Cross subsidies in Russian electric power tariffs not as bad as their reputation

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abstract

In most industrialized countries electric power tariffs for residential consumption are higher than for industrial customers. In Russia, as in some other transition countries, this pattern is reversed, but at the same time the overall level of tariffs is very low. Cross subsidization of residential tariffs through industrial tariffs has been repeatedly criticized by economists and international organizations. This note argues that, while it is inefficient to keep tariffs below social cost, cross subsidies can be efficient. In fact, back of the envelop calculations for Russia suggest, that, given the prevailing level of tariffs, which is much too low, their structure is probably efficient.

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1. Introduction

In many formerly socialist countries, the policy of keeping prices for so called essential goods low has survived the collapse of the old ideology. In Russia this is the case with tariffs for rail–transport, electric power, gas, heating and water among others. In some cases, i.e. electric power, the provider has to cover the losses from serving residential customers at low rates through the profits from industrial customers which pay higher rates. This policy of cross subsidizing is routinely being criticized by economists and international organizations.[1] However, given the poverty of large parts of the population, policy makers have been reluctant to increase residential tariffs for social reasons and therefore failed to rebalance tariffs. This note argues that in the case of electric power the critique is in fact somewhat misplaced. Aside from social concerns, cross subsidies are justified for purely economic reasons.

It is a sound economic principle to charge every group of customers tariffs as close as possible to marginal cost. As it is more expensive to serve low voltage customers this would, in fact, require higher tariffs for residential users. However, if tariffs deviate from marginal cost for some reason, then the elasticity of demand has to be taken into account. The stronger demand responds to a change in price, i.e. the higher the price elasticity of demand is, the more important it is to keep tariffs close to marginal cost in order to minimize the efficiency loss from price distortions. As a rule, industrial users have a much higher price elasticity than households. In Western countries, where prices are usually *above* marginal cost in order to recover fixed cost of capacity, tariffs for residential users exhibit a higher 'mark up' on marginal cost than those for the industry. In this sense, households subsidize the industry. However, in Russia the situation is opposite. All tariffs are far *below* marginal social cost, and firms increase energy consumption much more than private households in response to low prices for power. In spite of cross subsidization, Russian households' power consumption is only half of that of Western European households, whereas the Russian industry consumes more than twice as much as their counterparts.[2] In order to limit wasteful power consumption it is, therefore, more important to keep industrial tariffs high. In other words, the cross–subsidization of residential

[1]Usually it is argued that cross subsidies should be abolished and poor households should be entitled to means tested subsidies instead, e.g. International Energy Agency (2002).

[2]OECD (2002)

households by the industry is efficient, given that tariffs in general are far too low.

In the next section we briefly review the main features of current power tariffs in Russia. Then we outline a simple model of second best tariffs, which clarifies the trade–offs to be taken into account in the Russian context. Finally, we present a rough quantitative calculation showing that the present relation between industrial and residential tariffs in Russia is probably efficient, though the overall level of tariffs is clearly not.

2. Electric Power Tariffs in Russia

At the retail level power tariffs are currently being regulated by the Regional Energy Commissions, which set specific tariffs for each groups of customers.[3] As the figures in table 1 indicate, the features of the schedules vary substantially between different regional energos.[4] In some regions agriculture obtains electric power cheaper than industry and city residents. In other regions it is opposite. Overall, however, residential customers get their electric power at a substantial discount, at less than 13 $/MWh compared to more than 17 $/MWh which industry had to pay in 2001.

This structure stands in marked contrast to tariffs in Western countries, whether regulated or shaped by market forces. For example, in Germany, tariffs used to be about 75 $/MWh for industrial customers and 110 $/MWh for residential users before deregulation. After liberalization, competition brought average tariffs down to around 55 $/MWh and 98 $/MWh respectively. This comparison, however, does not only illustrate the reversed structure of Russian tariffs but also their low level, begging the question, what an adequate level of power tariffs in Russia would be. The opportunity cost of providing electric power to domestic consumers are the lost revenues from selling fuel on world markets, the cost of labor, the environmental pollution, and the cost of replacing worn out capital. Measured against these cost, current tariffs, both for industry and households, appear to be far too low. Although it is difficult to come up with exact figures, we will argue below that 35 $/MWh is a

[3]Under the present plans of reform the Regional Energy Commissions are supposed to relinquish most of their power to a federal agency, but the original deadlines for the establishment of this agency slipped already, and the changes this will bring for tariff setting are not clear.

[4]With few exceptions ROA–UES holds a controlling stake in regional energos. For more details on the current structure of the industry see Hubert (2002), and OECD (2002)

Table 1: Cross Subsidization: selected regional tariffs [$/MWh]

AO-energo	industry	transport	agriculture	residential city	residential village
Mosenergo[1]	large 17.80 middle 29.78 small 27.38	20,20	15,06	21,56	15,06
Lenenergo[2]	large 16.00 other 29.00	22,00	22,00	21,00	15,00
Buryatenergo[1]	27,90	20,54	26,46	19,17	19,17
Irkutskenergo[1]	5,86	5,82	3,42	3,42	2,39
Krasnoyarskenergo[1]	10,70	10,98	11,36	9,58	9,58
Novosibirskenergo[1]	18,76	18,76	13,69	16,77	11,64
Tomskenergo[1]	22,61	17,73	15,74	15,74	15,74
Average RAO UES[3]	17.15			12.67	

Source: Company data, own calculation.

[1] Figures are for end of 2001. [2] Figures are for March 2001. [3] Average in 2001.

lower bound for these opportunity cost. With the current rates, the electric power sector survives only because it obtains fuel at a large discount, yields no return on investment, and ignores depreciation of capital and damage to the environment. As a result, Russian power users are induced to waste energy with little benefit at home, instead of selling the fuel expensive abroad or saving scarce resources for the future.

Before we look at the magnitudes of these effects, however, we shall state more precisely how to derive the optimal structure of tariffs.

3. Second Best Tariffs - Theory

We first outline the standard model of Ramsey pricing which is then adopted to capture the particularities of the situation in Russia. For simplicity we consider only two groups of power users, industrial and residential customers, indexed with I, and R respectively. The inverse demand is $P_I(x)$, and $P_R(x)$, with x denoting power consumption. The social cost of providing electric power, denoted C, is assumed to include all cost at their full value including the cost of capital, i.e. a normal return on investment. Due to the need for low voltage distribution these cost are somewhat higher for residential consumption, $C_I < C_R$.[5]

To make subsidies explicit, we assume that the power industry is charged with full social cost of power production and receives a transfer covering part of these cost. The state also taxes the industry. In practice transfers, as well as taxes, take a large variety of forms. For convenience we lump together all types of transfers and taxes and denote the net transfer by T, which would be negative in the case of taxation. Then the power industry's profit can be written as:

$$\Pi = P_I x_I + P_R x_R - C_I(x_I) - C_R(x_R) + T$$

Transfers and taxes of power industry interact with the overall system of public finance. In order to raise one dollar in tax–revenues the state has to inflict cost on taxpayers exceeding one dollar by what is called the dead–weight loss of taxation. Let $\lambda > 0$ denote the marginal loss of welfare from general taxation. Then the opportunity cost of the transfer T is given by $(1 + \lambda)T$. With this notation we obtain the consumer surplus as

$$CS = \int_0^{x_I} P_I(x)dx - P_I x_I + \int_0^{x_R} P_R(x)dx - P_R x_R - (1+\lambda)T.$$

and the social surplus:

$$S = \Pi + CS = \int_0^{x_I} P_I(x)dx + \int_0^{x_R} P_R(x)dx - C_I(x_I) - C_R(x_R) - \lambda T$$

Taking the shadow cost of taxation as given we have to select x_I, x_R and T in order to maximize welfare, subject to the condition that the industry breaks even.

$$\max_{x_I, x_R, T} \quad S, \qquad \text{s.t.: } \Pi \geq 0$$

From the first order conditions one easily obtains the well known Ramsey formula,

$$\frac{P_i - C_i'}{P_i} = \left(\frac{\lambda}{1+\lambda}\right)\frac{1}{-\epsilon_i} \qquad i \in \{I, R\} \tag{1}$$

stating that the relative mark up over marginal cost (the left hand side) should be proportional to the inverse of the price elasticity, ϵ_i, of demand of the respective

[5] For simplicity we assume that cost are separable and abstract from fixed cost. Recall, that we adopt a long term perspective, so that all cost of generation capacity and even some cost of transmission capacity are variable. The inclusion of fixed cost would not alter our results.

group of customers (the right hand side). Since $\lambda > 0$, prices should be above marginal cost but all profits will be taxed away, $T < 0$, in order to relieve the burden from taxation of other activities. Comparing formula (1) for the two groups, reveals why residential power users should pay higher rates. First, due to distribution losses, their long run marginal service cost are higher, $C'_R > C'_I$. Hence, the same 'mark up' requires a higher rate $P_R > P_I$. Second, residential customers have a lower elasticity of demand $\epsilon_R < \epsilon_I$ and should therefore be charged a higher 'mark up', which will raise tariffs even further.[6]

In order to analyze the Russian practice, we have to introduce two more constraints. First, we take into account that policy makers prefer a positive transfer to the power industry, $T = T_p > 0$. Note, that this desire will reduce welfare according to the usual criterion because it requires an increase of taxes in other sectors of the economy. Second, politicians want these subsidies to be passed on to power users in form of lower tariffs and not to create extra–profits in the power industry, $\pi \leq 0$. As prices for power fall below the marginal social cost of producing power, consumption will increase over its first best level, thereby reducing social welfare even further. To see this formally we solve

$$\max_{x_I, x_R, T} S, \quad \text{s.t.: } T = T_p > 0, \quad \text{and} \quad -\Pi \geq 0.$$

Let $\mu \geq 0$ and $\gamma \geq 0$ denote the Lagrange variables associated with the first, respectively second constraint. For $T_p > 0$ both constraints are binding and the shadow cost of making transfers to the power industry is given by the sum of the marginal welfare loss of raising taxes elsewhere in the economy and the loss from overconsumption of power, $\mu = \lambda + \gamma$. The first order conditions for x yield the modified Ramsey rules:

$$\frac{P_i - C'_i}{P_i} = \left(\frac{-\gamma}{1-\gamma}\right)\frac{1}{-\epsilon_i} \qquad i \in \{I, R\}. \tag{2}$$

The only change compared to expression (1) is that the shadow cost of taxation λ has been replaced by $-\gamma$. As γ measures the marginal gain of welfare caused by a small increase of tariffs, one can argue that policy makers insisting on low tariffs act as if one dollar paid in transfers would cost society only $(1-\gamma)$. It should be stressed

[6] For simplicity, and given the lack of empirical evidence on the elasticities of power demand, we assume them to be constant.

that we do not see a justification for such a policy of low tariffs. We only take into account that policy makers may have a different opinion and ask how tariffs for the two groups should be set in order to minimize the loss from overconsumption.

As before, higher service cost for households push for higher residential tariffs. But now we have a countervailing effect. Since the price elasticity of industrial demand is higher, the welfare loss from deviating from marginal cost pricing is larger in this sector. Hence, the relative discount (left hand side of (2)) should be *smaller* than for private households who respond less to lower prices.

To see this more explicitly, we solve the expression of the industrial tariff for the implicit marginal welfare cost of low tariffs obtaining:

$$\gamma = -\frac{-\epsilon_I(P_I - C_I')}{P_I + \epsilon_I(P_I - C_I')}.$$

Substitution in the formula for residents yields the second best residential tariff P_R^* as

$$P_R^* = C_R' \cdot \left(1 - \frac{P_I - C_I'}{P_I} \cdot \frac{\epsilon_I}{\epsilon_R}\right)^{-1},$$

which can be compared with its real life counterpart, to asses the consistency of the tariff structure.

4. Is the current tariff structure consistent?

Theory helps to understand the trade–offs in tariff setting, but it requires numbers for elasticities and marginal cost to assess the current practice in Russia. Unfortunately, knowledge of long term price elasticities of power demand is scant.[7] In Russia current consumption pattern of the industry was not derived from cost minimization and the economic situation of private households has seen dramatic changes during the last decade. Hence, it is even more difficult to judge long term price elasticities. It appears sensible to assume a price elasticity for industry somewhere at −1.5 and

[7] The main difficulty arises from the fact, that long term price elasticities are largely determined through the impact the tariffs have on the choice of appliances, for which it is difficult to disentangle the influences of income and price (Dubin & McFadden (1984)). Once the stock of appliances is given, short run price elasticities are usually very low, in the range of 0 to 0.4. For example Reiss & White (2001) find that the average elasticity for Californian households without electric space heating and without air conditioning is 0.08, and almost half of all households did not respond to prices at all.

for residents between −0.7 to −1. This would roughly correspond to estimates for the USA in the early seventies, when a long period of cheap energy prices came to the end.[8]

Being interested in a welfare assessment we must look at the marginal opportunity cost of power consumption to Russian society as a whole. In principle, these cost consist of cost of generation and transmission capacity, cost of labor and fuel, and environmental damages.

The collapse of the Russian economy left the country with huge overcapacities in the electric power industry. One might therefore argue, that the opportunity cost of capacity are zero as assets in the power industry have little other use anyway. In the long run, however, old equipment has to be replaced to maintain a capital stock large enough to satisfy demand with a reasonable safety margin. Notwithstanding considerable controversy about reasonable capacity requirements, RAO UES wants to install 5000 MW over the next years in order to replace depreciated assets, and even critics acknowledge that after a decade of almost zero investment, there is an increasing need to upgrade assets. In March 2002 RAO–UES reached an agreement with the German utility E.ON on a feasibility study for 1000 MW capacity of combined cycle gas turbines with an estimated installment cost up to 600 \$/kW. We will use this project to estimate the marginal cost of generation capacity. In order to transform the initial investment I of 600 \$/kW into the current fixed cost of providing capacity f, measured in \$/MWh, which can be added to the variable cost, we ask which average price would be needed in the long run to recover the expenditure I. The answer depends on the lifetime T of the plant, usually assumed to be 20 years for combined cycle gas turbines, the load factor l and the appropriate annual interest rate r for real investment in Russia according to:[9]

$$f = \frac{I}{l \cdot 8.76} \cdot \frac{r}{1-(1+r)^{-T}}.$$

In the year 2000 the average load factor for RAO–UES thermal plants was 0.39 (Brunswick 2001). As this figure is likely to increase over time and combined cycle

[8] See for example Chapman & Tyrell & Mount (1972).

[9] The first term relates investment cost to electric power typically produced during the 8760 hours of a year and changes units of measurement from kW to MW. The second term accounts for the need to discount future payments. For further details see Stoft 2002.

gas turbines are somewhat in between typical base load generators such as nuclear plants or coal fired station on the one hand and peak load generators as gas turbines on the other, we consider a range of 0.45-0.60 for the load factor. Assuming an interest rate of 15%, which appears to be low for real investment in Russia, we obtain fixed cost of power generation in the range of 18 to 24 \$/MWh. A more conservative interest rate and a somewhat lower investment cost would yield similar figures.

The Russian Government keeps the price of natural gas in the country deliberately low. Hence, internal gas prices do not reflect the opportunity cost of gas to society. We assume here that, at the margin, these are given by the lost revenues from selling gas in Western Europe.[10] In 2001 the price for delivery in Germany reached about 120 \$/Tm^3 while the average price in Russia was at 13.5 \$/Tm^3 (International Energy Agency (2002)). However, in the mid nineties prices in Western Europe used to be somewhat smaller in the range of 90 to 100 \$/Tm^3. From these figures we have to deduct the cost of transport through Belaruss and Poland, which will be in the order of 20 – 30 \$/Tm^3. Hence for a power plant in western Russia the opportunity cost of gas will be in the range of 50 to 90 \$/Tm^3. Assuming an energy efficiency of 55% for the combined cycle gas turbine, 1000 Tm^3 gas will produce about 5100 MWh electric power which leaves us with fuel cost in the range of 9.80 – 17.60 \$/MWh. Adding fixed capacity cost and variable fuel cost we obtain generation cost in the range of 28 to 53 \$/MWh.

Losses and internal consumption in Russia's electric power system reach almost 20% of total consumption. To the extend that these occur in low voltage distribution, they have to be attributed to residential consumption otherwise to both. We assume that half of the losses is due to distribution. Given that industry has a share of almost half in total consumption, we inflate cost of generation by 10% for both customers and by yet another 20% for residents to obtain cost of supply in the range of 31 to 58 \$/MWh for industry and 37 to 70 \$/MWh for residents. As these figures do not

[10]Given the fairly large share of Russian gas in the Western European market, one might argue that Russia enjoys considerable market power. As a monopolist would already have chosen exports in order to maximize profits a marginal increase of exports could not increase profits. In this case the opportunity cost of gas would have to be calculated from the true cost of delivering gas in Russia. These too are much higher than current prices as is evident from the losses Gasprom suffers from its sales in Russia.

Table 2: Second best tariffs for residential customers [$/MWh]

industrial tariff	marginal cost for industry/housholds [$/MWh] 30/36	35/42	40/48	45/54	50/60	60/72	γ for 30/36
60					90.00	72.00	3.00
50				67.50	60.00	51.43	1.50
45			61.71	54.00	49.09	43.20	1.00
40		56.00	48.00	43.20	40.00	36.00	0.60
35	50.40	42.00	37.33	34.36	32.31	29.65	0.27
30	36.00	31.50	28.80	27.00	25.71	24.00	0.00
25	25.71	23.33	21.82	20.77	20.00	18.95	-0.23
20	18.00	16.80	16.00	15.43	15.00	14.40	-0.43
17	14.23	13.47	12.95	12.58	12.29	11.88	-0.53
15	12.00	11.45	11.08	10.80	10.59	10.29	-0.60
10	7.20	7.00	6.86	6.75	6.67	6.55	-0.75

Assumptions: Price elasticity for industry: 1.5, for households: 0.75

account for the cost of transmission and distribution capacity, maintenance, labor, and environmental damage they still underestimate the long run opportunity cost of power consumption to society.

With these assumptions we calculate figures for the optimal residential tariff as they depend on the industrial tariff and on marginal social cost (see table 2). The first column gives alternative tariffs for industrial users as the regulator might set them. The next six columns give the corresponding second best residential tariffs for various assumptions about the marginal cost of supply of power to industry and households. If we assume that marginal cost for industry are at their lower bound of 30 $/MWh and cost for residents 20% higher at 36 $/MWh, then we are in the second column. If the regulator would set industrial tariffs equal to cost, i.e. to 30 $/MWh, then residential tariffs should also exactly cover cost, hence be set equal to 36 $/MWh. The last column indicates the marginal welfare impact of distorted prices, which is zero in this case, since tariffs would be at their first best level. If, however, industrial tariffs are raised *above* marginal cost by 5 $/MWh to 35 $/MWh, residential tariffs should raise much faster by almost 15 $/MWh up to

50.40 $/MWh. This is the situation which prevails in Western Europe. However, the average industrial tariff in Russia was *below* cost at 17 $/MWh. In this case residential tariffs should be decreased down to 14.23 $/MWh. The last column indicates the substantial marginal welfare losses of this policy. More than half of the value of the subsidies is lost, because power users waste energy. These effects get stronger as we assume to higher marginal cost. At the upper bound of 60 $/MWh for the industry, residential tariffs should be lowered to 11.88 $/MWh. Hence, at the present rate of 17 $/MWh for industrial customers, cross subsidization it is in fact optimal over the whole range of social cost which we consider here. Surprisingly, our admittedly rough estimate yields figures which compares favorable to the current average of 12.67 $/MWh in Russia. Hence, it appears as even if the magnitude of current cross subsidization is at least not out of range. Furthermore, it would require about a twofold increase of industrial tariffs before residential tariffs should catch up, which still implies cross subsidization, as low voltage service cost are higher. However, one has to bear in mind that our estimates are rough and the case for cross subsidization gets weaker as one assumes lower opportunity cost, higher elasticity for demand for households or higher relative service cost.

X. Conclusion

The only practical way to improve the energy efficiency in Russia is to increase tariffs. Such an increase is also needed to obtain a clear picture what capacity is truly needed in the power industry in the long run. It is to be expected that even modest increases in tariffs will induce the Russian industry to become more energy efficient and prevent scarce funds from being wasted on investment in new capacity in power generation and transmission. Delaying the adjustment runs the risk of perpetuating Russia's exaggerated dependence on energy intensive industries as new investment is again guided into areas of industry, transport and agriculture which appear profitable only because they obtain power extremely cheap.

However, given that power tariffs are far too low, cross subsidies from industry to private households do not present yet another problem. Quite to the contrary, in such a second best environment, cross subsidies are needed to minimize the welfare cost of price distortions. Rough calculations show that the current structure of power tariffs in Russia is reasonably efficient — at least if one takes the cost of maintaining present capacities into account. A need to rebalance tariffs arises only as industrial tariffs are increased. According to our estimates, it would require about a twofold increase of industrial tariffs before residential tariffs should catch up.

This insight has important implications for energy policy. Russia is currently following the international drive to open the power market for competition. While it is not yet clear, how much of the plans will be implemented, the overall aim is to stimulate competition between power generators, while focussing regulation on the transmission system. International experience suggests that competition develops much easier in the wholesale market. Hence it is likely to put particular pressure on tariffs for industrial customers which at their present level allow for positive profit margins. As these margins are being eroded the energos would loose the revenues needed to cover current losses in the residential sector. Finally, they would be left with little choice but to raise residential tariffs. While this process would abolish cross subsidies and bring tariffs in line with current *private* marginal cost, tariffs for industry would depart even further from *social* marginal cost and energy efficiency would decline.

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