# Energy Price Incentives in a Planned Energy Economy

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While understanding of price and rebate mechanism operation in the U.S. may be imperfect, in Poland most of the necessary infrastructure simply does not exist. Of all the former Soviet bloc countries, Poland has moved most quickly to a market economy, however the stresses have been and continue to be significant, particularly upon the pensioned. The energy sector of the economy is still centrally planned, as the legal framework for a transition to a regulated market is created. Some utilities have made more rapid progress than others in the transition.

Part of the Clean Fossil Fuels and Energy Efficiency Project was designed to test the efficacy of energy price incentives in the residential heating market. As an example of the detail of regulation in a planned energy economy, heating control is not exercised by the resident using a thermostat. Rather, municipal utility engineers vary system supply water temperature at the central electric power and heating station, in response to weather conditions. Heating energy has been highly subsidized, at up to 90% of cost, and the pricing is based only on apartment size, not on measured energy use at either the apartment or the building level.

The paper describes a one year experiment involving design, implementation and analysis of a pilot pricing, conservation and heating system control experiment in 264 apartments in four buildings. The results, and U.S. experiences, will be used to guide the pricing decisions of the municipal district heat utility, Miejskie Przedsidsiorstwo Energetyki Cieplnej w Krakowie (MPEC), and the conservation and air quality strategies of the Kraków Development Authority, Biuro Rozwoju Krakowa (BRK).

Development of a price incentive strategy involved considerations of public policy toward fixed income occupants and ownership of energy metering. Thermostats were installed to permit occupant control, and building level conservation and control techniques were implemented. Physical constraints required use of German “cost allocator” metering technology at the apartment level.

Final subsidy or “pseudo pricing” design included building level incentives as well as apartment performance inducements. Results include insights on communication and cultural impacts and guidance for future testing as well as energy conservation effectiveness values.

## Introduction

As the countries of Eastern Europe come out of the long period of centrally managed economies, Poland is often recognized for its impressive transition toward a market economy. Poland is making its transition without the rampant inflation and long lines for food and fuel of some neighbors, albeit at the cost of double digit unemployment and an economy, although fast-growing, that is still in shock. Joint ventures with multinational enterprises contributing capital and experience are actively pursued, and a small stock market is developing with about 20 companies currently being traded. Long lines are seen in front of banks which conduct market trading, and stories of investment successes and failures by neophyte traders who are using their inflation ravaged pensions are commonplace. Of note however, is the understandable lack of experience with forming and operating regulatory bodies, such as the U.S. Securities Exchange Commission, the Federal Trade Commission, and the Public Utility Commissions, which establish guidelines for many aspects of the American market economy. Perhaps a common misperception amongst former ‘central planners’ is the extent to which a natural monopoly such as an electric utility really operates under government regulation, which in the U.S. is striving to approximate the effects of a free market economy. While the understanding of price and rebate mechanisms and their operation in the U.S. may be imperfect, in Poland much of the necessary infrastructure simply does not exist.

## General Utility Background

The energy sector of the Polish economy is still centrally planned, as the legal framework for a transition to a regulated market is evolving. This sector in Poland is currently the subject of much proposed legislation, designed to privatize utilities, provide market incentives and encourage conservation and economic growth. Consideration is now being paid as well to the health and environmental costs of air pollution from coal fired generation and the prevalence of local boiler houses. The Polish government is aggressively pursuing international funding for such environmental improvements via sources such as the World Bank. All of these potential changes must also occur while putting into place a system of regulation to prevent monopolistic abuses, to allocate costs equitably and to protect consumers who may be unable to afford energy necessities.

Independent, investor owned generating companies have been formed to sell electricity into the national power grid. These companies are paid by the federal electric grid company, PSE, which owns and operates the grid. The Leg combined power and heat plant outside of Krakow sells electricity to the grid as well as selling heat to MPEC for district heating. The newly developing corporate structure also includes thirty three distribution companies, now being privatized, to purchase electricity from the grid.

Currently, the price paid by the distribution utility to the grid is set by one ministry of the federal government while end user electricity prices are set by another ministry, with little apparent coordination. In similar fashion the price MPEC pays Leg is set by one ministry while its selling price is set by another. It is not uncommon, for example, for major industrial end users to have time of day rates, which the distribution utility's non-time differentiated fixed cost per kWh may not cover during the off-peak period. These structural pricing inconsistencies lead to a strong disincentive for the utility to promote off-peak use or on-peak conservation. Further, government subsidies are often required at both the production and consumption levels to offset shortfalls. The eventual removal of these and other federal subsidies, and the resultant impact upon individuals and the economy, is a source of great concern and many government studies.

As of March, 1994, average electric rates are about 1100 Polish zloty per kWh. At the exchange rate of 22,000 zloty per U.S. dollar, the Poles are paying about five cents per kWh. (Although Poland's inflation rate is low by eastern European standards, the zloty has dropped from about 11,000 per dollar in 1992 to about 22,000 per dollar today, a loss of value versus the U.S. dollar of about 3% per month. Therefore, use caution when comparing prices over time.) The price of electricity, approximately the same as in the U. S., needs to be contrasted, however, with the average Polish family income of $200 to $300 per month, and the high unemployment rate. It should be noted that residential electricity use is very low compared to the U. S., given its significant price tag in comparison with income. Industrial applications, particularly steel and coal, comprise about 90% of the Southwestern Polish market for electricity.

## Utility Examples

In Kraków, the municipal district heat utility, Miejskie Przedsiebiorstwo Energetyki Cieplnej w Krakowie (MPEC), charges approximate market prices, about 80,000 zloty per GJ. Heating for residential customers, however, is subsidized by the state. At the beginning of the 1992-1993 winter, the subsidized rate was 1120 zloty per month per square meter of apartment floor area. That is, the customers pay 1120 zloty per month per square meter of apartment, without regard to actual use. The apartments are small, averaging about 50 to 60 square meters (500 to 600 square feet). The cost to the resident works out to about 700,000 to 800,000 zloty annually for the typical apartment, versus the MPEC bill to the housing cooperative of about 3.3 million zloty. The difference is currently made up by state subsidy, but the willingness of the state to continue these subsidies is known to be short-lived.

In the predominant residential housing, heating control is not exercised by the resident using a thermostat. Rather, municipal utility engineers vary system supply water temperature at the central electric power and heating station, in response to weather conditions. Such controls by the municipal utility are set daily and the effects take about one day to impact the system. Naturally, any severely undersized radiators are eventually replaced, while oversized units are not. As a consequence, there is substantial overheating in mild weather, and windows are routinely opened to regulate temperatures, even in large metropolitan high-rise office buildings. While radiator valves are present, they are not used for control, due to valid occupant fears of leaks and/or being unable to open the valves again when it became colder. Therefore, any inherent efficiencies attributable to district heating are largely negated by the inability of consumers to restrict the heat. It is easy to sympathize with the resident's fear of rising heating bills and disappearing subsidies. It is not as easy to see the heat wasted through open windows while recognizing the wasted production costs, all in an economy that can ill afford to waste any resources.

The most striking part of the district heat pricing equation is that most buildings are not metered by MPEC. Rather, the heat utility designs the building radiator sizing, based on calculated heat loss, and then the design peak rate of energy use is calculated, based on the installed radiator capacity. The calculated peak rate, or demand, is charged for the six winter months. The monthly energy used is also calculated, not metered, and a monthly bill, with energy and demand components, is determined. Table 1 shows the MPEC criteria for calculating peak demand, based on current construction codes.

**Table 1.** Design Heating Power Rates and Peak Demand

| Volume in $M^3$ | Watt/ $M^3$ K | KCal/ $M^3$ h C |
|---|---|---|
| 500 | 0.70 | 0.60 |
| 1000 | 0.64 | 0.55 |
| 1500 | 0.58 | 0.50 |
| 5000 | 0.52 | 0.45 |

## The Kraków Project

The Kraków Clean Fossil Fuels and Energy Efficiency Project was created to develop methods of improving the air quality in and around the city of Kraków, Poland. Subproject 1, District Heat and Energy Efficiency, attempts to find feasible methods to conserve district heating energy. This is primarily to permit extension of the system, which is limited by heat source, pump and piping capacity, and to allow shutdown of highly polluting local boiler houses. Extension would allow district heat to substitute for in-home coal stoves, while the Leg combined power and heat plant generates less pollution than the local boiler houses for the same heat output. In addition, of course, conservation also provides the benefits of an overall reduction in coal burned. Part of the subproject was designed to gather information about the efficacy of energy price incentives in the residential heating market. The finding for this project stemmed from a U.S. AID grant.

The Polish American team led in Krakow by the Kraków Development Office, Biuro Rozwoju Krakowa (BRK), conducted a one year experiment. The experiment involved design, implementation and analysis of a pilot pricing, conservation and control experiment in four identical multifamily buildings, numbers 4, 6, 8, 10, on Wolasa Street in Kraków. Each of the buildings contains 66 apartments, all occupied. For purposes of testing the impact of price incentives, the relevant comparison is between Wolasa 6 and Wolasa 8. Number 4 was kept as a control, and number 10 was weatherized in addition to the pricing experiment. Building heat metering was installed in September, 1992, and the first half of the winter was used to establish baseline conditions.

In Wolasa 6, a building level control system was installed to vary building heating water temperature in response to outdoor temperature. This system was the minimum energy efficiency retrofit recommended by both MPEC and the U.S. engineering team. In Wolasa 8, thermostat valves were installed on essentially all apartment radiators to permit occupant control of energy use. German manufactured "cost allocators" were installed to estimate the amount of heat used by each radiator since the building's piping configuration made it infeasible to directly meter each apartment with a heat meter. The results of number 10 Wolasa Street, with added savings due to weatherization, will serve as an interesting commentary on the effectiveness of the cost allocator technology. All the plumbing retrofit was performed before the beginning of the heating system, but the improvements were disabled during the baseline period–prior to January, 1993.

The energy pricing test could not rely on modifying actual prices, since the heating cost paid by the residents was mandated by law and was a small portion of the actual cost, and judged too small to have a noticeable impact. We therefore decided to pay rebates, or "pseudo price incentives" to the residents, based on the approximate unsubsidized cost of the heating energy. The rebates were set up to be based on monthly apartment energy use, as estimated by the cost allocators, as a percent savings from the estimated energy. Recognizing the imprecision in our apartment level measurements, we set the rebates as a two step function. Apartments saving at least 10% of the target energy use in a month would receive a 100,000 zloty rebate. Those saving 25% or more would receive an additional 100,000 zloty rebate, for a total of 200,000 zloty. Each resident was guaranteed that his bill would not increase due to the project. In addition, MPEC agreed to not increase the total building bill above the contract rate, even if the metered amount exceeded the MPEC projections. Any reduction would be refunded to the housing cooperative. Apartment rebates would be paid based on heating energy use during February, March and April, 1993. The target for each apartment was calculated according to Equation 1.

$$\text{Target} = \sum \text{Radiator in Apt} * \text{Hrs in Mo.} * \text{Fxo} \quad (1)$$

Fxo is a factor of outdoor temperature, wind and cloud cover used by MPEC to estimate heating requirements for the entire system and set supply water temperature. Table 2 shows an illustration of the determination of Fxo.

Much of the energy use at the building level occurs in heating the common areas, such as the hallways and stairwells. In addition, we recognize that our price signal feedback mechanism is crude. Both the calculation of the apartment targets and the readings of the cost allocators are subject to high variability. Therefore an additional "Solidarity" rebate was initiated, based on the total building monthly heating energy use, using Equations 2 and 3. The maximum monthly apartment "Solidarity" rebate was set at 100,000 zloty, at a twenty percent building monthly heating energy reduction. Because the building improvements were made earlier than the cost allocators were installed, we were able to schedule the "Solidarity" rebates for January through April.

$$\textit{Rebate} = 100{,}000\ z\ell * (\textit{Target} - \textit{Actual})/(0.2 * \textit{Target}) \quad (2)$$

$$\text{Target} = \text{Design Heat Loss} * \text{Hrs} * \text{Fxo} \quad (3)$$

To introduce the program, printed materials were prepared and a "town meeting" was held with the residents of the buildings. Trained technicians were on site performing retrofit work in number 10 Wolasa street for several weeks prior to the beginning of the rebate period, and discussed the concept with the residents.

## Results

### Behavioral Effects

Consistent with expectations based upon improvements in comfort, the residents at number 8 Wolasa Street did use their thermostats. Figure 1 shows the operation of one thermostat at different settings. The temperature profiles clearly demonstrate that the thermostats were operational. At least once during the project we were called to an apartment with a complaint of "no heat." On arrival we found a group of men in tee shirts, playing cards. The apartment temperature was well above 20°C (68°F). Upon being asked about the complaint, the resident went to the radiator and said that it was cold. This reaction was not unusual, since in the past, the radiators were normally hot all winter; a cold radiator was a sign of trouble. In this case though, the radiator had been shut off by the thermostat. While learning the lessons of radiator thermostats was quite foreign at first, residents have related their satisfaction with controlling their own heat even now when they are no longer receiving rebates for doing so.

As residents became more familiar with the thermostats, they began to trust them more and to enjoy the increased comfort. In interviews with the residents, the increase in comfort was cited repeatedly and with great enthusiasm. The project called for temporary disabling of the thermostats from apartments beginning this past mid-winter in order to further assess their savings potential, however many residents refused to allow their removal. Further, residents spoke of friends who would like such improvements and were offering to pay for materials and for installation if such a service were available. At this time such an investment would be based upon comfort alone, since there is currently no payback to the resident for reducing his usage of heat.

### Savings Results

Table 3 shows the initial rebates paid to each apartment in Wolasa 8. These included payments for the building level rebates for January through April, and for the February and March apartment level rebates. An additional five

**Table 2.** Determination of Factor Fxo by MPEC

| Temp | Cloudy | | | Partly Cloudy | | | Sunny | | |
|---|---|---|---|---|---|---|---|---|---|
| | Wind Speed (m/s) | | | | | | | | |
| (°C) | <3 | 3-8 | >8 | <3 | 3-8 | >8 | <3 | 3-8 | >8 |
| -20 | 1.00 | 1.04 | 1.07 | 0.99 | 1.03 | 1.06 | 0.98 | 1.02 | 1.05 |
| -19 | 0.97 | 1.01 | 1.04 | 0.96 | 1.00 | 1.03 | 0.95 | 0.99 | 1.02 |
| . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . |
| 12 | 0.20 | 0.21 | 0.21 | 0.15 | 0.16 | 0.16 | 0.10 | 0.10 | 0.11 |

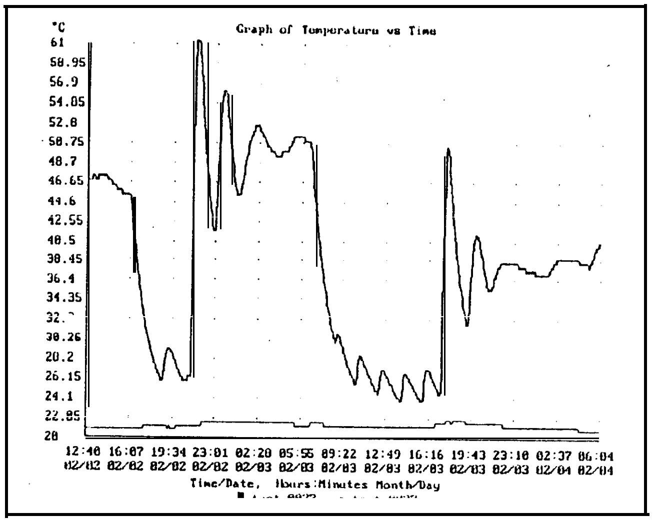

**Figure 1.** Radiator Surface Temperature at Different Thermostat Settings

million zloty was subsequently paid for the April apartment level rebates. Of the 26,690,000 zloty in total rebates, 80% were building related. As the table shows, over half the apartments received only the 215,000 zloty "solidarity" rebate. Figure 2 shows the distribution of the rebates.

Total annualized building heating energy savings were 12.4% at Wolasa 8, versus 3.5% at Wolasa 6—an apparent 8.9% benefit for the combination of thermostats and price signals. However, the building reset controller was erratic for some portion of the experiment, resulting in periods when Wolasa 8 was maintained at a lower temperature than the occupants desired. This undoubtedly contributed to the apparent savings, so the 8.9% value must be viewed as a maximum.

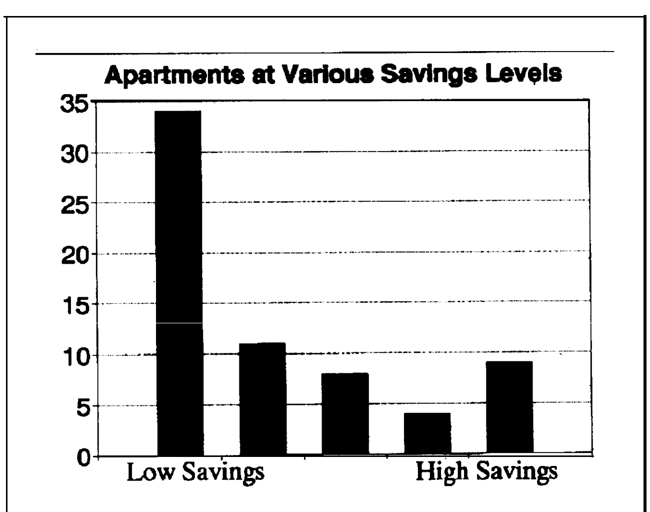


**Figure 2.** Number of Apartments at Various Rebate Levels

The cost allocators used were not demonstrated to be functional for this purpose. As evidence of this, we can look at Wolasa 10, which was treated like Wolasa 8, but with the addition of low cost weatherization and insulation. There, the total building heating energy savings exceeded 20% and the occupants were comfortable all winter. Yet the use of the cost allocators resulted in total rebates of 27,700,000 zloty for number 10, only 4% more than Wolasa 8 despite having 75% more energy savings.

As a very rough gauge of the accuracy of the designed rebate structure, the total amount rebated for Wolasa 8 and 10, just over 54 million zloty, is about 20% less than the amount refunded to the cooperative by MPEC, due to the metered use being lower than calculated.

## Recommendations

The results, and U.S. experiences in pricing experiments, will be used to guide the pricing decisions of the municipal utility, Miejskie Przedsiebiorstwo Energetyki Cieplnej w Krakowie (MPEC), and the conservation and air quality strategies of the Kraków Development Office, Biuro Rozwoju Krakowa (BRK).

The experiment is continuing through the 1993-1994 winter, with weatherization of Wolasa 8 in mid winter. MPEC's initial enthusiasm for cost allocator technology has been dampened, The pricing mechanism was new to the residents, and they got limited and late feedback during the 1992-1993 winter, but individual heat metering and payment is rare in U.S. centrally heated multifamily housing as well.

As was painfully evident in the U. S., utility revenue issues can be a critical element in a conservation program. MPEC evidences many of the same concerns we have seen in the U.S. MPEC would like to help their customers, and wants its customers to like them. This argues toward energy efficiency. MPEC is also concerned that conservation will raise rates, hurting some customers and creating ill will. There is also a fear that increasing prices will reduce sales sufficiently to create what has been called a "death spiral" in the U.S. As in the U. S., it appears that these concerns in Poland are overly magnified. MPEC is now quite concerned with its metering program, fearing that only the more efficient buildings will sign on. To some extent that is happening already. A cooperative has contracted for energy efficiency improvement and paid for metering to save on its heating bill.

On the electric side, consumers have long paid for the metered energy. The market problems here concern the federal government as "THE GRID" into which generation companies must sell and from which distribution companies must buy.

**Table 3.** Wolasa 8 Rebates - Jan through Apr Building, Feb & Mar Apartment

| Unit | Rebate - złoty | Unit | Rebate - złoty |
|---|---|---|---|
| 1 | 415,000 | 34 | 615,000 |
| 2 | 315,000 | 35 | 615,000 |
| 3 | 615,000 | 36 | 315,000 |
| 4 | 415,000 | 37 | 215,000 |
| 5 | 215,000 | 38 | 215,000 |
| 6 | 315,000 | 39 | 215,000 |
| 7 | 215,000 | 40 | 215,000 |
| 8 | 315,000 | 41 | 215,000 |
| 9 | 215,000 | 42 | 315,000 |
| 10 | 215,000 | 43 | 215,000 |
| 11 | 215,000 | 44 | 215,000 |
| 12 | 615,000 | 45 | 415,000 |
| 13 | 215,000 | 46 | 215,000 |
| 14 | 215,000 | 47 | 215,000 |
| 15 | 215,000 | 48 | 215,000 |
| 16 | 515,000 | 49 | 215,000 |
| 17 | 415,000 | 50 | 215,000 |
| 18 | 515,000 | 51 | 215,000 |
| 19 | 415,000 | 52 | 215,000 |
| 20 | 215,000 | 53 | 215,000 |
| 21 | 615,000 | 54 | 315,000 |
| 22 | 215,000 | 55 | 215,000 |
| 23 | 215,000 | 56 | 215,000 |
| 24 | 615,000 | 57 | 215,000 |
| 25 | 215,000 | 58 | 315,000 |
| 26 | 215,000 | 59 | 315,000 |
| 27 | 615,000 | 60 | 615,000 |
| 28 | 315,000 | 61 | 215,000 |
| 29 | 315,000 | 62 | 415,000 |
| 30 | 615,000 | 63 | 415,000 |
| 31 | 515,000 | 64 | 515,000 |
| 32 | 415,000 | 65 | 215,000 |
| 33 | 315,000 | 66 | 215,000 |
| Total | | | 21,690,000 |
| Mean | | | 328,636 |
| Standard Deviation | | | 144,481 |