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Ukraine Gas Pricing Policy: Distributional Consequences of Tariff Increases

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Ukraine Gas Pricing Policy

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Abstract

Ukraine's gas pricing policy subsidizes gas and heating for all households. As the cost of imported gas rises, this policy increasingly weighs on government finances, sustains energy over-consumption, dampens investment in delivery systems, and undermines incentives for domestic production. However, gas price hikes have been deferred to the medium-term as they are politically unpopular. Through estimation of household demand functions by income quintiles to evaluate the distributional consequences of tarriff reform, this paper finds that tariff reforms combined with targeted social support can address the economic inefficiencies of the current pricing policy without large welfare costs to the lower income segments of the population.

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A. Introduction

In Ukraine, implicit subsidies to households through under-priced household gas and heating tariffs have been a prevailing policy for many years. However, they are increasingly costly. A shift in policy, towards economic efficiency—setting household gas and heating tariffs at their marginal cost, reflecting gas import prices—is politically unpopular and deferred to the medium-term.

Under-pricing of household gas and heating prices has typically been a poor instrument for achieving distributional or welfare objectives. The implicit cost of foregone revenue in Ukraine is significant (almost 5 percent of GDP per annum). Moreover, while low tariffs support poor households, they disproportionately favor those who consume the most, typically wealthy households.

The policy is also proving financially and economically unaffordable. It drains government finances, sustains energy over-consumption, dampens investment in delivery systems, and undermines incentives for domestic production expansion into gas reserves that could significantly reduce Ukraine's need for gas imports. In the presence of budgetary constraints untargeted implicit gas subsidies also divert resources away from other social and infrastructure spending. These problems have intensified over the past decade as Russia has withdrawn gas price discounts on its sales to Ukraine.

The authorities recognize that a shift in gas pricing policy is ultimately necessary. They are concerned that large tariff increases will cause considerable economic distress, particularly for poorer households and see these increases as the last stage of a multiyear effort that begins by upgrading to energy-saving infrastructure. These long-term improvements focus on renovation of the current housing stock to better control gas and heating volumes and to improve insulation. Household access to low-cost loans for energy-saving home renovation is an important component of this strategy.

IFIs have advised gradual but immediate tariff increases, supplemented by social assistance reforms targeting the most vulnerable members of society. A credible commitment to a schedule of regular tariff increases until full cost recovery would incentivize energy savings. Increased building-level metering will strengthen billing transparency as well as improve households' willingness to both pay their full utilities' bill and accept tariff increases. These reforms will provide financing to update gas and heating infrastructure and to invest in exploration and development of domestic gas endowments. At the same time, reforming social assistance programs for household utilities to unify and streamline benefits and subsidies while instituting means-tested programs would rapidly redirect social assistance to those most in need.

This paper contributes to the gas pricing policy dialogue by providing an analysis of household gas and heating demand and by assessing the impact of higher gas and heating tariffs on households' consumption and welfare. In turn, implications for government finances through lower implicit subsidies and higher social assistance expenditures are discussed.

Key findings include:

- Tariff increases will reduce gas consumption, even in the short run. For example, our analysis shows that in response to a 20 percent tariff increase households would react by reducing consumption by around 5 percent for gas and 3 percent for heating, increasing with income level.

- As heavier users of energy, the absolute value of consumer surplus loss for wealthier households is 1½ times larger than for lower income households. However, as a percent of income, lower income households experience a greater welfare loss.

- While uniform tariff increases can be regressive, social assistance programs can fully defray the cost to poorer households. Government savings are a multiple of their welfare loss and targeted government transfers can offset the cost of higher tariffs to the poorest households. For example, government savings from a tariff increase can allow for higher growth-enhancing expenditures while fully offsetting the additional cost to the poor.

The remainder of the paper provides background on the economic implications of gas subsidies (Section B), and then assesses the implications of higher gas and heating tariffs on household welfare in theory (Section C) and in practice by modeling and estimating household demand curves (Sections D and E). Section F concludes.

B. Stylized Facts: Economic Implications of Gas Sector Subsidies

Ukraine has been slow to initiate gas sector reform. Pricing distortions are among the largest in the region, with heavily regulated prices for household gas and heating. Underinvestment in domestic gas production has created a dependence on Russian gas imports to meet two thirds of Ukraine's consumption needs. Domestic distribution infrastructure relies on outdated delivery systems coupled with little investment in energy efficient tools such as better insulation, double-paned windows, etc.[2]

Household Gas Prices, 2010 (U.S. dollars per MBtu)
Less than 10 | 10 to 20 | More than 20
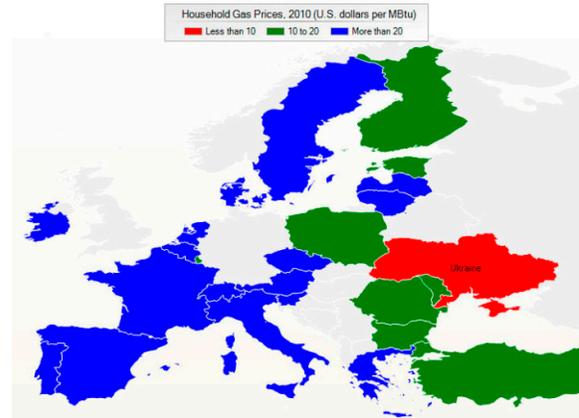
State-owned enterprises dominate Ukraine's gas and heating sectors.

- Naftogaz (NG), a state-owned holding company, is composed of a multitude of subsidiaries specializing in domestic oil and gas exploration and production, gas imports, storage, gas transit from Russia to Europe, and domestic distribution. Households, industries, and budget institutions all purchase gas from NG for direct use.[3]

- Heating utilities, largely municipally-owned, purchase gas from NG to generate and distribute residential heating and hot water.[4] Gas is about 90 percent of the energy input in heating generation.

Household gas and heating tariffs continue to be regulated by the state. Years of gas import subsidies from Russia were terminated in 2006 when Ukraine's import prices were raised to European levels. Domestic tariffs for the industrial half of NG's customer base have been adjusted to import parity. In contrast, prices paid by households and heating utilities to NG remain heavily regulated—at one fifth and one third of import costs, respectively. Heating tariffs involve a second stage of mispricing where heating utilities only embed half their gas cost into the heating tariff charged to households. Despite a 50 percent increase in the gas-component of household gas in August 2010 and a 15 percent increase in heating tariffs in January 2011, household gas and heating tariffs remain among the lowest in Europe and well below import parity.

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[2] The authors' assessment of the current state of Naftogaz's extraction, transportation, and distribution systems is based on the discussions with energy experts. However, this assessment is disputed by Naftogaz.

[3] Most of the chemical industry purchases gas directly from Gazprom (about 15 percent of Ukraine's total gas imports).

[4] Heating tariffs paid by households include hot water costs.

Gas Prices
(U.S. dollars per thousand cubic meters)

- Imports
- Households
- Utilities
- Industry

Sources: Naftogaz; and IMF staff estimates.

Ukraine: Gas Consumption, 2011
(total = 49 billion cubic meters)

- Households
- Utilities
- Budget
- Industries

Sources: Authorities; Staff estimates.
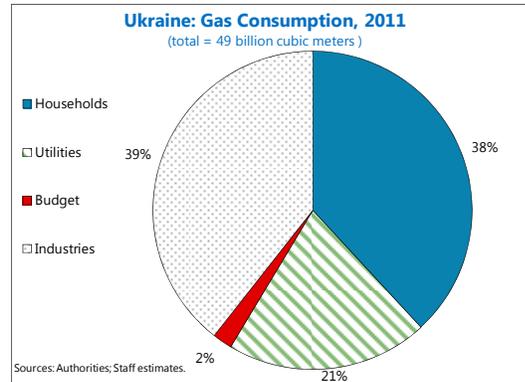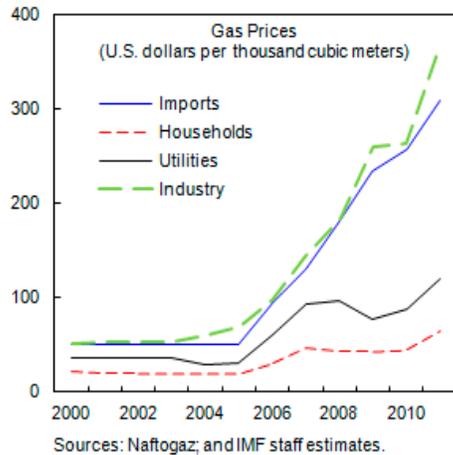
Mispriced gas and heating tariffs create losses for NG and heating utilities, whose deficits are financed by the government:

- NG's losses (1½ percent of GDP in 2011) from selling imported gas to households and heating utilities below cost-recovery are compounded by under-priced domestically produced gas, poor payment enforcement, alleged siphoning of gas from households to industrial users, and output losses from weak infrastructure. Gas transit revenues received from Gazprom and cost-recovery pricing for industrial customers only partially offset these losses. The government finances NG's deficit mainly through government bonds purchased by state-owned banks (at below market yields), and also through cash transfers, tax offsets, and guarantees on NG's external loans.

Naftogaz Financials 2011		
	in bln UAH	in percent GDP
Revenues	114	8.7
Gas Sales	86	6.6
Households	9	0.7
Heating Utilities	8	0.6
Industry	56	4.3
Other	13	1.0
Gas Transit Fees	25	1.9
Other	3	0.2
Expenditures	135	10.3
Gas Imports	74	5.6
Domestic Gas	6	0.5
Other	55	4.2
Cash Balance	-21	-1.6

- Heating utilities' deficits stem from heating tariffs set below cost recovery, energy inefficient distribution infrastructure, and household payment arrears. The latter partially reflects a lack of meter coverage (under 40 percent coverage) which leaves households feeling that heating utilities are charging them in excess of their actual consumption. Heating utilities' losses are partially covered by direct government subsidies and arrears to Naftogaz, which are often written off.

In addition to support from low tariffs, households receive social assistance from the government. This assistance is divided between explicit subsidies and benefits to households for gas and heating consumption. Benefits compensate special categories of people such as those in socially important professions, war veterans, and Chernobyl victims for their gas and heating consumption. Explicit subsidies, in contrast, are provided to households whose

spending exceeds 15 percent of their income (or 10 percent of income for pensioners and the disabled). Benefits are more than ¾ the government's total social assistance budget for gas and heating (0.2 percent of GDP). Only 20 percent of benefits go to the poorest two income quintiles while 30 percent is distributed to wealthiest income quintile. In fact, about 85 percent of people below the poverty line do not receive any social assistance (neither in the form of benefits or explicit subsidies) for household utilities and only 5–12 cents per dollar spent of social assistance in this area contributes to reducing the poverty gap.[5]
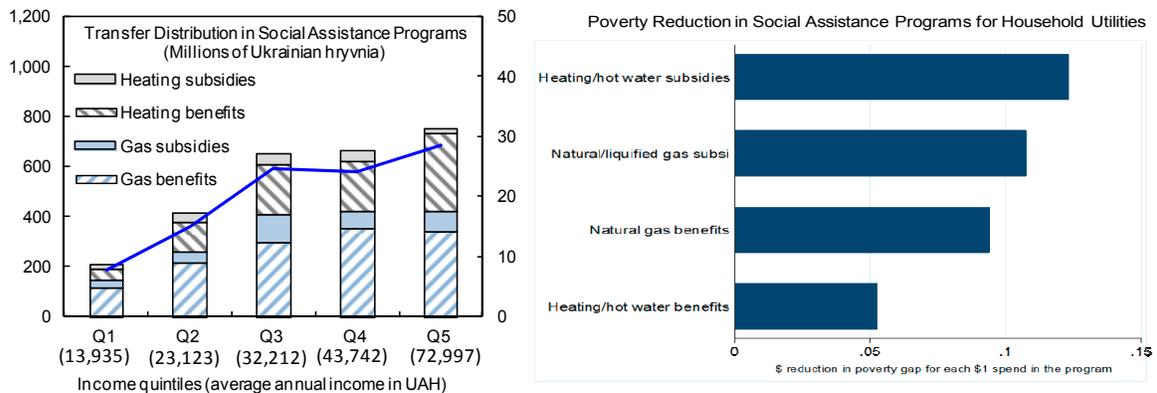
Source: 2010 Household Survey, State Statistics Service of Ukraine. IMF staff estimates using ADePT's Social Protection module.

The implications of mispricing gas and heating tariffs are manifold:

Overall, natural gas-related transfers from the government to households total 6 percent of GDP.[6] The bulk of this transfer (5 percent of GDP, see table below) reflects below-cost gas and heating tariff pricing, while social assistance in the form of explicit subsidies and benefits to households account for a much smaller portion (¼ percent of GDP). The remainder stems from heating utility companies' subsidies (¼ percent of GDP) and debt arrears (½ percent of GDP).

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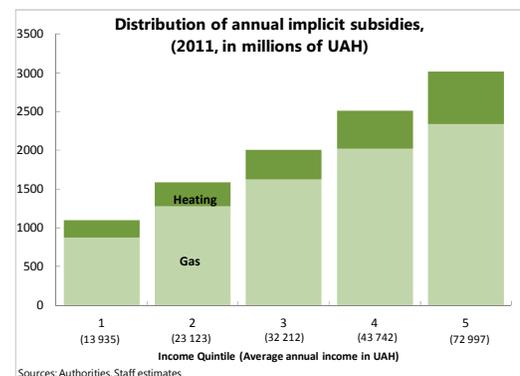
[5] The latter statistic is calculated as the hyrvnia equivalent necessary to bring the poor above the poverty line.

[6] These transfers should be interpreted as the opportunity cost of underpaid revenues and dividends. This is money that needs to be paid by the economy through higher taxes or forgone public services. If the subsidy was completely eliminated, Naftogaz's operations would have been generating significant profits rather than losses of 1.6 percent discussed above, enabling it to make significant transfers to the state budget.

Impact of below-cost tariffs on Naftogaz 1/

|	Volume consumed, bcm (V)	Price paid to NG, USD/tcm (P)	Import price, USD/tcm (Pm)	NG loss = V*(P-Pm)	
				US$ billions	in percent GDP
Households	16.6	54.4	415	-6.0	-3.2
Heating Utilities	8.8	118.5	415	-2.6	-1.4
Total	25.4	...	...	-8.6	-4.7

1/ Applying latest 2012 data
Sources: Authorities, Staff estimates.

Underinvestment in domestic production has reduced production from around 20 to just over 15 billion cubic meters over the past decade, increasing Ukraine's import dependence. Outdated gas transport and delivery systems result in large technical gas loss, further increasing gas needs.[7] In addition to updating domestic production and distribution infrastructure, annual investments of US$1.5 billion in unexplored gas endowments would halve the volume of Russian imports within a decade, eventually permitting Ukraine self-sufficiency in gas supply and export gas.[8]

Ukraine's Gas Production
(in billions of cubic meters)
Sources: Authorities; World Bank; IMF staff estimates.
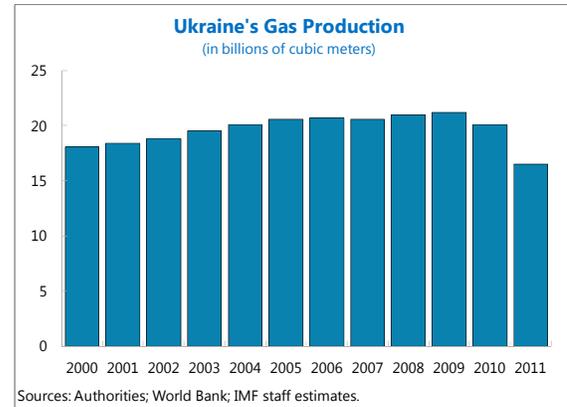
Heavily regulated tariffs and a lack of transparency make it difficult to unbundle and privatize NG, as is the government's objective. Legislation to "unbundle" NG was approved by Parliament in April 2012 and privatization of NG's business segments would increase their operational efficiency and enhance service quality. However, regulated tariffs and low or negative profitability of the majority of NG's business segments due to underpriced household gas and heating tariffs would deter investors.

Under-priced tariffs have induced gas overconsumption and benefits disproportionately larger gas users. Despite some progress over the last decade, Ukraine remains one of the most energy-intensive countries in Europe (even after taking into account its energy-intensive industry structure), with annual gas consumption of about 50 billion cubic meters. Energy efficiency is only 60 percent of European Union averages. Low tariffs reduce incentives

Energy Use, 2009 1/
(Kilograms of oil equivalent per $1000 GDP in constant 2005 PPP)
Sources: World Bank, World Development Indicators

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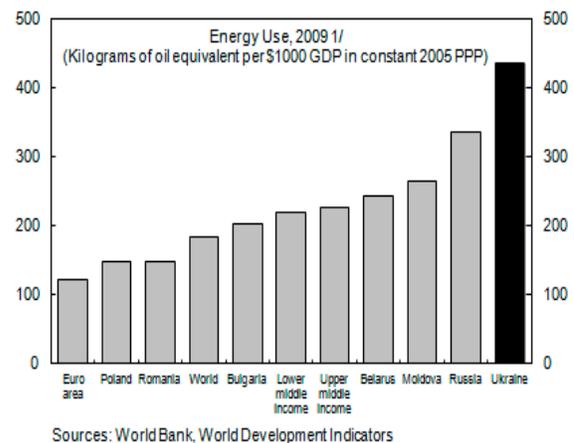
[7] Technical gas is the gas consumed or lost as a part of the production and distribution process.

[8] World Bank staff estimates.

for households to reduce consumption or invest in energy efficiency, including through better housing insulation. They also undermine the government's efforts to give households control over heating volumes by increasing residential building-level meter coverage to almost 40 percent. The higher income factions of the population tend to have the physically largest homes and thus receive the greatest implicit subsidies for gas and heating. The large price differential across industries and households provides incentives for alleged illegal siphoning of gas from households to industry.

C. Theory: Implications of Higher Gas and Heating Tariffs

In the face of higher gas and heating tariffs households will need to reduce gas and heating consumption or other expenditures or savings. This trade-off will vary across households of differing income levels. Social assistance will provide relief to some households. However, with greater social assistance demands, the government will need to decide how to allocate its savings from higher gas and heating tariffs across maintaining or even improving the well being of the poor, continued social assistance for the wealthy, and growth-enhancing investment.

Households

Short-term effects of price changes on households are often assessed through welfare changes. Demand curve estimation permits quantification of welfare changes by measuring changes in expenditures and consumer surplus (a method first introduced by Hausman (1981) and Vartia (1983)). Applying this methodology to gas and heating tariff hikes, households will be adversely impacted in two ways:

- Household expenditures will rise.[9]

    ❖ The maximum increase occurs at the moment of tariff increases, since consumption volumes are almost perfectly inelastic. Households move from point 1 to 2 in the graph below. Household expenditures increase by C+D+E (from *A+B* to *A+B+C+D+E*).

    ❖ In the short-term, households mitigate much of the initial expenditure increase by reducing consumption volumes at the new tariff (moving from point 2 to 3). Measures such as better home insulation help reduce consumption. Households' net expenditure increase from the tariff hike is *C-B* (from *A+B* to *A+C*).

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[9] In line with the literature, energy demand is presumed inelastic. Thus, the discussion in this paper assumes gas and heating tariff increases result in increased household expenditures on those items. If gas and heating demand were very elastic then increased tariffs, accompanied by reduced consumption volumes, would imply lower expenditures than prior to the tariff hikes.

- Consumer surplus will fall.[10] In the graph below, consumer surplus will fall from *C+D+F* to only *F*. A part of the lost consumer surplus, area *C*, is transferred from households to NG and utilities since it is part of the expenditure increase.

Welfare changes (described above) vary across households of different income levels. Taking two extremes, wealthy households have more elastic heating and gas demand than poor households. They have larger houses making them more likely to over-consume at low tariffs and they can afford to invest in better home insulation when tariffs rise. Meanwhile, poorer households have little room to adjust consumption since it is set to meet basic needs and they have no money to invest in better insulation. Consequently:

- For the wealthy a tariff increase results in higher nominal expenditure rises than for the poor, (*C'-B' > C-B)* since the wealthy consume greater quantities than the poor (as illustrated in the graphs below).

- However, the wealthy suffer larger consumer surplus losses (*C'+D' > C+D)*.
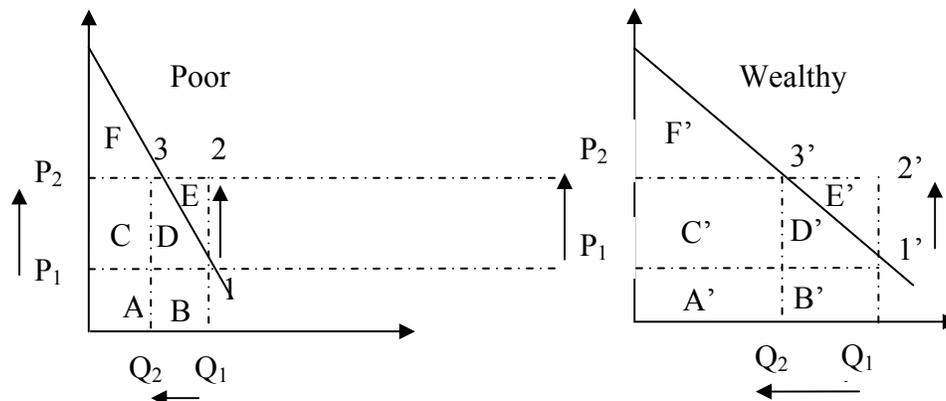
Households' reaction to higher gas and heating tariffs have mixed effects on aggregate demand.[11] In the short run and given inelastic demand, despite some reduction in consumption volumes, higher tariffs mean higher energy bills, which crowd out other expenditures. Anticipation of future tariff increases also gives rise to precautionary savings. These negative effects on aggregate demand are countered by increased demand for energy-saving household materials, renovations, and in the longer run construction of more energy efficient homes. Ultimately these changes also reduce consumption volumes and eliminate the initial crowding out of household non-energy expenditures.

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[10] For each quantity between zero and the quantity consumed, the consumer is willing to pay a price as high as the corresponding point on the demand curve. The difference between the highest price a consumer is willing to pay and the price the consumer actually pays is a gain to the consumer. The sum of all these gains is called the consumer surplus.

[11] Kilian (2008) provides a review of the effects of energy price increases.

Social Assistance and Implicit Subsidies

Social assistance can partially offset the adverse effects of tariff increases for some households. Households currently receiving social assistance because their utility bill exceeds 15 percent of their income will require larger amounts of social assistance. Others who were not previously receiving social assistance, may now require it as higher tariffs push their utility expenditures above 15 percent of their income. Tariff increases will significantly raise the cost of social assistance in the form of benefits[12] (rising in proportion to tariffs) since most of the benefit recipients are wealthy households who consume large amounts.

The government will face a choice between social assistance that pursues social equity versus distributional objectives. Eliminating social assistance, particularly benefits, to the wealthy would free resources to ensure the welfare of the poor is unchanged under tariff increases without the need for additional budgetary resources.[13] A reformed social assistance program would eliminate benefits, provide the poor with targeted explicit subsidies (compensation for utility expenditure exceeding 15 percent of income), and provide cash subsidies equivalent to consumer surplus loss from tariff increases. Without social assistance, the wealthy will have an even greater incentive to reduce gas and heating consumption.

Tariff increases reduce the implicit subsidy to households, freeing government resources for increased social assistance and growth-promoting investment. The new higher tariff, P_2, works towards reducing the gap with import prices, P_M. The government's cost of implicit subsidies to households is reduced by $(P_M - P_1)*Q_1 - (P_M - P_2)*Q_2$. These government savings can be used to provide increased social assistance to poorer households, invest in expansion of domestic gas production and improved infrastructure, and investment in growth-promoting activities—including general infrastructure, healthcare, and education. In the long run, all these factors will support higher economic growth, providing greater financial gains to both poor and wealthy households than underpriced gas and heating tariffs.

As an extreme illustration, in the graphs above, assume the tariff was increased all the way to import prices ($P_M = P_2$). Then implicit subsidies would be reduced by C+D+E (from C+D+E to zero) for poor households and C'+D'+E' for wealthy households. In this case,

> ➢ The welfare of the poor could be left unchanged (i.e. bring their price back to P_1) by transferring the implicit subsidy savings of wealthy households to poor households.[14]

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[12] Recall from section B that benefits are defined as the government compensating special categories of people, such as those in socially important professions, for their gas and heating expenditures.

[13] Previous studies have shown that the poor are likely to experience higher economic distress because they spend a larger share of income on energy (World Bank, 2004 and 2007).

[14] While for operational reasons it is easier to deal with prices, a cheaper way to maintain the welfare of the poor unchanged would be to leave prices at P_2 but provide a cash transfer of C+D.

➤ There would still be plenty of left over savings for the government to invest in energy infrastructure and growth-promoting investment since (C'+D'+E') > (C+D+E).

D. Model

In this section we estimate household gas and heating demand to assess the impact of tariff increases on household welfare through changes in utility expenditures and consumer surplus, as well as on social assistance programs. Household demand for gas and heating are estimated as a function of price, income, housing[15] and household characteristics, borrowing from the literature on general energy demand as well as that for electricity demand. [16,17]

Reactions of poorer and wealthier households to gas and heating tariff increases are differentiated by modeling explicit income-based heterogeneity in price elasticities. Incorporating interaction terms of price and income for each income quintile permits estimation of intra-household differences in price sensitivities driven by existing consumption quantities, habits and other psychological forces which may all be related to household income levels.[18] Alternatively, a model with homogeneous price elasticities can be estimated separately for each income group. However, this analysis is not undertaken since it sacrifices sample size.

The log-linear heating demand for a household i is:

$$\ln Q_i = \alpha + \beta lnP_i + \sum_{j=3}^{5} \beta_j I_{ij} \, lnP_i + \delta_1 lnY_i + \delta_2 ln \, area_i + \sum_{k=3}^{9} \delta_k X_k + \varepsilon_i \, ,$$

where Q_i is annual heat consumption and P_i is the effective price of heat. Price is independent of quantity since heat is sold under a flat rate. The effective price for each household is the flat rate price net of any heating-related social assistance in the form of benefits and subsidies received by the household. I_j is a categorical income variable with I_j =1 if the household is in income quintile j (j=3,4,5). Y_i is household income, $area_i$ is the total physical floor area of a dwelling, X_k is a vector of household characteristics including the number of people in a household, the number of rooms, the year of major renovation, and dummy variables for whether the dwelling is an apartment (vs. a house), located in a rural area, built prior to 1980

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[15] It is especially important to control for housing characteristics since they play an important role in the demand for gas and heating. For example apartment owners have less flexibility in controlling heating than individual households.

[16] A contemporaneous demand function is modeled. Absent sufficient data, modeling long term demand or spillovers to income, demand in other sectors, and more generally the overall impact on aggregate demand are left for future research.

[17] Taylor (1975), Hartman (1979) and Bohi and Zimmerman (1984) provide reviews of electricity demand studies.

[18] Zhang (2011) applies a similar model for electricity demand in Turkey.

(these building were often built with thicker walls and better insulate heat),[19] cannot directly control heating to an individual apartment, and has a non-government supplied heating system.

The log-linear gas demand for a household is formulated in the same way as that of heating demand, replacing heat consumption and effective heating prices with natural gas consumption and effective gas prices. The vector, X_k, of household characteristics is also the same except dummy variables for the presence of a gas water heater and ease of gas availability are applied in place of heating not controlled by an individual apartment and a nongovernment supplied heating system.

For the first two income quintiles, β is the percent change in annual consumption for a one percent tariff increase. Income levels in these two quintiles are so low that all of these households are expected to consume gas and heating only to meet basic needs. As such, they are assumed to have the same price elasticity. $\beta + \beta_j$ (j=3,4,5) is the price elasticity for households in income quintile j.

The robustness of the above equation, especially the price elasticities is tested by estimating a model of homogeneous price elasticity across income quintiles:

$$\ln Q_i = \alpha + \beta \ln P_i + \delta_1 \ln Y_i + \delta_2 \ln area_i + \sum_{k=3}^{9} \delta_k X_k + \varepsilon_i \text{ , and}$$

a model where household income enters the interaction term as a continuous variable:

$$\ln Q_i = \alpha + \beta \ln Y_i \ln P_i + \delta_1 \ln Y_i + \delta_2 \ln area_i + \sum_{k=3}^{9} \delta_k X_k + \varepsilon_i$$

The model is estimated using 2010 household survey data collected quarterly by the State Statistics Survey of Ukraine. The survey collects information from 10,428 households on their socio-economic status, living standards, income, and consumption expenditures (including on gas and heating), representing—with appropriate household weights—17 million households across Ukraine. Household heating and gas tariffs were provided by Naftogaz and social assistance data was provided by the Ministry of Labor.

Demand curve estimation uses effective household prices (prices net of social assistance), which represent the true cost of utilities consumed and differ across households. Figures for 2012 are projected by adjusting 2010 household incomes for IMF inflation and wage growth projections, and applying actual 2012 gas and heating prices to the model. Table 1 lists the summary statistics of the variables applied in the analysis.

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[19] Since 1980 cheaper building materials and looser application of building code have resulted in thinner, less energy-preserving walls.

E. Results

Demand Elasticities

Both gas and heating demand are price inelastic in the short-run. The results (Tables 2 and 3) are consistent across all three sets of OLS estimates. Heating consumption will fall by 1.65 to 1.82 percent when tariffs increase by 10 percent. Gas demand is also inelastic, though more sensitive to price changes. It falls by 2.63 to 2.83 percent in response to a 10 percent tariff hike.[20] For both gas and heating demands, the homogeneous price elasticity and the continuous price-income interaction elasticity evaluated at average income fall within the range of heterogeneous price elasticities.
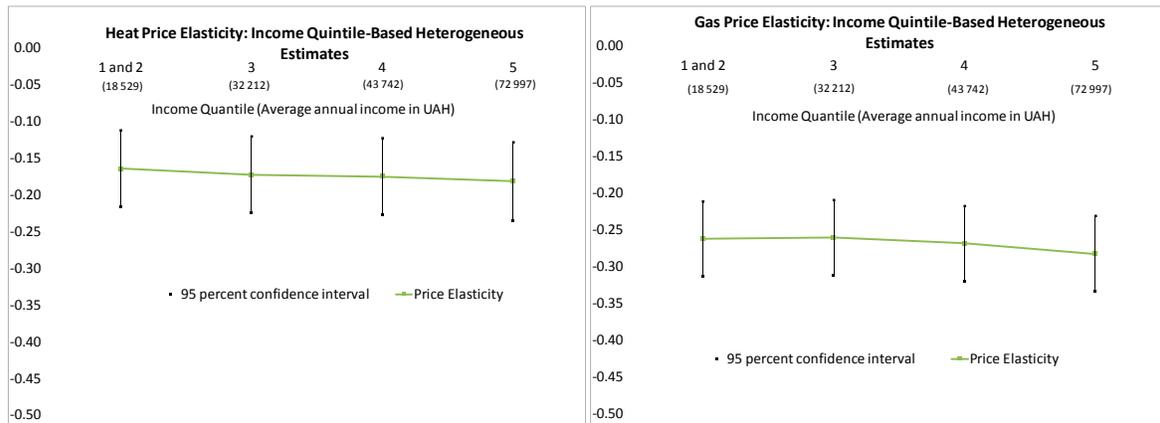
Confirming theoretical predictions, the Wald test finds that wealthier households' gas and heating demands are more elastic than those of poorer households. Recall, that elasticity for the jth quintile is estimated as $\beta + \beta_j$ (j=3,4,5). If the elasticity of the fifth quintile is equal to that of the first two quintiles then $\beta = \beta + \beta_5$, which is equivalent to testing for $\beta_5 = 0$. The Wald test rejects the hypothesis that $\beta_5 = 0$ for both gas and heating. The wealthiest income quintile's heating and gas price elasticities are, respectively, 10 and 8 percent higher than those of the lowest two income quintiles. However, the Wald test finds

Wald Test Results

Hypothesis	F-stat	p-value	Elasticity is different from that of first two quintiles?
Heating			
$b_3 = 0$	2.55	0.11	No
$b_4 = 0$	2.87	0.09	Yes*
$b_5 = 0$	4.09	0.04	Yes**
Gas			
$b_3 = 0$	0.28	0.59	No
$b_4 = 0$	1.32	0.25	No
$b_5 = 0$	7.90	0.00	Yes***

*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

that there is no difference between the elasticities of the first two quintiles and the third quintile and very little difference with the fourth quintile.

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[20] These elasticity estimates are consistent with the literature. Short-run price elasticities for natural gas have been estimated at -0.12 (Bernstein and Griffin, 2006) and -0.2 (Bohi and Zimmermann, 1984). General energy demand price elasticities are similar, ranging from -0.14 (Bentzen and Engsted, 1993) to 0.22 (Prosser, 1985).

Since the price elasticities for the third and fourth income quintiles are less significant (for heating and gas demand), the price elasticity under the continuous price-income interaction model is evaluated for each individual household, confirming increasing price elasticity across the third and fourth income quintiles.
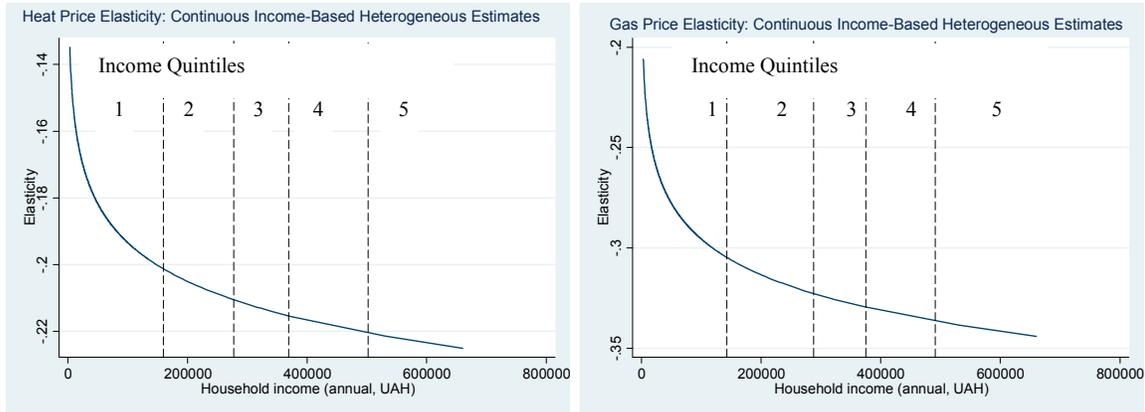
The coefficients of other variables are also consistent with expectations.[21] All estimates have the expected sign and are statistically significant. Estimates of income elasticity suggest that a 10 percent increase in annual household income will cause heating and gas consumption to increase by about 1.1 and 1.7 percent, respectively. Many additional factors are important in determining heating and gas consumption.

- The larger the apartment or house and the more people in a household, the greater both gas and heating demand. Heating demand is more sensitive to the physical size of the house, while gas demand is more sensitive to the size of the household.

- Heating demand is higher for apartment buildings over individual homes and for urban over rural households since (i) rural households have alternative forms of heating (including wood burning); and (ii) apartment buildings are more prevalent in urban areas and tend to have poorer insulation quality.

- Gas demand, in contrast, is much lower in apartments and urban areas since these households are less likely to use gas for heating water.[22]

- Better renovated apartments and individual homes, reflecting either or both better initial construction quality or more recent renovations, consume less heating and gas.[23]

[21] These factors control for non-price determinants of demand. Future analysis may also look at the interaction between each of these non-price factors and price, in place of income. The results are likely to be similar to those found in the analysis above since most of the nonprice determinants are partially a function of income.

[22] They receive piped hot water from a central source for several buildings.

- When heating is centralized as opposed to controlled by a single household, more is consumed. When households use an independent heating source they tend to consume more heat.

- Household gas consumption rises when gas is used to heat water and when gas is easily available.

Implications of a 20 percent tariff hike in 2012

Household expenditures on heating are almost twice as sensitive as gas to tariff increases. This is largely explained by the price elasticity of heating consumption being a third smaller than that of gas consumption. Consequently, compared to gas consumption, households lower heating consumption less and spend more on it. These results are consistent across household income levels, both before and after consumption levels have been adjusted downward.
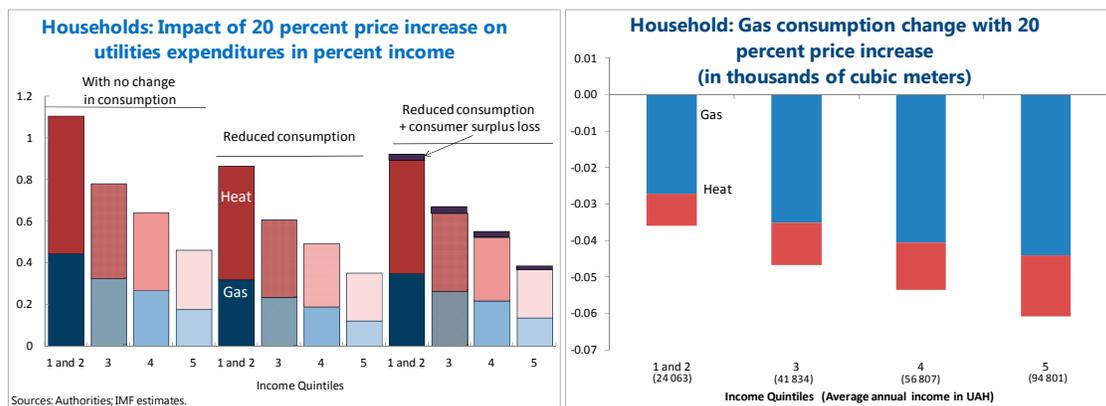
The impact of the tariff increase for the average household is well below one percent of income. When households in the third and fourth quintiles (together 40 percent of households) are unable to adjust consumption volumes, utilities' expenditures rise by $^2/_3$ to $^3/_4$ of 1 percent of income. With some flexibility to reduce consumption, they are able to limit their expenditure increase to $^1/_2$ to $^2/_3$ of one percent of income. Consumer surplus losses for the average household are very small.[24]

Wealthy households' utilities' expenditures relative to income are little impacted by tariff increases, unlike that of the poor. Even when wealthy households (20 percent of households) are initially unable to adjust consumption volumes, their utilities' expenditures rise by less than ½ of one percent of income. In the near term, they reduce consumption nearly 1½ times that of the poor bringing their expenditures down to 1/3 of one percent of their income.

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[23] The exception in these results is that gas demand reacts positively for households built prior to 1980 (which tend to be better built). It may be that while these houses are better insulated for heat, the quality of their gas pipes is no different from newer homes.

[24] Consumer surplus loss is measured as the triangle D in the demand curve graphs of Section C.

However, the poorest households (40 percent of households) face the largest rise in their utility bill relative to income. Initially, unable to adjust consumption volumes, their expenditures rise by just over one percent of income. Even after reducing their consumption volumes, utilities expenditures are nearing one percent of their income.

Consumer surplus loss relative to income is also lower for wealthy households. Although the absolute value of consumer surplus loss is greater for wealthy households, the loss in proportion to their income is less than for poorer households. Consequently, wealthy households' total welfare loss (consumer surplus loss plus utilities expenditures) in relation to income is only minutely higher than the rise in post-consumption adjusted utilities expenditures. Meanwhile, poorer households suffer the greatest loss of consumer surplus in proportion to income across all income groups.

Social assistance costs, currently 0.2 percent of GDP, remain almost unchanged rising by 0.02 percent of GDP. Direct subsidies increase from 0.02 to 0.03 percent of GDP.[25] Three quarters of which goes to households already receiving social assistance for utilities expenditures above 15 percent of their income. The remainder is for households newly applying for social assistance. These costs remain relatively unchanged even after households have reduced near term consumption volumes. Additional cash compensation for lost consumer surplus of all social assistance recipients will cost very little (0.01 percent of GDP) and may help galvanize public support for this difficult reform.

Tariff Hike (20 Percent) Impact: Utility-to-Income Distribution

— No tariff hike
— Hike w/o volume adjustment
— Hike with volume adjustment

Social assistance eligibility

Density

Utility bill-to-income, percent
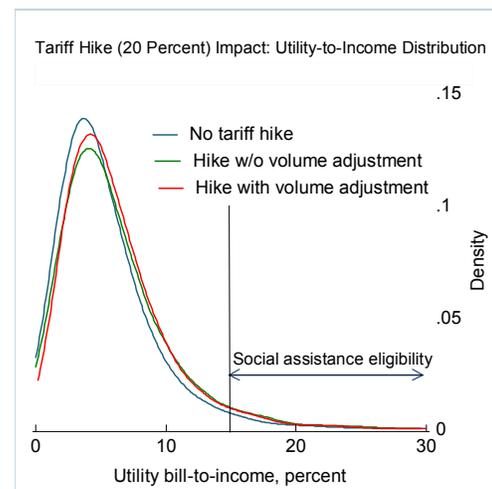
The burden on government finances will be reduced, freeing resources for growth-enhancing investments. NG and heating utilities' revenues will rise by 0.3 percent of GDP, after taking consumption adjustments into account. Elimination of benefits to middle class and wealthy households (almost 0.2 percent of GDP) would also free some resources. Additional targeted social assistance costs (0.02 percent of GDP) are minimal, hardly eroding these savings. Alternatively, the government could fully use the savings to compensate all but the wealthy for their additional costs (0.6 percent of GDP) or only the poorest households (0.2 percent of GDP).

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[25] Households in the first four income quintiles are considered for social assistance.

F. Conclusions

Gas and heating tariff increases are necessary to address the current pricing policy's economic inefficiencies and distributional distortions. As shown in this paper, the bulk of gas and heating subsidies to households are distributed through below cost pricing. Tariff increases will reduce these implicit subsidies which favor larger consumers, in this case wealthy households. At the same time, tariff increases will reduce massive overconsumption by lowering household gas and heating demand while incentivizing adoption of energy saving technologies. Over time, industrial energy efficiency would also increase with less illegal siphoning of gas from households to industries (reacting to the shrinking price differential between the two).

A schedule of gradual tariff increases will provide financial incentives for reduced energy consumption while ensuring affordability. Gradual tariff increases will mitigate the impact on the poor and middle class whose utilities' expenditures are a non-trivial portion of income. It will also give them time to adjust their consumption which analysis has proven to be less price elastic than that of the wealthy. Meanwhile, a single measured tariff increase—as illustrated by the 20 percent tariff increase example—has little impact on the welfare of the wealthy. Consequently, a credible schedule of tariff increases over the medium-term is necessary to motivate lower consumption by the wealthy.

Social assistance reforms can partially compensate the poor and middle class while further reducing distributional distortions. Under the current system, wealthy households whose utilities' expenditures are low relative to their income receive about 20 percent of gas and heating social assistance through untargeted benefits. Elimination of these benefits would free almost 0.2 percent of GDP for targeted social assistance expenditures. A reformed system concentrated on targeting the most vulnerable would limit the costs of tariff increases for poor and middle class households by ensuring no household in the first four quintiles pays more than 15 percent of income for utilities expenditures. To enhance public support for phasing out utility subsidies, the income of social assistance beneficiaries can be boosted through cash compensation for consumer surplus losses stemming from the tariff increases.

Government savings from higher household tariffs can be channeled into a higher quality of life for all households. Overall, under-pricing gas and heating utilities provides a 5 percent of GDP subsidy to households. The analysis suggests that even with just a 20 percent tariff increase the government will gain almost 0.3 percent of GDP. The associated increase in social assistance costs will be minimal and more than offset by the elimination of benefits to the wealthy. Government savings should first be used to finance energy-saving infrastructure investment, helping to reduce the burden of tariff increases on households. Investment of additional savings arising from gradual tariff increases in domestic gas exploration and development as well as growth-enhancing activities will eventually provide greater financial gains for all households than underpriced gas and heating tariffs.

Table 1. Summary Statistics

	Min	Max	Mean	Standard Deviation	Observations
Heating consumption (thousand cubic meters)	0	26	2.5	4.0	10428
Gas consumption (thousand cubic meters)	0	15	0.8	0.9	10428
Effective heating tariff (UAH/Gcal)	0	244	219.5	45.8	3529
Effective gas tariff (UAH/tcm)	0	895	799.9	181.0	9212
Income (annual household income in UAH)	3051	660251	37198	24999	10428
Household size (number of people)	1	13	2.4	1.3	10428
Area (square meters)	12	279	60.1	23.2	10121
Number of rooms	1	8	2.5	1.0	10428
Apartment	0	1	0.4	0.5	10428
Rural	0	1	0.3	0.5	10428
Built pre-1980	0	1	0.7	0.4	10428
Year of major renovation 1/	1	6	5.1	1.2	10343
Central heating	0	1	0.4	0.5	10428
Individual/independent heating	0	1	0.4	0.5	10428
Gas water heater	0	1	0.2	0.4	10428
Ease of gas availability	0	1	0.7	0.4	10428

1/ 1=not renovated, 2=pre-1970, 3=1970-79, 4=1980-90, 5=1991-2000, 6=2001 and later.

Table 2. Determinants of Heating Demand

Explanatory Variables	OLS		OLS w/ homogeneous price elasticity		OLS w/ continuous income interaction term	
	Coefficient	Std Error	Coefficient	Std Error	Coefficient	Std Error
LN(price)			-0.170 ***	0.027	-0.177 *** 1/	0.003
Income quintiles 1 and 2	-0.165 ***	0.027	…	…	…	…
Income quintile 3 2/	-0.173	0.005	…	…	…	…
Income quintile 4 2/	-0.176 *	0.006	…	…	…	…
Income quintile 5 2/	-0.182 **	0.009	…	…	…	…
LN(income)	0.111 ***	0.031	0.058 ***	0.016	0.057 *** 1/	0.025
Household size	0.028 ***	0.008	0.026 ***	0.008	0.026 ***	0.008
LN(Area)	0.361 ***	0.057	0.363 ***	0.057	0.362 ***	0.057
Number of rooms	0.130 ***	0.020	0.129 ***	0.020	0.129 ***	0.020
Apartment	0.517 ***	0.119	0.518 ***	0.119	0.517 ***	0.119
Rural	-0.618 ***	0.092	-0.622 ***	0.092	-0.622 ***	0.092
Built pre-1980	-0.060 ***	0.016	-0.059 ***	0.016	-0.059 ***	0.016
Year of major renovation	-0.041 ***	0.009	-0.041 ***	0.009	-0.041 ***	0.009
Central heating	1.606 ***	0.124	1.606 ***	0.124	1.609 ***	0.124
Individual/independent heating	0.668 ***	0.127	0.664 ***	0.127	0.667 ***	0.127
Constant	-1.886 ***	0.395	-1.354 ***	0.293	-2.270 ***	0.267
R-squared	0.327		0.327		0.327	
Observations	3376		3376		3376	

*** Significant at the 1 percent level

** Significant at the 5 percent level

* Significant at the 10 percent level

1/Price elasticity evaluated at average income; income elasticity evaluated at average price.

2/ Price elasticity for income quintiles 3 to 5 is derived by adding the coefficient of the relevant price-income interaction term to the price elasticity for income quintiles 1 and 2.

Table 3. Determinants of Gas Demand

Explanatory Variables	OLS		OLS w/ homogeneous price elasticity		OLS w/ continuous income interaction term	
	Coefficient	Std Error	Coefficient	Std Error	Coefficient	Std Error
LN(price)			-0.264 ***	0.026	-0.270 *** 1/	0.003
Income quintiles 1 and 2	-0.263 ***	0.026	...	...	...	...
Income quintile 3 2/	-0.261	0.004	...	...	...	...
Income quintile 4 2/	-0.269	0.005	...	...	...	...
Income quintile 5 2/	-0.283 ***	0.007	...	...	...	...
LN(income)	0.172 ***	0.034	0.100 ***	0.018	0.100 *** 1/	0.025
Household size	0.112 ***	0.007	0.111 ***	0.007	0.111 ***	0.007
LN(Area)	0.159 ***	0.035	0.159 ***	0.035	0.159 ***	0.035
Number of rooms	0.106 ***	0.012	0.106 ***	0.012	0.106 ***	0.012
Apartment	-1.298 ***	0.022	-1.300 ***	0.022	-1.300 ***	0.022
Rural	0.064 ***	0.021	0.064 ***	0.021	0.064 ***	0.021
Built pre-1980	0.045 **	0.018	0.046 **	0.018	0.046 **	0.018
Year of major renovation	-0.055 ***	0.007	-0.054 ***	0.007	-0.054 ***	0.007
Gas water heater	0.302 ***	0.020	0.303 ***	0.020	0.302 ***	0.020
Ease of gas availability	0.731 ***	0.022	0.731 ***	0.022	0.731 ***	0.022
Constant	-1.522 ***	0.393	-0.802 ***	0.264	-2.560 ***	0.202
R-squared	0.559		0.558		0.558	
Observations	8957		8957		8957	

*** Significant at the 1 percent level

** Significant at the 5 percent level

* Significant at the 10 percent level

1/Price elasticity evaluated at average income; income elasticity evaluated at average price.

2/ Price elasticity for income quintiles 3 to 5 is derived by adding the coefficient of the relevant price-income interaction term to the price elasticity for income quintiles 1 and 2.

Bibliography

Bentzen, J. and T. Engsted (1993): Short- and long-run elasticities in energy demand: a cointegration approach. Energy Economics 15, 9–16.

Bernstein, M.A., and J. Griffin (2006). "Regional Differences in Price-Elasticity of Demand for Energy". *The Rand Corporation Technical Report*.

Bohi D. R. and Zimmerman, M. B. 1984. An Update on Econometric Studies of Energy Demand Behavior. *Annual Review of Energy*. 9: 105–154

Hausman, J.A. 1981. Exact Consumer Surplus and Deadweight Loss. *American Economic Review* 71: 662–676.

Kilian, L. 2008. The Economic Effects of Energy Price Shocks. *Journal of Economic Literature*. 46 (4): 871–909

Liu, H., Liu, H., Zheng, G., Liang, Y. and Ni, Y. 2004. "Research on Natural Gas Load Forecasting Based on Support Vector Regression". Fifth World Congress on Intelligent Control and Automation. 15–19 June 2004. Vol.4, 3591A-3595.

Prosser, R.D. (1985): Demand elasticities in OECD countries: dynamic aspects, Energy Economics 7, 9–12.

Vartia, Y. 1983. Efficient Methods of Measuring Welfare Change and Compensated Income in Terms of Market Demand Functions. *Econometrica* 51: 79–98

World Bank. 2004. Azerbaijan Raising Rates: Short-Term Implications of Residential Electricity Tariff Rebalancing. World Bank Publication Report No. 30749-AZ. Washington DC.

World Bank. 2007. People and Power: Electricity Sector Reforms and the Poor in Europe and Central Asia. World Bank Publication. Washington DC.

Zhang, Fan. 2011. Distributional Impact Analysis of the Energy Price Reform in Turkey. World Bank Policy Research Working Paper 5831. Washington DC.