

An analysis of Energy Price Reform: A CGE Approach

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Abstract:

The energy industry is regulated and owned by the central government in Iran. Energy and specially electricity is also priced below the production costs. During recent years, the government has financed the gap between production cost and consumer-paid price. As the government revenue is heavily depends on the oil prices, it is no longer sustainable to manage the energy sector through government budget due to extreme volatilities in crude oil prices .

Fixed subsidized nominal price of energy, despite rapidly growing energy demand, has led to a heavy budgetary burden especially during the low oil prices. Budgetary constraints, efficiency concerns in the industry, and necessity of deregulation, altogether enforce the government to restructure the energy industry from state-oriented to a market-oriented one.

Energy subsidy reform highly increases the prices causing hyperinflation. We develop a Computable general equilibrium model based on a modified Micro Consistent Matrix (MCM) with implicit subsidy and implicit specific factor to assess the consequences of the policy. The results indicate that the policy reduces the activity level of all the sectors except services (the least energy intensive sector); on the demand side the results show a crowding out effect toward goods that government demands more; rural and urban welfare decreases by 13% and 12% respectively; and the price index increases by about 40%.

Keywords:

Computable General Equilibrium models, Energy Price Reform, Iran

JEL:

C68, D50, D58, Q48

1- Introduction

The structure of energy industry is highly regulated in Iran. Only the state owned companies are allowed to produce, transmit and sometimes distribute energy to retail customers. The government sets the price in the market , which there is no competition.

During the past decade, the government set the energy price under its production costs. The gap between consumer-paid price and production costs is subsidized by the government by using its vast oil export revenues. This kind of regulation of natural monopoly led to a high budget deficit especially during low oil prices. In recent years, efficiency considerations plus budgetary constraints made the government to restructure the regulation of the electricity market.

Table 1: Implicit subsidy on energy use, 2008 (domestic prices over export prices)

	Ratio of export price to domestic price	Subsidy rate based on domestic price	Subsidy rate based on import price
Electricity	3.2	227%	69.44%
Gas	7.0	600%	85.71%
Gasoline	2.4	140%	58.33%
Kerosene	9.0	809%	89.00%
Gas oil	9.0	809%	89.00%
Fuel Oil	8.8	784%	88.69%
Liquid Gas	37.9	2797%	96.55%

Overall subsidies are estimated at about 27 percent of GDP in 2007/08. The implicit government lost (quasi-fiscal expenditure) is estimated \$32 billion (11 percent of GDP) by under-pricing crude oil and its derivatives in the domestic market in 2007/08 (IMF , 2008). In recent years, efficiency considerations plus budgetary constraints made the government to restructure the regulation of the energy market. Therefore, the full-regulation policy has shifted to an energy taxation strategy.

In recent years, the topic of less intervention in electricity markets has received a great deal of attention. After a policy shift toward less government intervention in the economy, the industry has begun a period of radical change. The first change in the electricity industry was the competitive contracting for wholesale power. At first, the barriers to entering to the market are eliminated and the private sector got the permission to enter to the production of electricity .To date, there are constant increases in the private sector plants of electricity production.

The second change comes in the pricing scheme. The restructuring policy sets the subsidy-free and competitive prices, which is expected to increase the average domestic prices and finally decrease the high electricity consumption. There are two kinds of subsidies in the industry: the implicit subsidy at the production stage on input prices (cheap oil and gas); and the explicit subsidy at the distribution stage on the retail prices. The government intends to remove both kinds of subsidies to have a less regulated, more efficient, competitive industry.

Table 2: Central Government Expenditure on Subsidies in Selected Oil-Producing Countries, 2002–07 (In percent of central government expenditure)

	2002	2003	2004	2005	2006	2007
Azerbaijan	24	23.1	24	23.5	18	18.1
Bahrain	8.9	8.8	9.9	11.4	10.2	12.5
Iran	12.4	13.3	13.3	15.5	15.8	16.8
Kuwait	25.3	25	28.9	30.3	44.1	38
Libya	4.4	6	5.9	7.1	7.2	6.7
Oman	2.6	3.5	4.2	6.3	5.4	6
Saudi Arabia	2.6	4	5.2	4.5	5.3	4.4
Syria	18.1	15.1	16.6	17.5	19.8	22.5

Source: IMF Country Report No. 08/285. (IMF , 2008).

In current stage, the government still, is the only buyer of the private sector electricity production. As the distribution is completely run by state-owned companies, the government is the only supplier to the final and intermediate consumers. Thus, as far as modeling concerns, we may have two different approaches in modeling the electricity industry under proposed policy: 1) we can consider the extra income generated as the a monopoly revenue; thus we have no more the well-known zero-profit condition of the standard CGE models. In this approach, we should consider government as an agent who receives markup revenue as monopoly profit. 2) The other approach is to assume the current policy as some sort of tax policy. The advantage of this approach is that we still could assume that the government is a non-profit organization, which seeks to maximize the social welfare function. Furthermore, in this approach, there is no need to relax the zero profit assumption. Therefore, it is not necessary to consider markup revenue.

The energy markets restructuring reflect a broader desire to improve the efficiency of electricity markets; however, policy-makers concern over the massive price increase and its impacts on consumers and producers. The question of how much the new pricing mechanisms impact the households consumption and expenditures and production of other goods and services is a matter of importance to policy-makers. This paper develops a CGE model to study the different energy pricing and taxation policies in Iran as a special case of an oil producing country.

Policy makers seem sensitive to the issues involved in energy taxation, but little is known about the effects of such policies. Different analyses of energy policy in general and energy taxes in particular focused on the effects on consumers in the form of higher prices and on energy producers in the form of lower revenues. The former have typically been considered regressive, as the poor spend a greater fraction of their income on direct purchases of energy than do the wealthy (Herendeen, 1974). However, the majority of energy is used in the production of goods and services, rather than in direct use by households. A different pattern of energy use across income classes emerges, when this indirect consumption of energy is taken to account.

2- Literature review

In the general economic equilibrium model, producers and consumers are assumed to take prices as given for their inputs and outputs. A market equilibrium solution is reached when the demand and supply are equal at an equilibrium price. The mathematical properties of this model provide a rich and powerful foundation for much of modern microeconomic theory. Prior to 1980s, in many practical applications it was difficult to develop the data, and formulate and solve the equations required to implement the model of general economic equilibrium (Weyant (1985)). To date, advanced optimization algorithms and computer technology allow us to analyze the wide range of energy policies using the CGE approach.

Much of the discussion about the impacts of energy policy focuses on the efficiency in energy production, incentives to explore and produce, and so forth. The impacts of energy taxes on the energy sector will also have consequences on labor and capital incomes, but given the comparative magnitudes of the energy and goods and services production, this is not likely to be a major source of backward shifting. Energy taxes will distort input choices in the production of goods, and altering demands for factors. These will also lead to changes in the composition of output, which also has the potential to affect factor incomes (Solow, 1985).

The pervasiveness of energy in the economy and the numerous ways in which energy taxation can distort resource allocations implies the necessity of a general equilibrium approach. There are some good CGE exercises in modeling power production. Kerkelä(2004) analyses recent moves of the Russian Dumas to boost gas and electricity prices to bring them into line with the market-based pricing in a GTAP based CGE model.. Holmøy (2005) derives a general equilibrium demand function for electricity by imposing a specific closure rule on a large CGE-model of the Norwegian economy. Yusuf & Resosudarmo (2007) run a various counter-factual scenarios analysis of the massive fuel price increase carried out in a CGE model for Indonesia. There are some other studies which evaluate the energy policy measures with emphasis on special issues like employment (Küster, Ellersdorfer, and Fahl (2007)), equity (Yusuf and Resosudarmo (2007)), climate change (Paltsev and Jacoby (2004)) efficiency (Böhringer, (2006)), renewable energies (Rutherford, Böhringer, & Hoffmann, (2006)) among others.

There are several CGE exercises for Iranian economy but few addressed energy sector. World

Bank reports a policy analysis of energy price distortions in Iran (Jensen & David, (2002)). They estimated that the combined fiscal impact of all the reforms (including non-tariff barriers and subsidies) is to be an increase by 18.5 of GDP. The surplus generated by the reforms presents great opportunities to help the poor with direct income payments. They found that despite the fact that many of the policy interventions are rationalized as support for the poor, direct income payments, even if not targeted to the poor, have the potential to increase the income of the poor compared with the market interventions that prevail. Economic Modeling Team (EMT) develops a CGE model to analyze the effect of an increase in energy export revenue on the dwelling prices due to oil price rise, the well-known Dutch disease effect (Haqiqi & Zahedi, (2009)). Other papers with CGE approach took no notice to energy sector.

The next section lays out the general structure, and data sources of the model And Section nine concludes the paper.

3- Data and Model description

Modified Micro Consistent Matrix

We employ a small open economy computable general equilibrium model of the Iranian economy. The data source is mainly 2001 Micro Consistent Matrix (MCM) constructed for energy analysis in MOE (Ministry Of Energy). The current model includes 18 production sectors, rural and urban household and government plus import and export. The three main principles of CGE models are employed: market clearance, income balance and zero profit condition for each sector¹.

The key modeling features that distinguish this paper from CGE modeling exercises is that we consider an implicit specific-factor in the model. In addition to the mobile capital that can be used in any sector without adjustment costs and sector-specific capitals we have an energy sector implicit specific-capital namely ownership of the mineral resources in oil extraction and gas.

In those oil producing countries that government owns the oil and gas resources, the IO and SAM data ignores the role of this capital on the production. It is added in the MCM table constructed for MOE.

Table 3 shows the common MCM table structure is a modified version of traditional Social Accounting Matrix (SAM). Positive numbers represent the value of commodity flows into the economy (sales, factor supplies, received subsidy or tax revenue), while negative numbers represent the value of commodity flows out of the economy (factor demands, final demands, tax payment). With this interpretation, a row sum is zero if the total amount of commodity flowing into the economy equals the total amount of commodity flowing out of the economy. This is market clearance, and one such condition applies for each commodity in the model.

¹ For more information about energy modeling in CGE, see (Küster, Ellersdorfer, & Fahl, 2007).

Columns in this matrix correspond to production sectors or consumers. A production sector column sum is zero if the value of outputs equals the cost of inputs. A consumer column is balanced if the sum of primary factor sales equals the value of final demands.

In the simplified model of this paper, there are two sets of produced commodities: energy and non-energy (en and g); set of factors of production (f); set of non-energy sectors (sa); set of energy sectors (se); set of consumers (ra); and government (gvt).

Table 3: Sample MCM (explicit payments only)

		non energy	energy	representative agent	government
	Indices	sa	se	ra	gvt
non energy	g	+(g,sa)	-(g,se)	-(g,ra)	-(g,gvt)
energy	en	-(en,sa)	+(en,se)	-(en,ra)	-(en,gvt)
factors	f	-(f,sa)	-(f,se)	+(f,ra)	+(f,gvt)
tax/subsidy	tax	-(tax, sa)	-(tax,se)	-(tax, ra)	+(tax, gvt)

The implicit subsidy is calculated by the difference between domestic price and export price. So the implicit payment for each energy good for each agent is:

$$\text{implicit energy demand} = \text{explicit energy payment(en)} * \frac{px_{en}}{pd_{en}}$$

Thus the implicit subsidy on the energy for each sector is given by:

$$\text{implicit subsidy} = \text{explicit energy payment(en)} * \left(\frac{px_{en}}{pd_{en}} - 1 \right)$$

And the implicit subsidy rate is:

$$\text{implicit subsidy rate(en)} = \frac{\left(\frac{px_{en}}{pd_{en}} - 1 \right)}{\frac{px_{en}}{pd_{en}}}$$

The implicit subsidy should be added in non energy sectors and representative agent to ensure zero sums of respective columns.

As The items of demand for energy changes, the energy supply should be changed accordingly to ensure zero sum of energy row. The implicit value of energy supply should only be calculated for domestically sold energy (because the exported energy price is not subsidized). for the sample table which has no export it is:

$$\text{implicit domestic energy supply value} = \text{explicit domestic energy sells(en)} * \frac{px_{en}}{pd_{en}}$$

This increase in the energy column should be paid implicitly to the specific factor that government supplies. This modified version of MCM data is used for analyzing implicit subsidy removal policy.

Table 4: Sample MCM with implicit subsidy and specific factor in energy

		non energy	energy	representative agent	government
	Indices	sa	se	ra	gvt
non energy	g	+(g,sa)	-(g,se)	-(g,ra)	-(g,gvt)
energy	en	-(en,sa) * px_{en}/pd_{en}	+(en,se) + Σ	-(en,ra) * px_{en}/pd_{en}	-(en,gvt) * px_{en}/pd_{en}
factors	f	-(f,sa)	-(f,se)	+(f,ra)	+(f,gvt)
tax/subsidy	tax	-(tax,sa)	-(tax,se)	-(tax, ra)	+(tax, gvt)
implicit subsidy	isb	+ $\Sigma(en,sa)*(px_{en}/pd_{en}-1)$	0	+ $\Sigma(en,ra)* (px_{en}/pd_{en}-1)$	+ $\Sigma(en,gvt)* (px_{en}/pd_{en}-1)$
specific factor	sf	0	- Σ	0	+ Σ

$$\Sigma = (px_{en}/pd_{en} - 1)(\Sigma(en,sa) + \Sigma(en,ra) + \Sigma(en,gvt))$$

*px stands for export price and pd stands for domestic price.

4- Income flow of the economy, Sectors and tax structure

Applied general equilibrium models are characterized by a comprehensive perception of the circular flow of the economy. Figure 1 illustrates the major economic activities modeled in our analysis. For the sake of completeness, we put all implicit and explicit taxes and subsidies in the figure 1.

Production is modeled by nested, linear homogeneous CES production functions, which relate production factors according to elasticities of substitution. Production factor inputs are weighted by a particular share parameter(öhringer, 2002). The sum of share parameters equates to unity, which reflects constant returns to scale. Factors are related to one another by constant factor substitution elasticities².

² For detailed information about energy production functions in CGE see (McDonald & Tlhalefang, 2001).

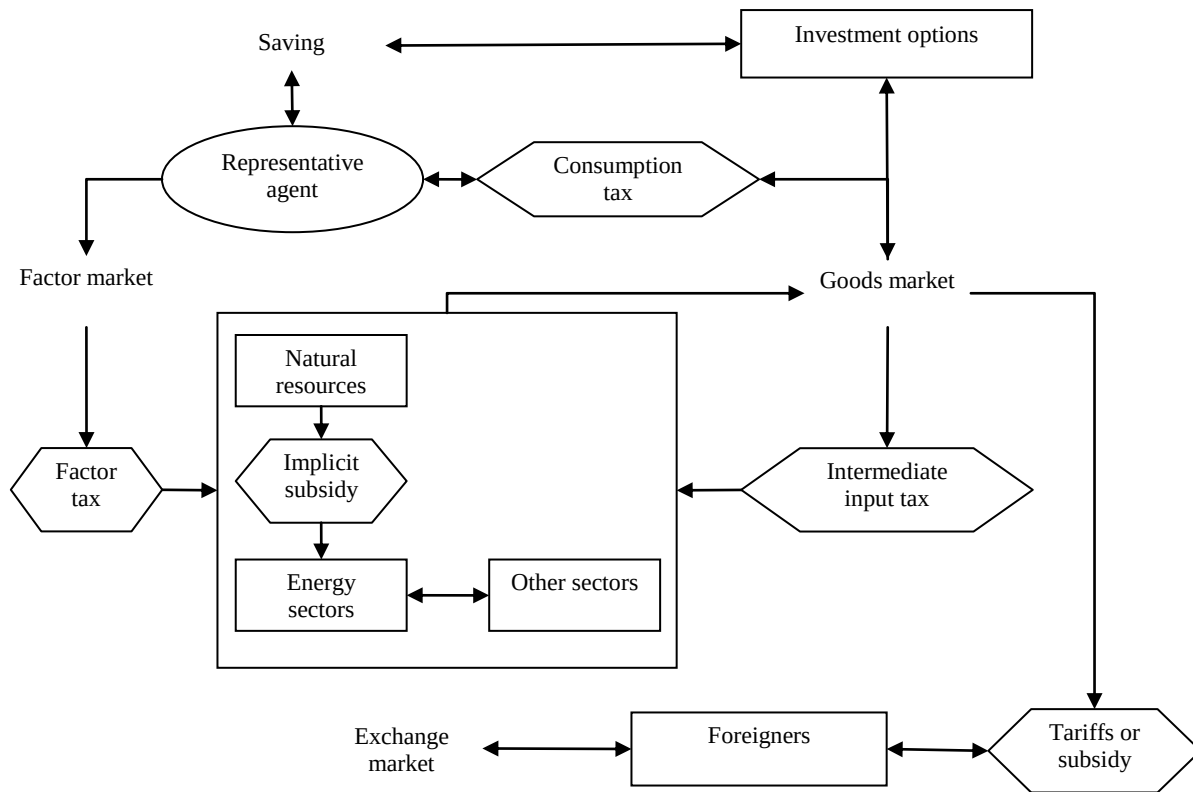


Figure 1: Taxes and subsidies in the economy

The idea of this paper is taking into account the implicit subsidy beside the explicit subsidy that is a case for some of the oil producing countries. As the oil sector is state owned in Iran, the government sells the oil and gas to the refineries at a very low price, due to low costs of oil production. We assume this as an implicit subsidy on the oil and gas input for production sectors. Therefore, we consider some kind of implicit subsidy on the benchmark data. On the other hand, we assume an implicit rent payment to the specific capital on the oil and gas-producing sectors to ensure the zero profit condition for oil sector and income balance of government. Although actually there is no physical payment, but this approach allows us making policy scenarios over these implicit taxes and subsidies.

We consider the production sectors in four categories: Oil and gas sector, Energy sectors, Energy intensive sectors (transportation, metals, etc) and other sectors listed in table 5. In all the sectors, zero profit condition exists. However, tax structure in each sector is different. In the oil and gas sector, implicit tax is levied on the output. In energy sectors, implicit subsidy is assumed on the gas and oil inputs. In other sectors the explicit subsidy is on the input goods but the tax is levied on the factors of production (labor and capital). Primary factors of production are capital and labor.

Table 5: Activities and commodities in the model

Categories	Sectors	Products (in joint production)
Natural resources	Crude Oil and Natural Gas Coal	
Energy sectors	Energy Industry	Gasoline Kerosene Gasoil Fuel Oil Liquid Gas Gas Other Refineries
	Electricity	
Energy intensive sectors	Iron stone Copper Mines Glass producing	
	Manufacturing	Brick Cement Plaster Non-Metal Manufacturing Iron and Steel Copper Aluminum Other Metals Machineries and equipments
	Transport, Rail	Transport Services, Rail Passenger Transport Services, Rail Cargo
	Passenger Transport, Road Cargo Transport, Road Transport, Pipe Transport, Sea Transport, Air Transport Supports	
Other sectors	Agriculture and Animal Husbandry Water Services and less energy intensives	

Activity's output is produced using aggregate non-energy intermediate goods, aggregate energy and primary inputs. For a general description of the model one may abstract from specific nesting structures to show that for each sector s the zero profit condition is given by:

$$\left(\sum_i \alpha_i^s (ps_i (1 - to_i))^{1-\tau_s} \right)^{\frac{1}{1-\tau_s}} = \left[\alpha_f^s \left(\sum_f \theta_f^s (w_f (1 + tw_f^s))^{1-\lambda_s} \right)^{\frac{1}{1-\lambda_s}} + \alpha_j^s \left(\sum_j \theta_j^s (p_j (1 + ti_j^s))^{1-\beta_s} \right)^{\frac{1}{1-\beta_s}} + (1 - \alpha_f^s - \alpha_j^s) (p_{ele} (1 - se_{el}^s))^{\theta_{el}^s} \left[\left(\sum_{ne} \theta_{ne}^s (p_{ne} (1 - se_{ne}^s))^{1-\eta_s} \right)^{\frac{1}{1-\eta_s}} \right]^{\theta_{nele}^s} \right]$$

Where p_i , p_j , p_e and w_f are supplier price of commodities, domestic price of goods, energy input prices, and factors prices; Moreover, to, ti and tw are taxes on output goods, intermediate inputs and factors of production; s_e stands for implicit energy subsidy in each sector. Production inputs and joint products are weighted by a particular share parameter α . The sum of share parameters equates to unity, which reflects constant returns to scale within inputs and constant elasticity of transformation within joint products³. In each nested level, θ shows the share parameters in composite or aggregate input. Accordingly, the nested structure may be shown by figure 2.

5- Import of goods and tariff structure

Domestic consumption of some of the energy goods are much more than domestic production. Therefore, import is needed in some cases. As the government fixes the domestic price under international prices, these imported energy goods should be subsidized. We have a huge explicit subsidy on imported gasoline and gasoil during the recent years.

As we have re-export of some imported goods, we applied a modified version of Armington aggregator. In the Armington formulation, we assume that import and domestic production are pooled and the output will be the export and domestic consumption.

Therefore there is no necessity to consider imported goods and domestically produced in nested production functions. For each commodity, we can write:

$$\left(\gamma_g^{ps} (ps_g)^{1-\varphi_g} + \gamma_g^{pm} (pm)^{1-\varphi_g} \right)^{\frac{1}{1-\varphi_g}} = \left(\mu_g^{px} (px)^{1-\omega_g} + \mu_g^{pj} (p_g)^{1-\omega_g} \right)^{\frac{1}{1-\omega_g}}$$

Where ps , pm , px , p stands for production price, import price, export price and consumer price of good g .

You can write the aggregator for energies putting e index for parameters of prices⁴.

As you can see the producer price is not the same as demander price in the economy. This assumption made to ensure transportation and wholesale value added to producer price are modeled correctly.

³ As we consider joint production in some sectors, the CET is assumed for output commodities.

⁴ Thus for energies, we have:

$$\left(\gamma_e^{ps} (ps_e)^{1-\varphi_e} + \gamma_e^{pm} (pm)^{1-\varphi_e} \right)^{\frac{1}{1-\varphi_e}} = \left(\mu_e^{px} (px)^{1-\omega_e} + \mu_e^{pj} (p_e)^{1-\omega_e} \right)^{\frac{1}{1-\omega_e}}$$

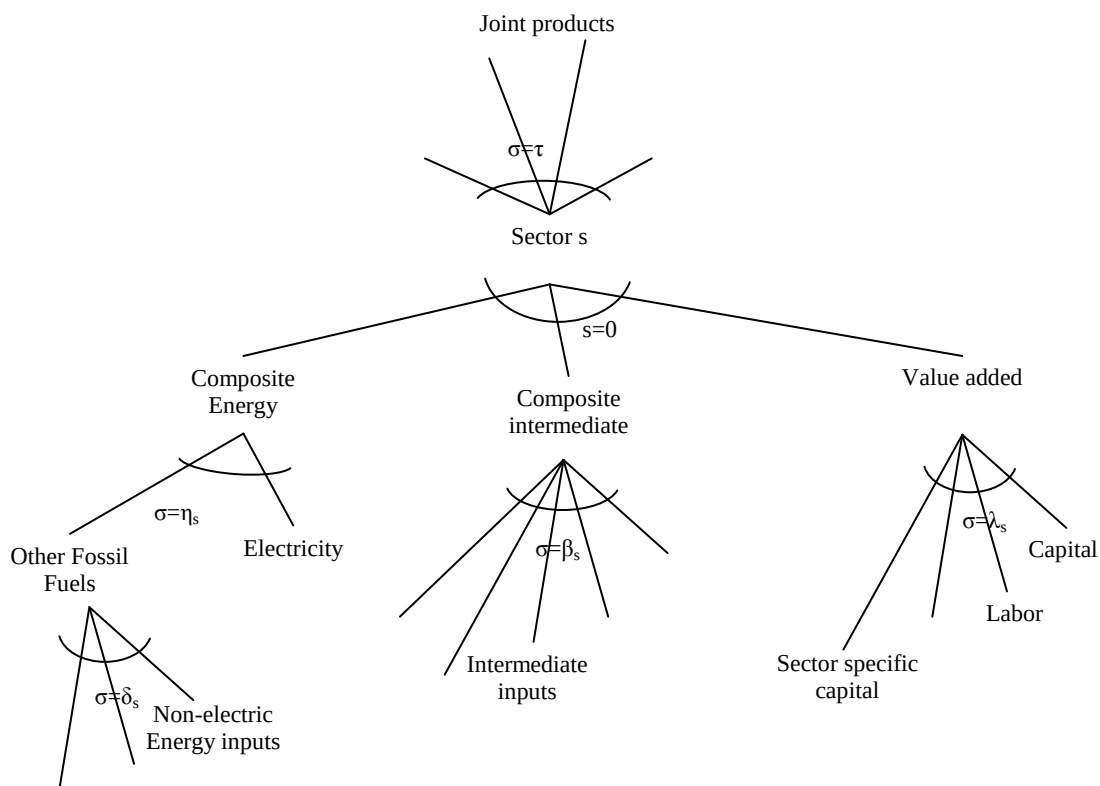


Figure 2: Nesting in production

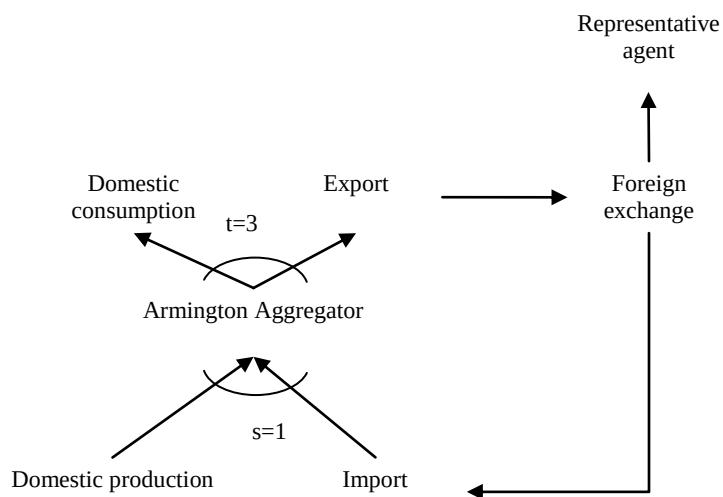


Figure 3: Nesting in Armington aggregator

6- Utility structure

A representative household purchases a bundle of goods and services. Utility is generated through consumption of goods and services in addition to saving in a static model. Saving is exogenously given by a fixed saving rate. Time does not enter the utility function and leisure is not considered.

Consumption is limited through an income restriction for the representative household whose endowment of labor and capital is fixed.

$$W_h = \left[\alpha_{sa}^h S + \alpha_j^h \left(\sum_j \theta_j^h (p_j)^{1-\beta_h} \right)^{\frac{1}{1-\beta_h}} + \right. \\ \left. (1 - \alpha_{sa}^h - \alpha_j^h) (p_{ele})^{\theta_{el}^h} \left[\left(\sum_{ne} \theta_{en}^h (p_{en} (1 - se_{en}^h))^{1-\eta_h} \right)^{\frac{1}{1-\eta_h}} \right]^{\theta_{nele}^h} \right]$$

Where p_j , p_{en} and p_{ele} are domestic price of non-energy goods, non-electricity energy, and electricity; se_{en} stands for implicit energy subsidy for households. Energy aggregates and non-energy aggregates are weighted by a particular share parameter α . In each nested level, θ shows the share parameters in aggregate bundle. Figure 4 provides a graphical exposition of the final consumption structure.

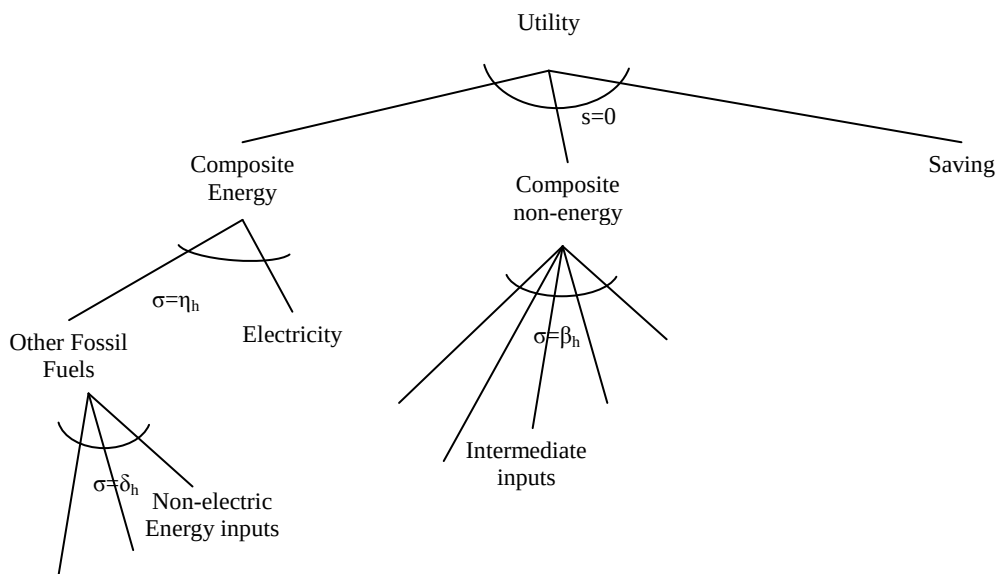


Figure 4: Nesting in utility

7- Results

We investigate the economic impacts of removing the implicit subsidy on electricity and other energies both from domestic production and imported energy goods. We are going to analyze the effects of policy on four areas: output and resource allocation; welfare; price levels and aggregate price index. The initial subsidy rates are listed in table 6. The policy aims to make the rates equal to zero.

Table 6: Implicit energy subsidy at the benchmark

Energies	Initial subsidy rate
Electricity	69.44%
Gas	85.71%
Gasoline	58.33%
Kerosene	89.00%
Gasoil	89.00%
fuel Oil	88.69%
Liquid Gas	96.55%

Output effect

After removing the subsidies, one of the most important expectations is activity deterioration. Direct consequence of removing implicit and explicit subsidies is fall in activity due to the rise of input prices. The more a sector benefiting from energy subsidy the more increase in costs and the more decline in activity. We call this as shrinking effect (Table 7).

We also expect a crowding out effect, due to a change in the supply and demand structure of the whole economy. At the demand side, as the public sector demand portfolio is quite different from private sector, transferring the policy revenue to government will shift the demand toward publically more desired commodities like education services, defense, etc. In addition, at the supply side, the distribution of resources in the economy shifts toward less energy intensive sectors like services.

Table 7: Shrinking effect and crowding out effect of removing implicit energy subsidies

Activities	Percent of change in activity level
Transport, Sea	-24.46
Transport, Pipe	-14.85
Ironstone	-14.62
Coal	-13.60
Glass	-12.33
Transport, Air	-11.87
Copper Mines	-11.79
Manufacturing	-11.67
Electricity	-10.86
Agriculture and Animal Husbandry	-9.54
Passenger Transport, Road	-9.49
Water	-8.00
Transport, Rail	-7.35
Cargo Transport, Road	-5.42
Energy Industry	-3.91
Crude Oil and Natural Gas	-1.07
Transport Supports	0.41
Services and less energy intensives	5.52

Inflationary effect

Cutting energy subsidies will increase the domestic prices from two channels. 1) Real energy cost in production will increase due to subsidy cut. 2) However nominal energy prices is not changed by initial subsidy removal, but as energy sectors are using energy inputs themselves, therefore, cost of energy production will go up and then nominal energy price increases (table 8).

Welfare effect

On the consumer side, the expected consequence of removing energy subsidy is a welfare reduction, which involves a change in consumption behavior. A very complex interaction of income effects and substitution effects will happen on both energies and non-energies. After subsidy removal, consumer price index will grow from 76% to 84% in different elasticities. Urban and rural welfare decreases by 12% and 13% respectively (table 9).

Table 8: Price index changes due to of removing implicit energy subsidies

Percent of change in price level	
Transport Services, Pipe	108
Transport Services, Sea	98
Transport Services, Rail Passenger	84
Plaster	71
Cement	68
Brick	62
Non-Metal Manufacturing	54
Copper	54
Water	53
Transport Services, Air	53
Glass Products	51
Other Mine	50
Other Metals	48
Transport Services, Rail Cargo	43
Transport Services, Road Passenger	43
Transport Services, Road Cargo	40
Agricultural Related Goods	39
Coal	38
Aluminum	38
Iron and Steel	37
Iron Stone	36
Other Services	36
Transport Support Services	32
Agriculture and Animal	30
Copper Stone	30
Machineries	29
Crude Oil	23
Natural Gas	20
Other Refineries	19

Table 9: Welfare effect of removing implicit energy subsidies

Percent of change in welfare level	
Rural household welfare	-12.88
Urban household welfare	-12.34
Welfare index	-12.47
Consumer price index	40.79

Table 10: Initial and final energy price change due to removing implicit energy subsidies

	Initial price increase	Final price increase (equilibrium)
Electricity	227%	250%
Gas	600%	610%
Gasoline	140%	162%
Kerosene	809%	815%
Gasoil	809%	821%
fuel Oil	784%	784%
Liquid Gas	2797%	2808%

8- Sensitivity analysis

We provided a detailed point estimate assessment of the alternative scenarios for substitution elasticity differentiation under central case assumptions. We have done a number of additional calculations to understand how changes in key elasticities affect our conclusions. As you will see later, our results remain robust⁵.

In the main case the substitution elasticity between non-energy intermediate goods is set to 0; the Armington elasticity of substitution between the domestic supply and the export is set equal to 3.0; and Substitution elasticity between electricity and other energies composite assumes to be 1.0. In the sensitivity analysis we let the parameters to change to 0.5, 1.0, 0 respectively.

⁵ See the appendix.

9- Summary and conclusion

The idea of this paper is taking into account the implicit subsidy beside the explicit subsidy that is a case for some of the oil producing countries. As the oil sector is state owned in Iran, the government sells the oil and gas to the refineries at a very low price. We assume this as an implicit subsidy on the oil and gas input for production sectors. On the other hand, we assume an implicit rent payment to the specific capital on the oil and gas-producing sectors in addition to the mobile capital; we have an energy sector specific capital namely ownership of the mineral resources in oil extraction and gas. This paper establishes a CGE/MPSGE model based on the MCM table with these specifications for a small open economy of Iran.

The model applied for the quantitative analysis of an energy price reform in Iran, addressing implicit subsidy removal. By removing the subsidy, we found four different effects: shrinking effect of activities, crowding out effect toward publically interested sectors, welfare decrease and price increase. With sensitivity analysis, in which we consider different elasticity parameters in production and trade, we found the results are robust.

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Appendix A:

Let's state our main assumptions and introduce the notation:

- Nested separable constant elasticity of substitution (CES) functions characterize the use of inputs in production. All production exhibits non-increasing returns to scale. Goods are produced with capital, labor, energy and material (KLEM).
- A representative agent (RA) is endowed with two primary factors: labor and capital. The RA maximizes utility from consumption of a CES composite subject to a budget constraint with fixed saving. The aggregate consumption bundle combines demands for energy and non-energy commodities. Total income of the RA consists of factor income and taxes (including carbon tax revenues).
- Supplies of labor, capital and our specific factor are exogenous.
- Constant elasticity of transformation functions (CET) characterize the differentiation of production between production for the domestic markets and the export markets. Regarding imports, nested CES functions characterize the choice between imported and domestic varieties of the same good (Armington).

Three classes of conditions characterize the competitive equilibrium for our model: zero profit conditions, Income balances and market clearance conditions. The former class determines activity levels and the first determines price levels.

Differentiating the profit function with respect to input and output prices provides compensated demand and supply coefficients (Shepard's lemma), which appear subsequently in the market clearance conditions. We use g as an index for commodities (aliased with i for sector output, j for input intermediates). The label en represents the set of energy goods and the label f denotes the set of factors. Following tables explains the notations for variables and parameters employed within our algebraic exposition.

Production sectors; for each sector we have (s)

$$\begin{aligned} \Pi^s = & \left(\sum_i \alpha_i^s (p s_i (1 - t o_i))^{1-\tau_s} \right)^{\frac{1}{1-\tau_s}} - \\ & \left[\alpha_f^s \left(\sum_f \theta_f^s (w_f (1 + t w_f^s))^{1-\lambda_s} \right)^{\frac{1}{1-\lambda_s}} + \alpha_j^s \left(\sum_j \theta_j^s (p_j (1 + t i_j^s))^{1-\beta_s} \right)^{\frac{1}{1-\beta_s}} + \right. \\ & \left. (1 - \alpha_f^s - \alpha_j^s) (p_{ele} (1 - s e_{el}^s))^{\theta_{el}^s} \left[\left(\sum_{en} \theta_{en}^s (p_{en} (1 - s e_{en}^s))^{1-\eta_s} \right)^{\frac{1}{1-\eta_s}} \right]^{\theta_{nele}} \right] = 0 \end{aligned}$$

Modified Armington aggregate; for each good we have (g):

$$\Pi^{ar} = \left(\mu_g^{px} (px)^{1-\omega_g} + \mu_g^{pg} (p_g)^{1-\omega_g} \right)^{\frac{1}{1-\omega_g}} - \left(\gamma_g^{ps} (ps_g)^{1-\varphi_g} + \gamma_g^{pm} (pm)^{1-\varphi_g} \right)^{\frac{1}{1-\varphi_g}} = 0$$

Welfare block (w) for households:

$$W_h = \left[\alpha_{sa}^h S + \alpha_j^h \left(\sum_j \theta_j^h (p_j)^{1-\beta_h} \right)^{\frac{1}{1-\beta_h}} + \right. \\ \left. (1 - \alpha_{sa}^h - \alpha_j^h) (p_{ele})^{\theta_{el}^h} \left[\left(\sum_{ne} \theta_{en}^h (p_{en} (1 - se_{en}^h))^{1-\eta_h} \right)^{\frac{1}{1-\eta_h}} \right]^{\theta_{nele}^h} \right] E_h$$

Export

$$Pfx.XL - \sum p x_g.XL_g = 0$$

Import for each good

$$pm_g.ML_g - Pfx.ML_g = 0$$

Market clearance conditions

Market for Factors of production (f)

$$EN_f = \sum AL_s \frac{\partial \Pi^s}{\partial w_f}$$

Market for Domestically consumed commodities (p_g)

$$AL_{ar} \frac{\partial \Pi^{ar}}{\partial p_g} - \sum AL_s \frac{\partial \Pi^s}{\partial p_g} = 0$$

Market clearance for domestically produced (ps)

$$AL_s \frac{\partial \Pi^s}{\partial ps_g} - AL_{ar} \frac{\partial \Pi^{ar}}{\partial ps_g} = 0$$

Market clearance for imported goods (px)

$$AL_{ar} \frac{\partial \Pi^{ar}}{\partial px_g} - px_g \cdot XL_g = 0$$

Market clearance for exported goods (pm)

$$pm_g \cdot ML_g - AL_{ar} \frac{\partial \Pi^{ar}}{\partial pm_g} = 0$$

Table 11: Sets

s	Sectors
g	goods
i	Output goods
j	Intermediate inputs
el	electricity
en	Energy
nele	Energy except electricity
f	Factors of production
ar	armington
h	households
sa	saving

Table 12: Activity variables and endowments

AL	Activity level for sectors and Armington
ML _g	Import activity level for goods
XL	Export activity level for goods
W	Welfare level
E	Expenditure level
EN	Factor Endowments

Table 13: Price variables

p	Output price of goods
pm	Import price of goods
px	Export price of goods
ps	Input price of goods
pfx	Exchange rate
w	Factor price

Table 14: Share and elasticity parameters in production

α_i	Share of good i in sector output
α_f	Share of factors aggregate in production
α_j	Share of intermediate goods aggregate in production
τ	Elasticity of transformation
λ	Substitution elasticity between factors
β	Substitution elasticity between intermediate goods
η	Substitution elasticity between non-electricity energies
θ_f	Share of factor f in factors aggregate
θ_j	Share of good j in intermediate aggregate
θ_{en}	Share of energy en in non-electricity energy aggregate
θ_{el}	Share of electricity in energy aggregate
θ_{nele}	Share of non-electricity energy en in energy aggregate

Table 15: Share and elasticity parameters in Armington aggregate

ω	Substitution elasticity between export and domestic supply
φ	Substitution elasticity between import and domestic production
γ^{ps}	Share of domestic production in Armington input aggregate
γ^{pm}	Share of import in Armington input aggregate
μ^p	Share of domestic supply in Armington output aggregate
μ^{px}	Share of export in Armington output aggregate

Table 16: Share and elasticity parameters in consumer expenditures

α_{sa}	Saving rate
α_j	Share consummation non-energy aggregate in expenditure
β	Substitution elasticity between consumption goods
η	Substitution elasticity between non-electricity energy aggregate
θ_j	Share of good j in consummation non-energy aggregate
θ_{el}	Share of electricity in consummation energy aggregate
θ_{en}	Share of energy en in non-electricity energy aggregate
θ_{nele}	Share of non-electricity energy aggregate in consummation energy aggregate

Appendix B: Sensitivity analysis scenarios

Table 17: Substitution elasticities in different Scenarios

		SC1	SC2	SC3	SC4	SC5
Substitution elasticity between non-energy input goods	β	0.0	0.0	0.5	0.5	0.0
Substitution elasticity between electricity and other energies composite	θ_{el}	1.0	0.0	0.0	1.0	1.0
Transformation elasticity between export and domestic supply	τ_r	3.0	3.0	3.0	3.0	1.0

Table 18: Shrinking effect and crowding out effect of removing implicit energy subsidies

	SC1	SC2	SC3	SC4	SC5
Transport, Sea	-24.46	-23.94	-28.40	-29.18	-24.45
Transport, Pipe	-14.85	-14.81	-19.97	-20.05	-15.06
Ironstone	-14.62	-14.59	-16.46	-16.50	-14.43
Coal	-13.60	-13.59	-16.30	-16.34	-13.43
Glass	-12.33	-12.35	-16.21	-16.23	-12.22
Transport, Air	-11.87	-12.11	-16.85	-16.21	-11.80
Copper Mines	-11.79	-11.80	-12.01	-12.07	-11.63
Manufacturing	-11.67	-11.68	-12.93	-12.96	-11.50
Electricity	-10.86	-5.90	-6.30	-11.51	-10.83
Agriculture and Animal Husbandry	-9.54	-9.58	-8.91	-8.89	-9.42
Passenger Transport, Road	-9.49	-9.61	-12.39	-12.17	-9.35
Water	-8.00	-8.08	-13.02	-13.00	-7.88
Transport, Rail	-7.35	-7.26	-12.27	-12.38	-7.41
Cargo Transport, Road	-5.42	-5.46	-6.57	-6.51	-5.37
Energy Industry	-3.91	-5.49	-5.53	-3.85	-3.83
Crude Oil and Natural Gas	-1.07	-1.08	-0.59	-0.57	-1.53
Transport Supports	0.41	0.22	-0.66	-0.31	0.36
Services and less energy intensives	5.52	5.52	5.79	5.79	5.56

Table 19: Price index changes due to of removing implicit energy subsidies

	SC1	SC2	SC3	SC4	SC5
Transport Services, Pipe	108	113	109	103	104
Transport Services, Sea	98	101	101	97	97
Transport Services, Rail Passenger	84	89	82	76	86
Plaster	71	76	71	66	73
Cement	68	72	71	65	69
Brick	62	66	67	61	63
Non-Metal Manufacturing	54	58	61	56	55
Copper	54	58	64	59	62
Water	53	57	63	57	55
Transport Services, Air	53	59	64	57	54
Glass Products	51	55	60	55	52
Other Mine	50	54	58	53	52
Other Metals	48	52	57	52	49
Transport Services, Rail Cargo	43	47	55	50	43
Transport Services, Road Passenger	43	47	53	48	44
Transport Services, Road Cargo	40	44	50	45	41
Agricultural Related Goods	39	43	48	44	40
Coal	38	42	47	42	39
Aluminum	38	42	49	44	40
Iron and Steel	37	40	47	42	38
Iron Stone	36	39	45	40	36
Other Services	36	40	44	39	37
Transport Support Services	32	36	41	36	33
Agriculture and Animal	30	33	38	34	30
Copper Stone	30	33	38	34	31
Machineries	29	33	38	33	30
Crude Oil	23	26	31	27	25
Natural Gas	20	21	29	26	21
Other Refineries	19	23	30	25	20

Table 20: Welfare effect of removing implicit energy subsidies

	SC1	SC2	SC3	SC4	SC5
Rural household welfare	-12.88	-13.01	-12.98	-12.84	-12.66
Urban household welfare	-12.34	-12.47	-12.39	-12.26	-12.21
Welfare index	-12.47	-12.60	-12.54	-12.41	-12.32
Consumer price index	40.79	44.49	49.54	44.81	41.82

Table 21: Initial and final energy price change due to removing implicit energy subsidies

Initial price increase		Final (equilibrium) price increase				
		SC1	SC2	SC3	SC4	SC5
Electricity	227%	250	254	258	253	252
Gas	600%	610	611	614	612	611
Gasoline	140%	162	171	175	164	163
Kerosene	809%	815	820	823	818	816
Gasoil	809%	821	822	825	823	822
fuel Oil	784%	784	784	784	784	784
Liquid Gas	2797%	2808	2810	2814	2811	2809

Appendix C: Share of energy in production

Table 22: Share of energy in intermediate input goods (considering implicit subsidy):

In billions of Rials	output	Capital rent payment	Labor wage payment	Input goods	Energy to output	Energy to input goods	Electricity	Gas	Gasoline	Kerosene	Gasoil	fuel Oil	Liquid Gas
Agriculture and Animal Husbandry	107,972	80,095	2,824	29,301	4%	16%	4%	0%	1%	1%	8%	0%	1%
Coal	564	195	238	197	16%	47%	36%	1%	1%	1%	7%	0%	1%
Crude Oil and Natural Gas	113,111	109,027	2,270	2,237	1%	40%	29%	3%	1%	0%	7%	0%	0%
Ironstone	945	702	69	284	17%	55%	49%	0%	1%	0%	4%	2%	0%
Copper Mines	1,145	906	81	224	8%	40%	26%	0%	0%	0%	9%	4%	0%
Energy Industry	106,664	88,167	3,695	14,072	1%	6%	6%	0%	0%	0%	0%	0%	0%
Glass	1,400	453	253	1,085	35%	45%	12%	19%	0%	0%	1%	7%	5%
Manufacturing	152,746	64,173	22,611	90,805	16%	26%	12%	7%	0%	0%	2%	4%	1%
Electricity	33,841	29,808	1,773	6,237	16%	86%	0%	67%	0%	0%	3%	16%	0%
Water	3,483	1,012	1,560	1,569	25%	56%	25%	3%	3%	0%	20%	0%	6%
Transport Rail	1,815	615	964	528	14%	49%	10%	0%	1%	0%	34%	3%	0%
Passenger Transport Road	15,083	7,900	2,167	7,023	20%	43%	1%	0%	18%	0%	24%	0%	0%
Cargo Transport Road	35,683	22,476	2,446	13,636	15%	40%	0%	0%	13%	0%	27%	0%	0%
Transport Pipe	566	83	302	482	66%	78%	32%	12%	0%	6%	7%	20%	0%
Transport Sea	6,152	1,773	881	10,484	128%	75%	0%	0%	0%	0%	1%	74%	0%
Transport Air	4,821	517	1,004	4,081	33%	39%	1%	0%	37%	0%	0%	0%	0%
Transport Supports	6,142	3,590	916	1,709	10%	34%	17%	3%	2%	0%	9%	0%	2%
Services and less energy intensives	435,344	258,315	104,659	86,008	6%	29%	13%	6%	2%	1%	4%	1%	2%

Table 23: Share of energy in household consumption (considering implicit subsidy):

In billions of Rials	income	saving	consumption	Energy to consumption	Electricity	Gas	Gasoline	Kerosene	Gasoil	fuel Oil	Liquid Gas
Rural household	123,959	11,603	100,053	10%	2%	0%	2%	4%	0%	0%	1%
Urban household	364,068	24,075	339,722	7%	2%	2%	3%	1%	0%	0%	0%