) [Statistical Center ofIran,2002]. Based on results extracted from running a model, if the subsidies continue to year 2019, then the subsidy to the energy sector will rise to 20% of GDP. So for the first time in Iran, environmental damage costs caused by air pollution have been assessed and entered the Cost-Benefit Analysis (CBA) in addition to the vast amount of subsidies.

Using a CBA Model which considers changes in level of social welfare and environmental quality as probable benefits (or costs), the B/C ratio for running price reform policy under two scenarios has been analyzed and calculated. The analysis shows that reducing energy subsidies for each energy form is considerably beneficial (Table 17). It is concluded that total present value of energy subsidy avoided under scenario 1 (reducing subsidies by year 2010) would be more than US$112 billion and under scenario 2 (reducing subsidies by year 2015) is US$74 billion (if the oil price of $ 25/bbl is considered). Apart from the environmental benefits -which has been shown in previous researches [TERP, 1997]- the increase in prices which leads to reduction in subsidies paid out by the government, can be a base for a re-distribution of income within the poor deciles of economy and this policy would increase the government revenue and economic growth in long-term.

Table 18. Present value of avoided subsidy (billion Rials)

Fuel	Scenario 1	Scenario 2
Gasoline	119,785	85,878
Gas oil	246,611	173,657
Kerosene	83,597	54,370
Fuel Oil	93,245	56,876
Natural	218,584	137,245
Electricity	141,288	90,711

However, the CBA model developed adopted in this paper has provided the authors with a powerful tool to incorporate any further presumed assumptions or alternatively, take care of possible oil prices fluctuations so that pertinent and reliable appropriate responses may be achieved.

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