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Coping with the Cold

Heating Strategies for Eastern Europe and Central Asia's Urban Poor

Julian A. Lampietti
Anke S. Meyer

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Cover photo by: Svend Erik Mikkelsen. Sellers of the fuelwood stoves on the street market in Vanadzor, Armenia.

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Foreword

Europe and Central Asia (ECA) is unique among developing regions in that the cold winters necessitate additional expenditures on heat. This study is the first comprehensive examination of heat demand in ECA. For the urban poor in our region, covering heating expenditures has become a major challenge. Problems are compounded by the rapid deterioration or collapse of central heating services in some countries. The challenge ahead is to design policies and investments that enable all people (poor and nonpoor) to access clean, affordable heating.

The authors use household survey data from selected countries in the region to analyze household energy consumption and heating patterns. The analysis provides several empirical findings with significant policy relevance relating to household expenditures on heat, the income and price elasticity of heat demand, and fuel choices. In the countries studied, nonpoor people obtain heat at a cost of between \$30 and \$50 per year while poor people spend between \$25 and \$40 a year. The nonpoor also enjoy a higher quality heat supply at only slightly greater cost than the poor. This suggests that heating policy or investment interventions that result in higher costs than existing systems will face substantial implementation resistance among the poor. Indeed, although the absolute cost differences are small, proportionally the poor spend almost twice as much of their household budgets on heating as do the nonpoor. Also, consistent with the expectation that the poor already have cut heat consumption close to the minimum needed to avoid health problems and chosen dirtier fuels to further save money, the survey data show that the demand of the poor is less income and less price elastic than that of the nonpoor. This implies greater proportionate welfare losses to the poor and a more active search for substitutes if heating prices increase. It suggests the possibility of designing price-based heating subsidies that benefit the poor more than the nonpoor. However, in targeting subsidies, subsidy design must be based on an understanding of income-linked access rates to clean energy networks. If the poor lack network access, the bulk of network-based subsidies will be captured by the nonpoor and therefore subsidies for non-network solutions may result in better poverty targeting.

By providing new insights into how much energy people demand for heating and how much they pay for it, this study raises awareness in the Bank, as well as in the region, on the links between heating, poverty alleviation, and environmental sustainability. By increasing our understanding of heat demand, particularly at low income levels, it improves our ability to assess the advantages and disadvantages of various supply options and to identify policies that are most likely to lead to outcomes that are acceptable from a social, fiscal, and environmental point of view.

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Abstract

Heating is a critical issue for people's livelihoods in Eastern Europe and Central Asia. The region's cold climate, the legacy of central planning, and the drop in household incomes over the past 10 years influence profoundly the design of heating strategies for the urban poor. This paper provides new insights into how much energy people demand for heating and how much they pay for it and makes recommendations on how to design policies and investments that enable all people (poor and nonpoor) to access clean, affordable heating.

Acknowledgements

This report was written by Julian A. Lampietti (Task Team Leader) and Anke S. Meyer. The report was conceived by Laszlo Lovei (formerly Sector Leader ECSEG) and completed under the guidance and direction of Lee Travers (Sector Leader ECSIE) and David Craig (formerly Sector Leader ECSEG).

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Executive Summary

Heating is a critical issue for people's livelihoods in Eastern Europe and Central Asia. The region's cold climate, the legacy of central planning, and the drop in household incomes over the past 10 years influence profoundly the design of heating strategies for the urban poor.

This paper uses survey data from selected countries in the region[1] to study how people heat their homes. It provides new insights into how much energy people demand for heating and how much they pay for it. The reader must keep in mind that heating is a local issue and solutions depend on the local circumstances. Therefore the guidance offered in this report must be adapted based on analysis of local conditions.

Analysis of the survey data revealed that almost all households use electricity, with small differences between the poor and the nonpoor. Poor people are much less likely to use district heat and gas and much more likely to use wood and coal. Unfortunately, the data cannot tell us whether the poor are more likely to use dirtier fuels because they lack access to the clean network fuels or because the prices of clean network fuels are higher. However, fuel choices by the poor correlate highly with fuel prices, and those prices have been consistently lower for the dirtier fuels over the past decade.

Household demand for heat

The analysis of household demand for heat in Armenia, Kyrgyz, and Moldova provides several empirical findings with significant policy relevance. These findings relate to expenditures on heat, the income and price elasticity of heat demand, and fuel choices.

First, in the countries studied, nonpoor people obtain heat at a cost of between \$30 and \$50 per year while poor people spend between \$25 and \$40 a year. The nonpoor also enjoy a higher quality heat supply at only slightly greater cost than the poor. This suggests heating policy or investment interventions that result in higher costs than existing systems will face substantial implementation resistance among the poor. Indeed, although the absolute cost differences are small, proportionally the poor spend almost twice as much of their household budgets on heating as do the nonpoor.

Second, consistent with the expectation that the poor already have cut heat consumption close to the minimum needed to avoid health problems and chosen dirtier fuels to further save money, the demand models show that the poor are less income and less price elastic than the nonpoor. This implies greater proportionate welfare losses to the poor and a more active search for substitutes if heating prices increase. This suggests the possibility of designing price-based heating subsidies that benefit the poor more than the nonpoor. However, in targeting subsidies, subsidy design must be based on an understanding of income-linked access rates to clean energy networks. If the poor lack network access, the bulk of network-based subsidies will be captured by the nonpoor and therefore subsidies for non-network solutions may result in better poverty targeting.

Third, the analysis shows that such demand becomes much more elastic at consumption levels above 500 Kgoe and a price of \$0.20 per kilogram of energy equivalent (equal to \$0.017 per kWh). Because the long run marginal cost of clean energy sources is everywhere above that cost and unlikely to fall, network heat suppliers recovering full costs will be operating in an inelastic portion of the consumer demand curve. This inflection point will vary by country, but is useful to estimate because it provides policy guidance on the price above which consumer welfare begins to drop quickly and complementary interventions to address this drop may be needed.

In the countries studied, poor people cope with unreliable district heating and rising energy prices by substituting less expensive dirty energy, including wood, coal, and kerosene. But there are private and social costs associated with poor people's heating choices. Private costs include the opportunity cost of the time spent collecting heating material (especially wood) and illnesses and labor productivity losses associated with insufficient heating. Social costs include air pollution from the burning of dirty fuels and the environmental costs associated with deforestation and the loss of biodiversity. These costs must be taken into account when evaluating the economic implications of alternative heating policies and investments.

Solving heating problems in poor countries—and poor towns

Experience restructuring district heating systems in Eastern Europe, particularly in Poland and the Baltics, has shown that they can be modernized—approaching efficiency, cost, and service levels experienced in the market economies of the colder areas in Western and Northern Europe. In high-density urban areas district heating is typically the most comfortable, energy efficient, cost effective, and environmentally friendly heating mode, particularly when supplied from combined heat and power plants. It is available year-round and can be controlled individually by each consumer, and payment for heat is usually based on consumption.

Investment strategies in poor countries must carefully consider the advantages and disadvantages of different types of heating systems. District heating may be environmentally friendly and very cost-effective in areas with a high heat load and high population density. However, high fixed costs may make them too expensive in poor countries where households consume less heat than these systems are usually designed to supply and they have lower heat expenditures than required for cost recovery. Building-level boilers or individual heat technologies with low fixed cost and high variable (fuel) cost may be less environmentally friendly, but may be more attractive in areas with low demand and low population density. Both district and building-based heating systems require heat-metering devices to give consumers, especially the poor, control over heating expenditures. The individual heat technologies are much easier for individual consumers to control and also reduce the need for institutional reform needed to provide a demand-driven service.

Careful planning is required to make sure heating systems are affordable but also fully integrated into the national energy sector strategies. For example, investments in district heat may be justified because it is a byproduct from cogeneration plants critical to the national power supply system. Heating is the single most important use of energy in the residential and building sector; therefore the broader impact of heating fuel choices on energy networks requires careful consideration.

Policies and instruments for poor people

The challenge is to design policies and investments that enable all people (poor and nonpoor) to access clean, affordable heating. In an urban environment this is particularly difficult because whole communities are affected by these choices. Therefore it is critical that the choices allow poor people to opt in to the degree they wish to get the heat they want because they might not use and will not pay for the wrong investments.

Policy instruments such as regulations, taxes, and subsidies coupled with institutional reform and investments in technology offer a way forward. Those instruments can be used to encourage the poor to make clean choices. Investing in new technology or reengineering existing technology enables governments to do this in fiscally sustainable ways. If the goal is to provide access to clean and affordable heating, investments and policy instruments must be explicitly funded to cover the difference between household expenditures and the cost of supply.

If the focus is on promoting clean non-network fuels, targeted vouchers for equipment and possibly fuel may be promising instruments. If the focus is on promoting access and use of network energy, lifeline tariffs can be effective, as long as the size of the blocks is set to minimize capture by the nonpoor and the government explicitly compensates utilities for any social transfers they are asked to provide.

For new investments, there is a role for public sector intervention in either increasing access to low-cost clean non-network energy or extending clean energy networks into poor areas. Network investments must be coupled with investments in metering and control options and with consumption-based billing, allowing users to choose the amount of heat and levels of comfort and spending. Particularly promising, especially in areas where large increases in clean fuel prices are expected, are investments in efficiency and insulation that can produce substantial reductions in consumption. These investments must be coupled with innovative financial instruments that enable consumers, particularly the poor, to distribute capital costs over a longer period.

In addition to policy and investment instruments, there is considerable room to increase the institutional efficiency of heating service delivery. This can be achieved through a combination of training and commercialization of heating service providers, promoting effective collective action at the apartment building or community level, and encouraging participation of private sector service providers.

Note

1. Survey data comes from the following countries: Armenia, Croatia, Kyrgyz Republic, Latvia, Lithuania, Moldova, and Tajikistan.

CHAPTER 1

What is Unique about ECA

Heating is a critical issue for people's livelihoods in Eastern Europe and Central Asia. This paper provides new insights into the links between heating, poverty alleviation and environmental sustainability by taking a closer look at household demand for heating.

Urban areas in the region have three unique features that distort patterns of development and limit household choices when it comes to living conditions. The first is the region's cold climate, which necessitates high spending on heat, winter clothing, and food. The second is the legacy of central planning, which provided almost universal access to infrastructure services—many of which are rapidly deteriorating. The third is the drop in household incomes over the past 10 years.

These factors influence profoundly the design of heating strategies for the urban poor in Eastern Europe and Central Asia. The purpose of this paper is to facilitate the design of policies and projects that provide poor households with access to clean, affordable heat. The study covers only the urban poor because they have fewer affordable heating options than do the rural poor, resulting in more severe price shocks during the transition from central planning.

The cold winters

Average temperatures in the region are well below those in most other regions (Figure 1-1). During the coldest days of the winter temperatures often drop below minus 20° Celsius in many places, and as a result heating is required for five to seven months in most places. People at the same income level as in other regions are worse off in Eastern Europe and Central Asia because additional expenditures on heat, warm clothes, and food are necessary to survive during the cold winters.

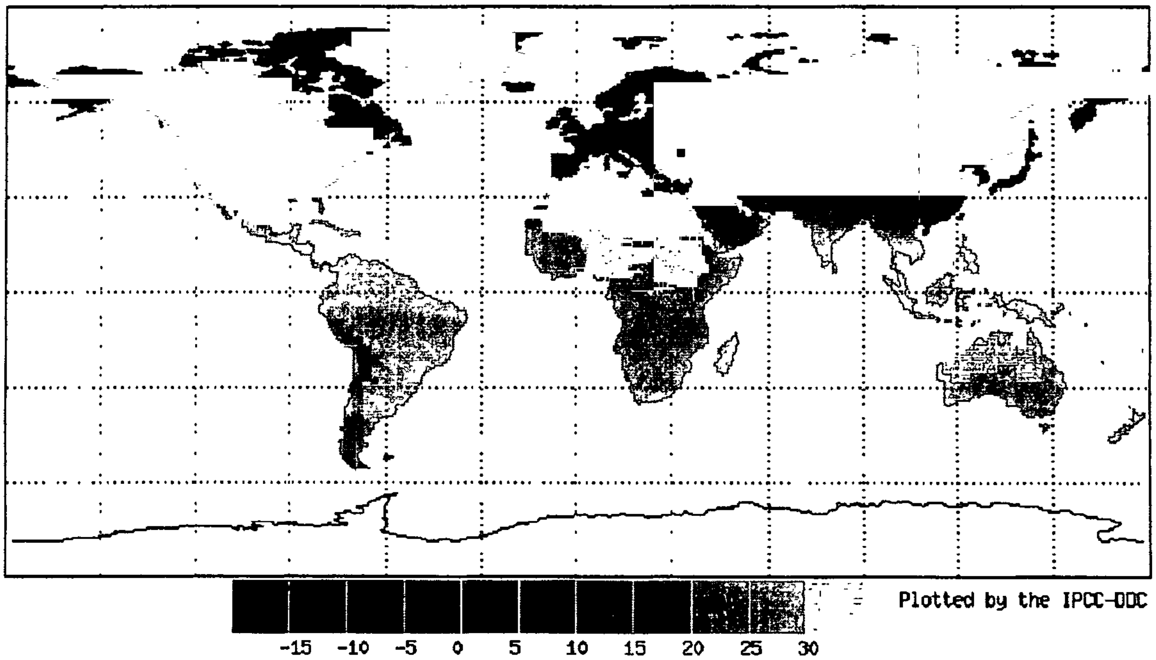
The crumbling legacy of central planning

Under central planning, the region's governments provided almost universal access to infrastructure services. For example, close to 100 percent of households have electricity connections. In urban areas, space heating and in many cases domestic hot water supply were also part of the cradle-to-grave centrally planned system. In the 1950s large, centralized district heating became the system of choice in most developed countries, including Eastern Europe and Central Asia, because it had the potential of efficiently using the waste heat recovered from power generation through combined heat and power (CHP) plants.

Users of district heating systems in centrally planned economies had no influence over when and how much heat was provided. They could be reasonably assured, however, that heat would be provided for free as soon as outside temperatures dropped below 8° Celsius for at least five days. Heating systems would then be operational until temperatures were above 8° Celsius for at least five days. Rooms would be heated to at least 20° Celsius most of the time and, lacking individual controls, consumers would respond to overheating by opening windows—even in the winter.

Even before the 1990s, district heating systems suffered from a lack of maintenance and financing. As a result temperatures within a district heating system—and within buildings—could be quite different from one area to the next. Moreover, breaks in hot water pipes became more frequent, requiring that the affected part of the system be shut down for repairs.

Figure 1-1 Observed mean temperature January 1961 to January 1990, degrees Celsius



Source Intergovernmental Panel on Climate Change

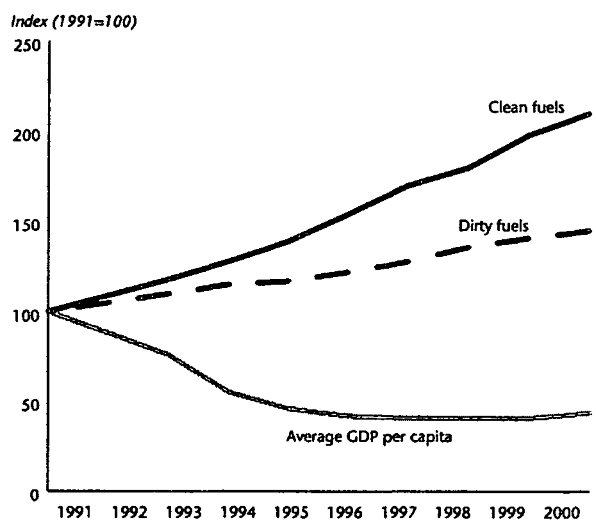
Financial problems created by the collapse of the centrally planned economies were aggravated by the increase in primary energy prices in these countries starting in the early 1990s. The costs of providing heat began to soar, and one government after another decided to raise residential heat tariffs closer to supply costs. Higher heat tariffs coincided with the lower household incomes caused by the contraction in economic activity.

While not having control over the amount of heat consumed may have been acceptable when heat was essentially free of charge, it became untenable as prices rose. Coupled with late or non-payment of salaries and pensions as well as a loss of entitlements, many households responded by not paying their heating bills, falling behind in their payments or switching to less expensive heating fuels.

Falling household incomes

Between 1991 and 1996 real incomes dropped by 14 percent a year in Eastern Europe and Central Asia. Between 1996 and 2000 real incomes grew slightly, by just under one percent a year. Such changes have been accompanied by increasing income polarization, and in many countries urban poverty has reached alarming levels.

Figure 1-2 Relative changes in energy prices and incomes in Eastern Europe and Central Asia, 1991–2000



Source: Author's calculations from International Energy Agency data and World Bank data.

While real incomes have stabilized, real energy prices have been rising. Governments have been eliminating energy subsidies, pushing utilities to raise prices in an attempt to improve cost recovery. Many of the price increases have been substantial—for example, between 1991 and 2000 the price of electricity jumped by an average of 177 percent throughout Eastern Europe and Central Asia.[1]

The changes in energy prices and incomes between 1991 and 2000 are shown in Figure 1-2. The figure separates price changes in clean (liquefied petroleum gas, electricity, district heat, natural gas, and kerosene) and dirty fuels (coal, wood, and diesel). The price of clean fuels rose much faster (110 percent between 1991 and 2000) than that of dirty fuels (45 percent). Thus energy, particularly from clean fuels, has become a relatively more expensive component of consumption.

Note

1. These data cover Armenia, Azerbaijan, Estonia, Georgia, Kazakhstan, Kyrgyz Republic, Latvia, Lithuania, Moldova, Tajikistan, and Uzbekistan.

CHAPTER 2

Household Energy Use

Heat is just one of many forms in which energy is consumed by households. This chapter starts by examining overall energy consumption because this provides key insights into the issues that need to be addressed to create a better policy environment and highlights important issues related to heating and access to clean energy infrastructure. The seven countries considered in this chapter—Armenia, Croatia, Kyrgyz Republic, Latvia, Lithuania, Moldova, and Tajikistan—were selected based on the availability of recent (end 1997 or later) household survey data with sufficient questions about energy expenditure patterns. Purchasing power parity and exchange rate conversions, data assumptions, and summary statistics for the data presented in this chapter are found in annexes 1, 2, and 3.

Between 1990 and 1997 the region's per capita commercial energy consumption fell by one-third (World Bank 2001). While much of this drop can be attributed to the collapse of industry, the decline in subsidized infrastructure services—coupled with higher prices and increasing poverty—may explain what appears to be a fundamental shift in energy consumption and spending among urban households.

Separating network and non-network energy use provides insight into this shift (Table 2-1). Almost all households use electricity, with small differences between the poor and the nonpoor. But poor people are much less likely to use district heat and gas. Are the nonpoor more likely to use network energy because they have better access to the network, or is it because they make different choices? Although this question cannot be answered with the data from household surveys, it points to the need for country-specific analysis to identify supply constraints—such as network location and capital equipment (such as gas heaters)—that limit poor people's access to clean network energy.

If poor people are not using network energy, what are they using? Primarily dirty non-network energy. Wood and coal use are consistently higher among the poor—except in Tajikistan, where coal is heavily subsidized for everyone (Table 2-2). Except in Latvia, the nonpoor are more likely to use liquefied petroleum gas (LPG), the cleanest non-network energy. The poor may favor dirty non-network energy because it is less expensive or because they do not have the resources to spend on appliances that enable them to use network energy, such as gas stoves. Burning dirty fuels has social costs—mainly air pollution and deforestation—that require careful, country-specific analysis to

Table 2-1 Urban network energy use in Eastern Europe and Central Asia (percent)

	District heating		*Central gas*		*Electricity*	
Country	*Poor*	*Nonpoor*	*Poor*	*Nonpoor*	*Poor*	*Nonpoor*
Armenia, 1999	11	14	4	16	97	99
Croatia, 1997	15	39	19	30	99	100
Kyrgyz Republic, 1999	17	55	13	33	100	99
Latvia, 1997	70	83	57	68	99	100
Lithuania, 1998	31	46	47	56	85	94
Moldova, 1999	17	57	37	70	65	89
Tajikistan, 1999	1	1	3	6	100	100

Source. Author's calculations from household survey data.

Table 2-2 Urban non-network energy use in Eastern Europe and Central Asia (percent)

Country	Liquefied propane gas		Kerosene		Coal		Wood	
	Poor	*Nonpoor*	*Poor*	*Nonpoor*	*Poor*	*Nonpoor*	*Poor*	*Nonpoor*
Armenia	17	27	14	11	n/a	n/a	47	50
Croatia	44	45	3	7	1	1	51	26
Kyrgyz Republic	24	39	31	17	60	31	46	22
Latvia	37	28	n/a	n/a	<1	<1	1	2
Lithuania	n/a	n/a	n/a	n/a	<1	<1	1	2
Moldova	6	7	n/a	n/a	9	5	12	9
Tajikistan	n/a	n/a	<1	1	11	18	47	32

n/a: Not available from household survey.
Source: Author's calculations from household survey data.

assess the size of these costs and evaluate the economic implications of raising the price of clean energy (annex 4).

Energy prices

Countries in the region have taken different approaches to reforming energy prices. In the countries in our sample the average price of a kilogram of oil equivalent (kgoe) is $0.25 (Table 2-3).[1] But in some countries (such as Croatia) some energy prices are much higher, while in others (Kyrgyz Republic, Tajikistan) they are much lower. Non-network LPG tends to be expensive, while coal and wood tend to be cheaper. Network electricity tends to be expensive, while the prices of network central heat and gas generally fall between those of electricity and wood.

Two competing hypotheses explain the region's energy use patterns. The first is that poor people choose non-network energy because it is less expensive; the second is that they do not have access to network energy. But two factors suggest that if there is an access issue, it is a local one: high network energy use before the transition indicates that network infrastructure is in place, and almost all fuels are available in all countries. Resolving this issue on a country-specific basis is important for the design of pro-poor heating strategies because it will influence policy and investment decisions. More information on this is provided in the final chapter.

Different pricing policies and differences in income, climate, and the availability of substitute fuels lead to very different consumption patterns across countries (Figure 2-1). In relatively wealthy Croatia energy consumption is 325 kgoe per capita per year, while in poor Tajikistan it is only 75 kgoe per capita per year. On average the nonpoor consume one-third more energy per capita than do the poor (160 kgoe compared with 118 kgoe). These consumption figures likely underestimate actual energy consumption, however, because the self-reported data include a number of very low values and do not include district heat.

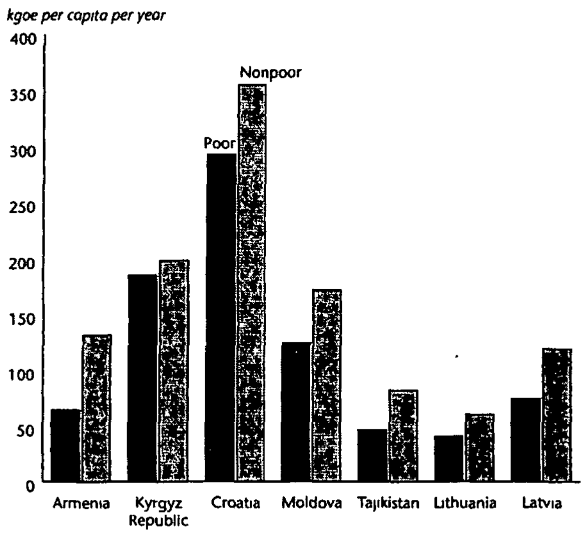
Households spend a large portion of their budgets on energy—from 3 percent in Tajikistan to about 12 percent in Armenia and Moldova (Figure 2-2).[2] (These expenditures include district heat, electricity, coal, LPG, kerosene, wood, and central gas.) In all countries except Latvia the poor spend a larger share of their household budgets on energy than do the nonpoor.[3] This

Table 2-3 Energy prices in Eastern Europe and Central Asia, (2001 U.S. dollars per kilogram of oil equivalent, most recent year available)

Country	*LPG*	*Kerosene*	*Coal*	*Electricity*	*Wood*	*Central gas*	*District heat*
Armenia	0.59	0.40	0.07	0.56	0.16	0.12	0.18
Croatia	0.88	0.17	0.21	0.94	0.11	0.25	n/a
Kyrgyz Republic	0.22	0.50	0.01	0.05	0.08	0.07	0.04
Latvia	0.35	0.21	0.12	0.60	0.17	0.76	0.35
Lithuania	0.26	0.21	0.13	0.60	0.11	0.20	0.28
Moldova	0.41	0.19	0.10	0.45	0.10	0.11	0.15
Tajikistan	0.33	0.11	<0.01	0.03	<0.01	0.06	0.13

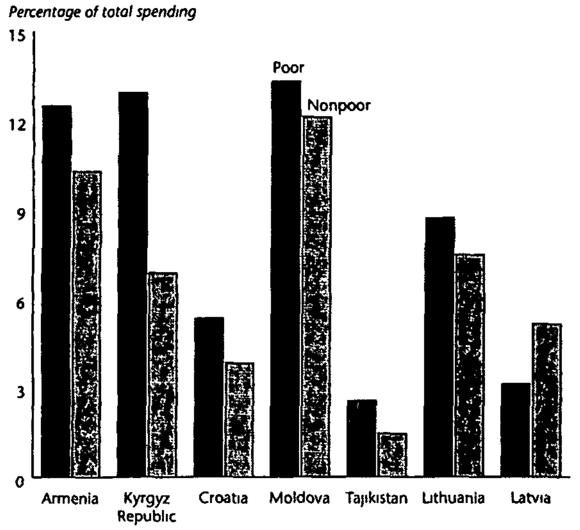
n/a: Not available.
Source: Author's calculations from household survey data and International Energy Agency data.

Figure 2-1 Per capita energy consumption in Eastern Europe and Central Asia



Source Author's calculations based on household surveys.

Figure 2-2 Share of energy spending in household budgets in Eastern Europe and Central Asia



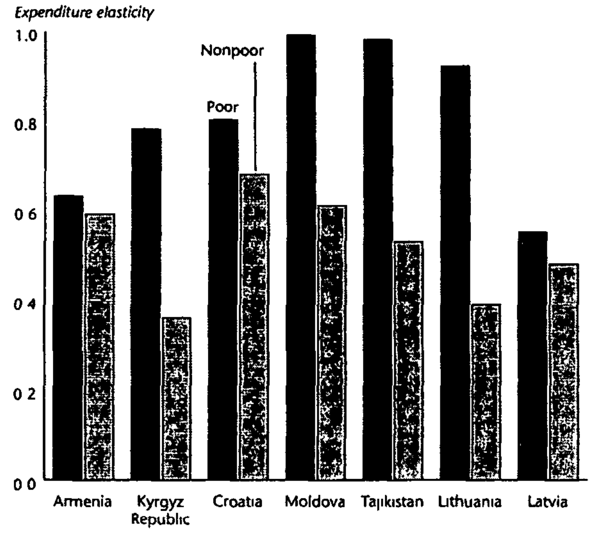
Source Author's calculations from household survey data

finding is the opposite of Freund and Wallich's (1996) finding in Poland. Clearly relative impacts will vary by country, but policy designed to raise energy prices must disaggregate impact by income class and, especially where energy consumption levels are quite high, anticipate substitution of cheaper, dirtier fuels by poor households.

Following the methodology in Subramanian and Deaton's (1996) study on the demand for food calories, a preliminary assessment of the tradeoff between income and energy expenditure can be made by running a simple log-log regression to estimate the expenditure elasticity of energy demand. In doing so, however, it must be remembered that differences in rates of change in household spending across countries may be confounded by local differences in policy and physical infrastructure.

The results of the regression for poor and nonpoor consumers are shown in Figure 2-3. Although there is variation across countries, the results show that relative to income, poor people's energy expenditures are consistently more elastic than those of the nonpoor. A 10 percent increase (decrease) in income results in an 8 percent increase (decrease) in energy expenditure for poor people and a 5 percent increase (decrease) for nonpoor people. In an environment of falling incomes the poor appear to be cutting back energy expenditures (as a percentage of income) faster than the nonpoor, probably by consuming less expensive, dirtier fuels. Thus heating policies designed to encourage the poor to use clean fuels must either increase their incomes or reduce their expenditures (through subsidies or investments in efficiency).

Figure 2-3 Expenditure elasticity of energy demand



Source Author's calculations from household survey data

Conclusion

This chapter has shown the considerable heterogeneity in household energy use, consumption, and spending across Eastern Europe and Central Asia—highlighting the importance of country-specific analysis. That poor people are less likely to use network energy than nonpoor people raises questions about the role of the public sector in providing subsidies or investing in new or rehabilitating old infrastructure. Unless clean energy networks are made accessible to the poor, the bulk of any energy subsidies will go to the nonpoor.

As noted, the elasticity of energy expenditure relative to total expenditure is 0.8 for the poor and 0.5 for the nonpoor. The poor spend a larger portion of their incomes on energy yet consume less energy in absolute terms. Energy pricing policy discussions tend to focus on the cleaner fuels because of their greater importance in quasi-fiscal activity. A failure to recognize the significant impact of energy prices on poor people's welfare and their option to substitute cheaper, dirty fuels may simply replace one bad with another.

When cheaper dirty fuels are available, the social costs associated with consuming them may warrant public intervention. In countries with high-energy expenditure elasticities, policymakers who want to encourage the poor to use clean fuels must either increase incomes or reduce the relative cost of clean fuels (through subsidies or investments in efficiency).

Notes

1. Comparing energy consumption patterns requires converting different fuels to equivalent energy values. Conversions to kilograms of oil equivalent (kgoe) are based on mean values of fuel energy content relative to oil, so the exact heat content of a given fuel will vary depending on its quality and efficiency in combustion. This paper uses the following equivalence values: 1 kilowatt-hour of electricity=0.085 kgoe; 1 cubic meter of central gas=0.833 kgoe; 1 kilogram of LPG=1.059 kgoe; 1liter of kerosene=0.824 kgoe; 1 kilogram of wood=0.376 kgoe; 1 kilogram of coal=0.541 kgoe. The source is the International Energy Agency.
2. These are reported expenditures, not subject to adjustment for arrears and nonpayments.
3. The result in Latvia may be explained by the large number of households on the central heating network.

CHAPTER 3

Household Demand for Heat

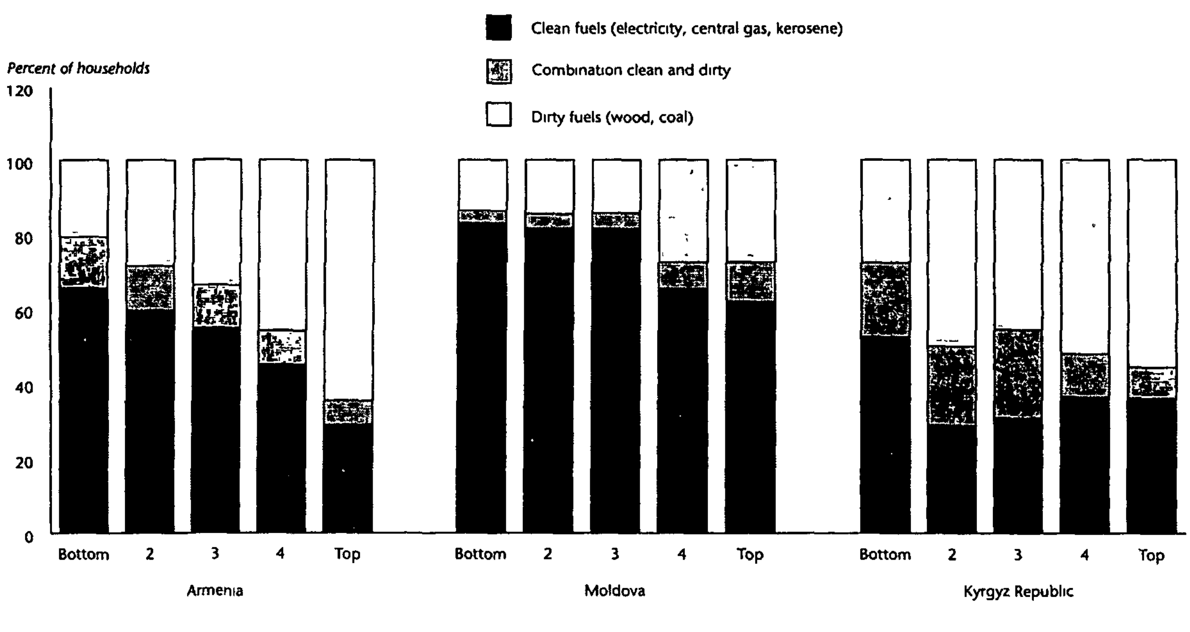
Studying how people heat themselves when left to their own devices provides insights into how much energy they demand for heating and how much they are willing to pay for it. Anecdotal evidence suggests that households—particularly poor households—have a wide variety of heating strategies. For example, in Russia it is reported that "wearing winter clothing indoors or sleeping under a multitude of blankets only keeps one warm for so long. One popular remedy is stuffing rags into an empty can, dousing them in vegetable oil, and setting them on fire" (Filipov 2001).

Household heating patterns and fuel choices

Figure 3-1 shows the heating fuel choices of households not on district heating networks.[1] When free to choose, the poor are more likely to use dirty fuels such as wood (Armenia) and coal (Moldova), while the nonpoor rely on clean fuels such as electricity and central gas.

These patterns have important implications for heating interventions. First, as incomes fall, people buy dirtier heating fuels. Second, while cash transfers[2] may offset the welfare effects of

Figure 3-1 Urban household heating fuel choices by welfare (income) quintile



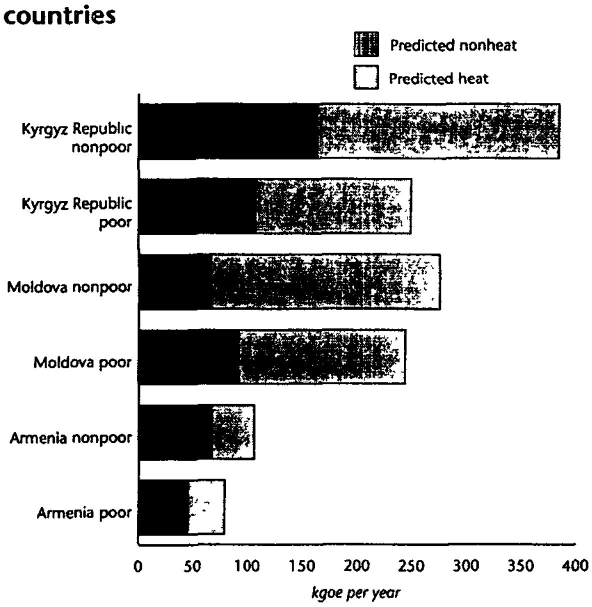
Note: Excludes district heating
Source Author's calculations from 1999 household survey data

higher heating prices, they will not stop households from using dirtier fuels if the prices of those fuels are not raised as well. Thus thought should be given to designing heating policies that take into account the social costs of burning dirty fuels. These include the health costs associated with not having enough heat and the resulting productivity losses, the health costs associated with burning dirty fuels, the environmental costs associated with deforestation, and the opportunity costs of time spent collecting heating material—especially wood (annex 4).

How much heat do households consume?

Household heat consumption was estimated by developing a model to predict household heat and nonheat energy consumption, then subtracting nonheat from the total (for details on the model and its validity see annexes 5 and 6).[3] Figure 3-2 presents heat consumption results on a per capita basis.[4] The figure reveals variations in household heat consumption—in Armenia and the Kyrgyz Republic the poor consume less heat per capita than do the nonpoor.[5] That the results are confounded by household size complicates the design of pro-poor heating tariffs such as lifelines, which are

Figure 3-2 Predicted per capita heat and nonheat energy consumption in selected countries



Note Excludes households on district heat
Source Author's calculations

based on a minimum consumption level per household.

Annual nonheat energy consumption ranges from 50 kgoe per capita in Armenia to about 125 kgoe in the Kyrgyz Republic. Annual predicted heat consumption ranges from 40 kgoe per capita in Armenia to 175 kgoe in Moldova to 180 kgoe in the Kyrgyz Republic. Thus heat consumption accounts for 40–60 percent of total energy consumption. Differences across countries are driven by differences in climate and energy pricing policies. The average temperature during the heating season is highest in Armenia (2.6^0 Celsius), followed by Moldova (0.6^0) and the Kyrgyz Republic (-2.9^0). Energy prices are highest in Armenia, followed closely by Moldova, and are substantially lower in the Kyrgyz Republic.

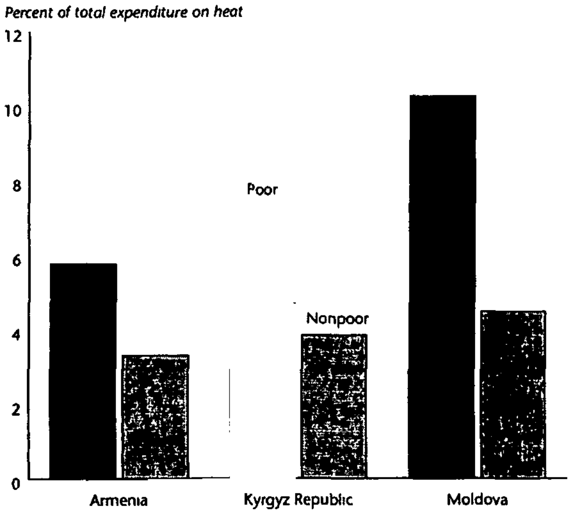
How much do households spend on heating?

To calculate heating expenditures, we multiply predicted heat consumption by the price of a household's primary heating fuel. These calculations indicate that heating accounts for 5–10 percent of household spending and for 20–40 percent of energy spending. On average the poor spend almost twice as much of their household budgets on heating as do the nonpoor (Figure 3-3). In absolute terms nonpoor households spend $30–50 a year on heating and poor households spend $25–40.

These results are important for three reasons. First, that the poor spend a larger share of their budgets on heating suggests that it is possible to design a heating subsidy that benefits them more than the nonpoor. Second, that heat is a large share of energy spending suggests higher heating prices will considerably reduce household welfare unless inexpensive substitutes are available. Third, poor people are unlikely to pay for heating systems that cost more than $25–40 a year because they can find less expensive ways to heat themselves. They might, however, be willing to pay slightly more for heating systems that are substantially more convenient.

One of the factors complicating this analysis is that we do not have data on actual heat consumption. But in a recent survey Armenian apartment dwellers were asked to estimate their

Figure 3-3 Predicted heat expenditure as a percentage of household expenditures



Note Excludes households on district heat.
Source Author's calculations.

previous year's spending on heating and their average indoor temperature during the heating season. Self-reported spending ranged from $10–20 a year, which is of the same order of magnitude as the model results (Table 3-1). In addition, poor households with full control of their heating arrangements keep their apartments at lower temperatures and spend less than do households on the district heating network—suggesting that the poor lose the most when they cannot regulate their heating use.

Demand for heat in selected countries

We expect a heat demand function to be kinked, sloping steeply around the minimum amount needed for survival and then rapidly leveling off as the quantity of heat goes from necessity to luxury. Identifying the location of this kink is important because at prices above it demand is inelastic and welfare losses are large—while at prices below it demand is more elastic and welfare losses are smaller.

A scatter plot of predicted household heat consumption against price per kgoe for Armenia, the Kyrgyz Republic, and Moldova suggests a function of precisely this shape (Figure 3-4). There is a steep downward slope below 250 kgoe and above $0.2 per kgoe followed by a rapid flattening out. It appears that

Table 3-1 Self-reported temperatures and heating expenditures in Armenia, 2000

Type of household	*Reported mean temperature (°C)*	*Reported mean expenditure (US$ per heating season)*	*US$ per degree*
Poor with district heating	15.62	17	1.09
Nonpoor with distict heating	16.51	21	1.27
Poor without district heating	14.53	9	0.62
Nonpoor without district heating	15.61	17	1.09

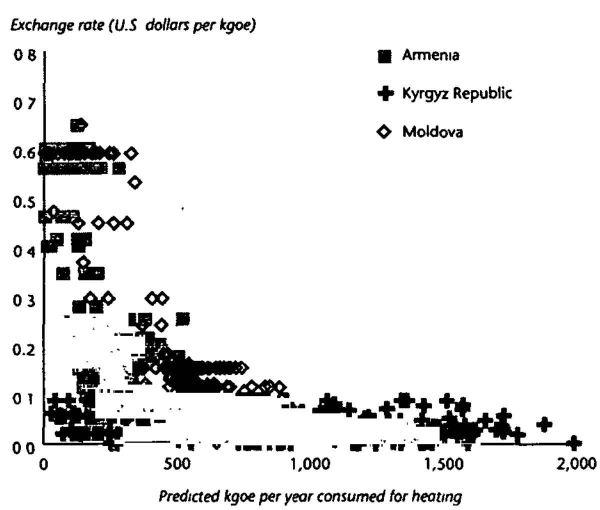
Source. Author's calculations from Armenia 2001 household survey data.

households alter their heating strategies quickly in response to price changes in the range of $0.01–0.20 per kgoe—and that for households without substitution opportunities, welfare losses will be greater when the price rises above $0.2 per kgoe. In these cases it will be particularly important to design policies that cushion the blow of energy price increases on the poor.

How will households respond to price and income signals?

The model can also be used to estimate the income and price elasticity of heat demand for the three countries. The income elasticity of

Figure 3-4 Demand for heat in selected countries



Note Excludes distnct heating
Source Author's calculations

demand is between 0.1 and 0.2, meaning that a ten percent increase (decrease) in income will produce a one percent increase (decrease) in energy consumption for heating by the poor and about a two percent increase (decrease) by the nonpoor. That the three data sets produce similar results and are consistent with economic theory increases our confidence in the model.

As expected, there is much greater variation in price response by income group and country. Price elasticity is –0.4 in Armenia and –0.2 in the Kyrgyz Republic and Moldova, meaning that a ten percent increase in price will produce about a four percent decrease in consumption in Armenia and about two percent in Kyrgyz and Moldova. In Armenia and Moldova the poor are less price elastic than the nonpoor. That the poor are less income and less price elastic than the nonpoor suggests that they will have greater welfare losses from price increases unless they can find less expensive substitutes.

Conclusion

The information in this chapter is important for designing pro-poor heating policies and investments. First, unless there is a significant improvement in heat quality, poor people are unlikely to pay for heating systems that cost more than $25–40 a year because they can find less expensive ways to heat themselves. Thus, cost recovery strategies must take into account consumer perceptions of system quality, which is a function of cost and convenience.

Second, the poor are less income and less price elastic than the nonpoor, suggesting that they will have greater welfare losses from price increases unless they can find substitutes. For poor people these substitutes tend to be dirtier fuels, and there are social costs associated with the use of these fuels. In these cases it will be particularly important to design policies that cushion the blow of energy price increases.

Third, on average the poor spend almost twice as much of their household budgets on heating as do the nonpoor. That the poor spend a larger share of their budgets on heating suggests that it is possible to design a heating subsidy that benefits them more than the nonpoor. The difficulty with designing such a subsidy is that the nonpoor tend to have higher access rates to clean energy networks. Therefore they are more likely to capture the bulk of the subsidy if it is passed through the network without first increasing the access rate of the poor.

Finally, the data from Armenia, the Kyrgyz Republic, and Moldova suggest that demand becomes much more elastic at prices below $0.20 per kgoe (equal to $0.017 per kWh). Although such inflection points will vary by country, they provide policy guidance on the price above which consumer welfare begins to drop quickly and complementary interventions to address this drop may be needed.

Notes

1. Most of the analysis in this chapter is limited to a sample of urban households from Armenia (1999), the Kyrgyz Republic (1999), and Moldova (1999).
2. Direct cash transfers are discussed on page 28.
3. The consumption and expenditure results in this chapter are not identical to those in the previous chapter because the analysis in this chapter focuses only on a subsample of urban households for which heating information is available.
4. While heat is a public good at the household level, larger (poor) households tend to consume more energy than smaller (non-poor) households. There are on average two more people in poor than in nonpoor households. Also there is not much differentiation in living area because commercial real estate markets are not well developed in the sample countries.
5. In Moldova the difference is not statistically significant at the five percent level.

CHAPTER 4

Rethinking Heat Supply

International financial institutions (IFIs) such as the World Bank and the European Bank for Reconstruction and Development (EBRD) were the main funding sources for rehabilitation investments for district heating systems in many cities in Eastern Europe and Central Asia in the 1990s. The experience in restructuring Soviet-type district heating systems in Eastern Europe, particularly in Poland (see Box 2 in Annex 8 and World Bank 2000c) and the Baltics,[1] has shown that, through a combination of investments, institutional improvements and sector reform, those district heating systems can be modernized—approaching efficiency, cost, and service levels as in Western and Northern Europe. There, district heating is considered the most comfortable, efficient, environmentally friendly heating mode; it is available year-round and can be controlled individually by each consumer, and payment for heat is usually based on metered consumption.

These solutions and experiences are not fully applicable, however, when devising solutions to the heating problems of households in extremely poor countries or in many small, poor towns in other countries of the region. The information from the previous chapters shows that many poor urban households consume less heat and have lower heat expenditures than usually associated with a district heating system. Even though district heating systems can be the most cost-effective heating mode given a high heat load, their high fixed costs make them potentially very expensive for consumers demanding less heat.

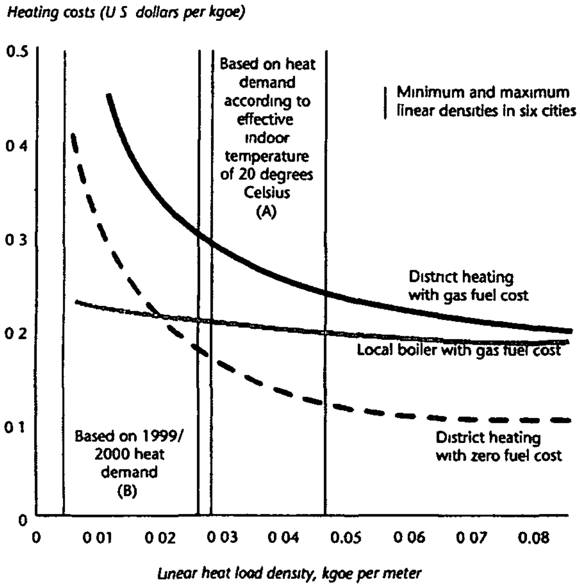
In the remainder of this chapter the typical costs of various heat supply options are compared for two levels of heat demand: full service, meaning provision of about 18° Celsius[2] in all rooms of a dwelling, and reduced service, meaning a lower temperature in one or several rooms. These results are compared with typical expenditure levels reported in chapter 3, and conclusions are then drawn regarding the implementation of financially and environmentally sustainable and affordable heating strategies that take into account the fixed and variable costs and investment requirements of various heat supply options.

The heat supply options compared in this chapter range from highly centralized district heating networks fed by cogeneration plants or heat-only boilers to building boilers that supply only one or a few buildings with heat to decentralized (individual) heating where each dwelling has its own heat source. Each of these heating options can be based on a wide range of fuels and comes with very different levels of efficiency and environmental performance.

The prevailing practice: Least-cost heating options for full heat service

Before the transition, consumers in Eastern Europe and Central Asia connected to central heating expected that every room in their living quarters would be heated to about 20° Celsius for 24 hours during the official heating season. In the following we call this "full heat service." Under such conditions, and with the typical high population densities in many suburban areas with high-rise residential buildings, the heating system that typically provides heat at the lowest cost is a district heating system supplied from cogeneration plants. Comparative studies ("heat plans") have been carried out in many cities in Eastern and Western Europe confirming this result for greenfield development as

Figure 4-1 Costs of different heat supply options in Moldova



Source. Based on SwedPower/FVB 2001.

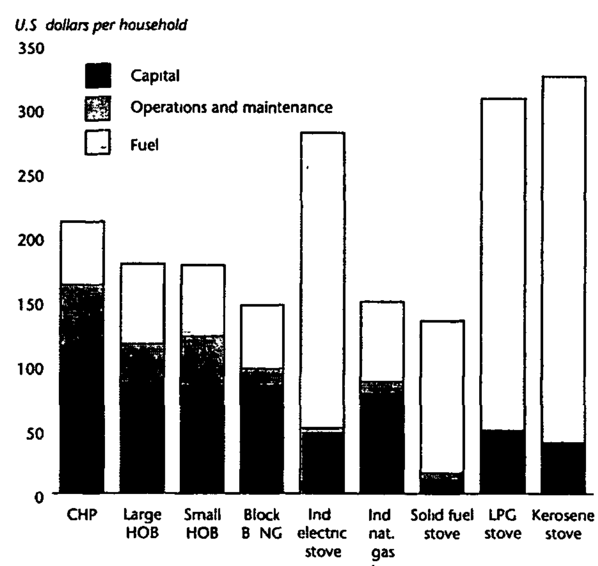
well as modernization of existing district heating systems.

Figure 4-1 gives a graphic illustration of this point with an example from Moldova. The figure shows the costs per unit of heat depending on the "linear heat load density." This is the total connected load divided by the total length of the network, with the length of the network defined as the total length of the route (in contrast to the length of single pipes, which would cover both supply pipes and return pipes). Full heat service results in a high heat load with the typically high population density in urban Moldova (high linear heat load density = A). Under these circumstances it is more cost-effective to build a district heating network and a rather capital-intensive cogeneration plant that delivers heat almost for free, rather than invest in an extensive natural gas distribution system with separate gas-boilers for one building or a small group of buildings.[3] The exact location of the cost curves depends on local costs and circumstances, particularly the price at which cogenerated power can be sold to the grid and the cost of fuels for heat generation. However, when the heat demand is much less, such as currently in Moldova (low linear heat load density = B), district heating loses its competitiveness to more decentralized options. Heating costs of about US$0.16 per kgoe would result in an annual household heating bill of $160, assuming heat consumption of 1000 kgoe (or 10 Gcal) per flat.

The costs of modernized district heating systems in various countries and cities have been well researched during the preparation of feasibility studies. The resulting costs per unit of heat delivered at the building entrance usually fall within a fairly similar range of $0.20–0.35 per kgoe, leading to annual household heating bills of $200–900, depending on dwelling size, specific heat consumption, and heat tariff level.

The costs of modern heating options other than district heating are less well known in Eastern Europe and Central Asia. According to studies recently carried out in Armenia, those heating options result in annual costs per household of $135–324 (Figure 4-2). Options based on natural gas have high investment costs and low fuel costs, while the opposite holds for heating based on electricity, kerosene, LPG, and wood stoves. For all heating options represented in Figure 4-2, investments have been included to ensure that the equipment would be functional over a lifetime of 20 years.[4] As a result, the costs

Figure 4-2 Annual costs of different heating options for full heat service in Yerevan, Armenia



Note The calculations are based on a comfort level of 17° Celsius and 110 heating days.
Source Based on COWI 2002a

per apartment are lowest for wood stoves, building-based natural gas boilers, and apartment-based natural gas heaters. But the current natural gas tariff for small consumers is only about 17 percent higher than that for large consumers, and so does not reflect the higher distribution costs.

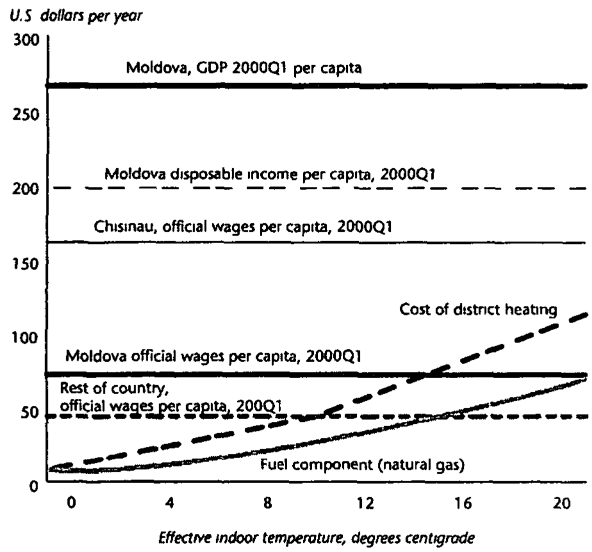
The new reality: Lower heat demand

The analysis so far has focused on heating options based on full heat service. But since the early 1990s many consumers in Eastern Europe and Central Asia have received less than full heat service as systems started to deteriorate due to lack of maintenance. More important, declining incomes have led many consumers to drastically reduce their heat consumption, with lower supply temperatures, shorter heating seasons, and less area heated. However, only for those households not on the network or that have disconnected from the network would this result in lower heat bills (see Chapter 3). Those still connected to district heating experienced rising heat tariffs and thus higher expenditures despite declining service levels. The reason is when supply-driven, inflexible district heating systems lose customers, heat not consumed does not materialize as fuel savings at the heat generation plant. Instead it is consumed somewhere else in the system, for example, in the form of heat losses or higher temperatures and open windows. Therefore, utilities are typically not able to reduce costs in the short to medium term in proportion to the decline in demand, let alone trying to reduce staff or fixed costs and the remaining customers have to bear even higher costs. In Bulgaria this vicious circle could be observed in 1996–99. Since then, customers have slowly started to reconnect due to efforts to meter heat consumption and bill customers accordingly (see Box 3, Annex 8).

Figure 4-3 shows the cost of district heating in Moldova at various temperature levels[5] and compares it with various measures of income in the country. Outside the capital city of Chisinau, the official per capita wage would barely cover the fuel costs of district heating supplied at 14° Celsius.

More flexible options—such as individual heat technologies—for which fuel accounts for a larger

Figure 4-3 Cost of district heating per capita at various effective indoor temperatures compared with national GDP and official wages per capita in Moldova

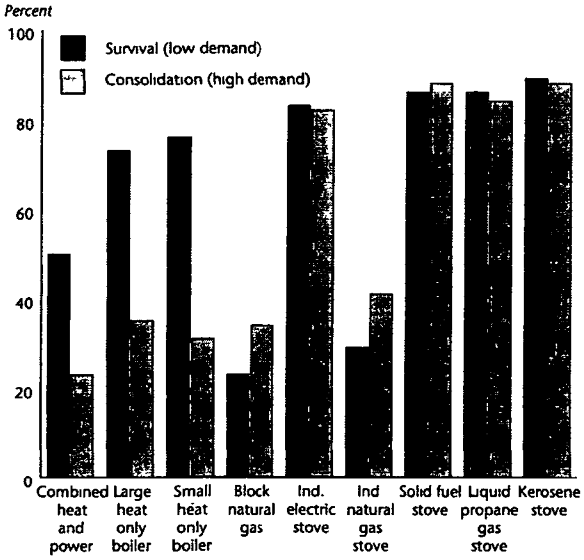


Note The cost of district heating is estimated using the current price of $0 18 per kgoe.
Source SwedPower/FVB 2001

share of total costs and which are modular are much easier to adapt to lower heat demand, as demonstrated in Chapter 3. With electrical heating, for example, fuel accounts for about 85 percent of total costs (Figure 4-4). Therefore while electrical heating has a high unit cost, it may be less expensive for the household to heat with because it is so much more flexible. In many countries of the region, however, the already overburdened electrical distribution network would have to be strengthened to be able to cope with additional heat loads. This would cause additional investments, reflected in higher electricity tariffs. Typically, district heating systems can only be adapted to a lower heat load in the medium to long term, when replacement investment and modernization of the system configuration take place. This is an option worth pursuing for those district heating systems that can be shown to be viable even at lower heat demand.

Centralized options are cheaper than electric heating or wood stoves when providing full heat service. Now that incomes have fallen, consumers, particularly the poor demand lower indoor temperatures and heat less living space. Under these circumstances individual options

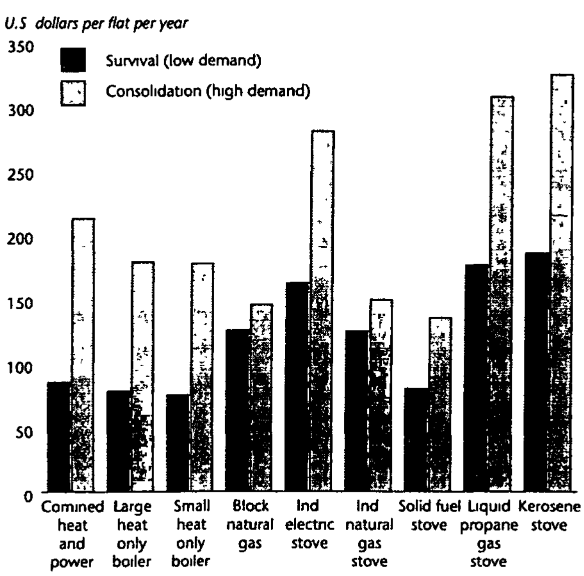
Figure 4-4 Fuel costs as share of total heat costs for different heat supply options and demand levels, Yerevan, Armenia



Source COWI 2002a

are less expensive than centralized options because they tend to be modular. Figure 4-5 illustrates this for Armenia. The result is corroborated for Moldova in Figure 4-5 comparing situation A with situation B.

Figure 4-5 Yerevan: Average cost of heating for high and low demand



Note Percent of population purchasing heating services at different prices 80% at US$50 per year, 60% at US$70 per year, 40% at US$100 per year.
Source. COWI 2002a, ERM 2002.

When the costs of different heating options are compared with what households are currently paying for heat, between $25 and $50 in Armenia (see Chapter 3), it appears that only the most basic heating could be considered. In fact, most people would be willing to pay more for a convenient heat supply during the entire heating season—according to the Armenia survey, between $50 and $100.[6] This would not entirely bridge the gap between the supply cost of most heating options and expected consumer payments. But the remaining gap may be narrow enough to make the financial support by the government to the poorest consumers feasible.

Figure 4-5 makes another interesting point. In the short-term, it may be possible to provide affordable heating with centralized heating systems by emulating how consumers use individual heating systems. The Armenia Urban Heating Strategy proposes that during the survival phase only one or two of the vertical risers supplying each apartment are kept connected, delivering a temperature of about 17° Celsius in those one or two rooms. Adopted for an entire centrally heated area, this should cut down considerably on fuel costs that have a cost share of 70–80 percent (see Figure 4-4). It is hoped that this would enable the heating company to cover its full cost and bill and, more importantly, collect accordingly. This is however only an interim strategy, suggested in Armenia to buy time for putting in place the basis for a more market-driven heat supply.

Armenia is not typical for the region because of its relatively low heating requirements, its extended natural gas distribution system and that its only cogeneration plant is industry-based and not critical for the power system. In Moldova and Kyrgyzstan, however, the combined heat and power plants in Chisinau and Bishkek are relatively modern and they are needed for the power system. There are thus additional factors favoring maintenance of the district heating system. Careful planning at many levels is required however to make heat from those systems as affordable as possible. Parts of the centrally supplied DH system that are not economic to supply must be shut down; minimum investment plans to make heat supply and consumption more efficient must be devised; financing sources must be identified;

Table 4-1 Payback times for energy efficiency investments in buildings

Investment	*Payback time (years)*
Reducing drafts, weather stripping windows	1–2
Installing heat meters at the building level	1–2
Installing meters for domestic hot water at the apartment level	1–2
Insulating pipes for domestic hot water	3–5
Installing controls for heating and domestic hot water for individual buildings	4–5
Installing radiator control valves	5–6
Insulating heating pipes	10
Insulating roofs	25
Insulating outside walls	50

Source. Based on SwedPower/FVB 2001.

and management and institutional measures to make the remaining truly least-cost district heating systems viable both for producers and consumers must be identified. The latter requires rebalancing tariffs between electricity and heat and commercializing the utilities.[7]

The importance of building-based efficiency measures

The importance and feasibility of improving the efficiency of delivering heat to consumers was highlighted in the previous sections of this chapter. For poor consumers it may however be even more important to have their buildings improved in order to cut down on the heating necessary to warm them up. As is well known, buildings in Eastern Europe suffer from bad construction and neglected maintenance, particularly in common areas (for details see Annex 8). These shortcomings lead to high energy consumption for heating that could be reduced considerably by energy-saving investments in those buildings. Some measures are independent of the type of heating system, such as repairing or replacing broken windows and doors, and insulating roofs and walls. Other measures are targeted at reducing the losses caused by a building's internal heating system, such as insulating pipes, balancing risers, controlling the temperature of the heating system, metering at the building and apartment levels, and allowing individual control of heat consumption.

Table 4-1 lists the most common investments for reducing heat requirements and lowering heating bills, as well as the payback times for those investments, based on full heat service. However, the expected savings cannot always be taken for granted. In many cases where buildings are under-heated, households tend to increase comfort first and save energy later, as experiences from Lithuania's Energy Efficiency and Housing Project show (see World Bank 2002).

For pilot projects to be carried out in Armenia, the costs of improving buildings' internal facilities to improve the centralized heat supply and to enable households to regulate and control heat and pay for it based on consumption were estimated to be $200–400 per apartment (for equipment and installation, including new piping and radiators), depending on the size of the building. Typical investment and recurrent costs that have been observed for metering and control installations in more than two million dwellings in Poland are reported in Table 4-2.

Conclusion

When putting together information on the costs of various heating options and the effective low level of heat demand in many of the poorer

Table 4-2 Typical cost of heat metering and individual controls in apartments

	Cost per unit (US$)	*Units required per apartment*	*Cost per apartment (US$)*
Total investment cost per apartment			145
Heat meter, building level	285	N/A	8[a]
Heat cost allocator (HCA)	4.20	4	17
Thermostatic radiator valve	30	4	120
Annual cost of billing and serviceper apartment	1.50/HCA + 8.50/apartment	N/A	15

N/A: Not applicable
a. Assumes 35 apartments per building.
Source. Supplier information for Poland.

countries in Eastern Europe and Central Asia, it becomes obvious that the traditional provision of heat at a full service level of 18° Celsius is too expensive in several countries of the region to enable district heat utilities to achieve cost recovery. The high fixed costs of centralized heating systems make them relatively slow to react to a heterogeneous heat demand. Decentralized heating options are less risky in this respect since they are modular.

Set against this must be the social costs associated with using low-efficiency heating appliances together with environmentally problematic fuels such as wood or coal and power system reliance on cogeneration plants. In those cities where incomes are growing, investments in high efficiency and environmentally benign centralized heating may be justified. However, centralized heating justified on these grounds must be equipped with metering and heat control devices needed to give the poor control over their expenditures. Energy efficiency investments help achieve that goal but often involve high initial costs poor consumers cannot afford. Here governments should consider providing support, such as with financial schemes that enable consumers to distribute initial costs over a number of years, or even with outright grants that enable poor consumers to overcome those initial costs.

Notes

1. For example, in the Estonia District Heating Project, considerable energy efficiency improvements were achieved: "The Project has made efficiency gains in the areas of heat production, transmission, distribution and consumption. In the production process, the specific fuel consumption has been reduced by an estimated five to ten percent, on average. The renovation of the transmission and distribution networks and installation of variable speed pumps has led to significant energy savings, again estimated in the order of up to ten percent heat and pumping losses. Very dramatic reductions in water losses have also been achieved through the switch from direct to indirect domestic hot water connections, amounting to a decrease of over 85 percent in Tallinn, of almost 90 percent in Tartu and over 90 percent in Parnu. The heat consumption in buildings equipped with renovated substations has been estimated to have been reduced by about 24 percent, on average" (World Bank 2000a: 7).
2. The effective indoor temperature would be 20°C, considering 2°C additional from appliances and body temperature.
3. If gas is used as heating fuel in a more decentralized way, substantial investment could be needed in the network to enable it to carry a larger load than it was originally designed for, as well as at the block and building levels, for example in metering.
4. The analysis is based on a cash-flow methodology where all future cash-flows are discounted by a discount factor of ten percent a year.
5. A reduction of indoor temperature by 1° Celsius reduces heat consumption by about six percent.
6. Households were asked how much they would be willing to pay for an improved heating system with the following characteristics. It would provide enough heat to heat each occupied room in an apartment, to a minimum of 16°C on a reliable 24-hour a day basis, for as many weeks per year as desired by the household; it would be installed at no cost to the household; households could control the amount of heat consumed using controls inside the apartment; bills for the improved service would be based on meter readings of the actual amount of heat consumed and payments would be spread out over 12 months. The survey results were as follows: 80 percent of households agreed with payments of $50, 60 percent with $70 and 40 percent with $100 (see ERM 2001, section 7.5).
7. For details see Swedpower/FVB (2001) and COWI A/S (2002b).

Chapter 5

Providing Clean Heat in Fiscally-Sustainable Ways

The challenge ahead is to design policies, institutions and investments that enable all people (poor and nonpoor) to access clean, affordable heating. In an urban environment this is particularly difficult because whole communities are affected by these choices. Therefore it is critical that the choices allow poor people to opt in to the degree they wish to get the heat they want because they might not use and will not pay for the wrong investments.

What we know so far

The transition has brought difficult choices to governments trying to rationalize budgets and to households trying to maintain living standards. Energy utilities, which evolved in a central planning framework characterized by massive price distortions and direct state control over resource allocation decisions, are caught in the middle. World Bank estimates of annual quasi-fiscal deficits in the power sector range from $34 million in Moldova[1] to $188 million in Georgia (3.6 percent of GDP) to $1 billion in Serbia.

Unable to cover the costs of operations and maintenance, many centralized heating systems have started deteriorating significantly. In an effort to rescue the systems, governments often raise prices. But the absence of meters on these systems and the difficulty of disconnecting nonpaying customers make it difficult to enforce payment. People, particularly poor people, do not like paying for heating systems that do not allow them to control their expenditures. There is an additional challenge of asking people to pay for a service that used to be free and that keeps deteriorating. The net result is a low-level equilibrium where on one side, often due to political pressure, some governments continue to pump money into antiquated district heating systems that are providing a failing service. On the other side, consumers are refusing to pay their bills as the quality of district heating erodes.

Poor people cope with failing district heating supplies and rising energy prices by substituting less expensive dirty energy, including wood, coal, and kerosene. But there are private and social costs associated with poor people's heating choices. Private costs include the opportunity cost of the time spent collecting heating material (especially wood) and illnesses and labor productivity losses associated with insufficient heating. Social costs include air pollution from the burning of dirty fuels and the environmental costs associated with deforestation and the loss of biodiversity. These costs must be taken into account when evaluating the economic implications of alternative heating policies and investments.

Policy instruments such as regulations, taxes, and subsidies coupled with investments in technology and institutional changes offer a way forward. Policy instruments can be used to encourage the poor to make clean choices. Investing in new technology or reengineering existing technology enables governments to do this in fiscally sustainable ways. If the goal is to provide access to clean and affordable heating, investments and policy instruments must be explicitly funded to cover the difference between household expenditures and the cost of supply. Finally, greater emphasis on commercialization of utilities, more involvement of the private sector and of households themselves through community-driven development activities are necessary to improve the daily life of poor households in cold climates.

Policy instruments to encourage clean choices

Regulations

Regulations involve designing and enforcing rules that limit household heating choices. They influence household behavior by indirectly raising the costs of using dirty energy. Examples include setting limits on pollution emissions, regulating access to forest resources by enforcing restrictions on the cutting of fuel wood, and setting standards that prohibit the use of certain technologies (such as wood stoves in high-rise buildings). This means that the new choices are only affordable if they involve decreasing consumption or if clean fuels become less expensive. In general, because the poor rely more on dirty fuels this approach places an additional burden on them. Regulations can also be difficult to enforce and are often expensive. Such regulations might only be a way forward if investments are made in more efficient technologies, such as improved stoves.

Taxes

An alternative to regulation is to tax dirty fuels to encourage households to make clean choices. Taxes on dirty fuels are simple to administer (unless the fuel being taxed is traded illegally) but politically difficult to implement. They may not make sense on equity grounds because they result in higher prices for poor households. It may be possible to return money raised by taxing dirty fuels to consumers in the form of direct payments or by cutting another tax. Such efforts, however, make such taxes much more difficult and costly to administer.

Subsidies

Across-the-board fuel subsidies can help ensure that poor people have access to clean, affordable heat such as from gas or electricity. Though politically attractive, these types of subsidies are costly, and among poor people coverage is limited to the share of connected households. When it comes to clean network energy other than electricity, evidence presented earlier on connection rates (Table 2.1) suggests that more nonpoor than poor households benefit from such subsidies. In addition, the nonpoor are likely to consume more clean energy than the poor, so the bulk of the subsidy ends up going to the nonpoor.

Lifeline tariffs

Restricting fuel subsidies to an initial block of consumption is less costly than providing across-the-board subsidies but preserves some of their politically attractive universal protection (Lovei 2000). However, these function only when consumption can be controlled and is metered at the household level—preconditions not met by most existing systems and rather expensive to retrofit, given the vertical piping of district heating and gas in buildings in the formerly centrally planned economies. In terms of targeting, a lifeline tariff depends on the share of the poor connected to the utility. Because more nonpoor than poor people use clean network energy, there will likely be leakage problems. One solution is to design a block structure that includes a fixed fee for a very low minimum needs level of consumption followed by a significantly higher price for following blocks.

Vouchers

Vouchers (or grants) are lump sum subsidies provided to consumers based on personal or household characteristics and tied to certain behavior. For example, during the winter poor households may be given vouchers for kerosene that can be redeemed at their leisure. The greatest danger with vouchers is the risk of voucher devaluation through trading on secondary markets. Another problem with vouchers is how to target the poor. Solutions to both problems include making vouchers nontradable and rationing their delivery. While more difficult to administer than taxes and subsidies, vouchers may well be fiscally less expensive if they can be effectively targeted.

Direct cash transfers

Another approach is to provide poor households with direct cash transfers or untied lump sums. Such transfers give households complete freedom in deciding how to use the money. Transfers are usually based on eligibility criteria. In practice, the coverage of the poor achieved by these programs seldom rises above 60 percent (Lovei 2000). The problem is that this instrument does not ensure conditional behavior, such as burning clean energy. In Armenia it was found that despite an additional transfer to help meet electricity payments in the face of a price increase, consumption of electricity dropped and consumption of wood increased—particularly among the poor (Lampietti and others 2001). In addition, the transfers are usually too small to allow poor households to cover all their basic needs.

Investments in heating technology

It is almost impossible to find clean heat supply options that deliver full service at $25–40 a year. Even reduced service from clean fuels comes with a price tag that many poor households can ill afford. Thus it is critical to recognize that if the goal is to provide access to clean heating, investments must be explicitly funded to cover the difference between household expenditures and the cost of supply.

There are two investment strategies. One is to continue or increase reliance on large-scale, centralized heating technologies. The other is to encourage smaller, less centralized technologies such as gas-fired boilers that could be supplied under a variety of institutional settings. One danger of the current system is that it encourages the buildup of vested interests with a stake in maintaining the status quo.

Central-planning-style district heating usually offers one fixed level and quality of heating, impeding flexibility. In an environment where the government can no longer afford broad subsidization of heat consumption (directly or indirectly), heat supply options need to be revamped and if necessary newly designed in a way that allows consumers to choose from a range of heating levels with corresponding payment levels.

If properly managed and provided basic investments are made, centrally provided district heating can be just as flexible as individual heating. However, if heat demand is expected to be low for the foreseeable future because of affordability reasons, district heating even if modern, flexible, and well managed will most probably not be the least-cost heating system. Furthermore, the investments required may not be affordable for those cities most in need of them.

In smaller towns, building- or apartment based individual heating options would normally be expected to be least cost and therefore preferable over district heating. Individual consumers decide how many points of service are needed, procure the needed equipment, and arrange for fuel supply. In densely built urban environments, however, individual heating is relatively expensive—usually more expensive than any form of central heating at full heat service levels. It can also have negative environmental impacts, including air pollution and possibly deforestation. Any broader intervention in the heating sector needs to recognize these tradeoffs.

Finally, governments, IFIs and other decision makers need to keep in mind that heating is a local issue and solutions depend very much on the local circumstances. Therefore the solutions and recommendations in this report can offer only broad guidelines and need to be adapted on the basis of local analyses. Decision makers also need to realize that heating has important linkages with the energy sector in general and the power sector in particular through combined heat and power facilities. Since heating is the most important energy use of the residential and building sector, the fuel sources and impacts of heating on energy networks need to be better integrated in national energy sector strategies.

Centralized options

In many of the poorer countries of Eastern Europe and Central Asia and in many smaller towns of the region district heating systems are in dire need of extensive renovation if they are to be operational for the next 15-20 years. This makes the investment decision similar to a decision about a greenfield development. Chapter 4 shows the conditions that make modern district heating the least-cost heating option. But while the costs of heat from a modern system will be lower than those from an old system, they will still not be affordable for many families. Full heating service from an existing system tends to cost between $200 and $900 a year. The cost of heat from a building boiler tends to be similar to that from district heating (see Chapter 4), but it would be easier to increase capacity should demand increase over time. This decreases the financing needs and risks created by unused capacity. Thus, even if a district heating system would be the most cost-effective under assumptions of full heat service, new investment should be targeted first at block heating systems that could later be joined and supplied from a more central generation facility, preferably on the basis of cogeneration.

Smaller-scale solutions such as building boilers could also be implemented more easily, based on the decisions of just one building, which tends to be more homogeneous than an entire community or municipality. A cooperative or condominium could contract with, say, a gas company or an entrepreneur for the delivery of heat services.

Meters and control options

All centrally provided heat supply options can be fitted with meters and control options that make the systems more flexible and allow users to choose the amount of heat and levels of comfort and spending. Many consumers in Eastern Europe and Central Asia have invested in meters and control devices, considerably reducing their heat expenditures, increasing their comfort, or both (see Box 2, Annex 8, for the experience in Poland and JP 2002 more generally for the international experience). Whether and how much consumers can actually save depends on the level of over- or underheating and the relationship between the system's fixed and variable costs. Only variable costs can be reduced in proportion to reduced consumption. In systems where underheating is common, many consumers tend to increase their comfort rather than save energy (see World Bank 2002). In general, however, individual metering and control can save 15–20 percent of heat energy.

In some countries where individual meters are not yet in place, a crude approximation of a flexible district heating system has been used. Consumers are allowed to disconnect some of their radiators, and payment is then based on the number of radiators (see Box 3, Annex 8, for the experience in Bulgaria).

Efficient stoves

Individual heating options can be clean and efficient as well as flexible. In some countries (Georgia, Mongolia) improved stoves for wood and coal have been developed and commercially distributed. These stoves use much less fuel, burn much cleaner, and do not cost much more than a regular, inefficient stove (for Mongolia see ESMAP 2001). Electric heaters are generally not a feasible heating option for poor people because high electricity tariffs make anything but the most basic heating very expensive. In addition electric heating may impose large demand on the power networks that will require major investments. If cheap nighttime electricity can be provided, and the needed time-based meters installed, partial electric heating might become an affordable option. Thus investing in efficient technology can produce substantial reductions in consumption, with this strategy being particularly important in places where prices are still very low but are bound to increase.

Better insulation of buildings

Most buildings in Eastern Europe and Central Asia use two to three times as much heat as buildings in comparable climates in Western Europe. Improving the tightness of the building shell lowers the requirements for heating and so the cost of achieving a minimum or desired comfort level. Such measures are rather expensive, however, and unless very bad conditions are remedied (such as broken windows), they are not as cost-effective as many measures on the supply side. Payback times of 5–10 years are typical; exterior insulation has an even longer payback time.

However, if poor consumers could receive financial support for improved insulation, this might enable them to participate in communal heating services (such as building boilers) that they could otherwise ill afford. A revolving fund could be established to help the population finance small heat-saving investments. This fund, which would be preferentially geared toward poor households, would finance up to 100 percent of such investments (depending on the financial condition of the debtor) through loans of up to, say, $200. The loan would be administered by local bodies (such as the municipality or household associations) and would automatically be repaid over several years from the savings achieved on the heating bills, assessed with some appropriate algorithm. Part of the savings (say, 70 percent) could be used to repay the loan, with the rest benefiting the household until the loan is repaid. Financing schemes such as this, appropriately communicated, would offer substantial incentives to the poor for improving their condition (see Kantor 2001). For very poor households outright grants could be considered, especially if this would enable them to participate in community-based activities to improve heating services.

Capital and recurrent costs

The main barrier to poor households accessing clean (modern) infrastructure services may well be the high initial costs—that is, the connection to network energy sources and purchase of necessary appliances. More centralized heating systems tend to have higher capital costs relative to variable and fuel costs (see Figure 4-4). For network energies (that is, in a utility context) much of the capital cost is initially expensed by the utility and charged to consumers over a fairly long period through monthly fees. In principle, this approach makes the service more affordable for households. But many poor people find themselves increasingly unable to afford high monthly payments for network energy. Innovative financial instruments need to be explored to distribute costs over a longer period. Microfinance instruments have been successfully used in some countries, including the Kyrgyz Republic and Romania, to finance small building boilers.

Institutional challenges

Commercialization of district heating and private provision of heating services

The costs of providing heat and the flexibility that a heat supply option offers are not the only considerations when making decisions about heat supply options. Institutional challenges need to be considered carefully as well. District heating requires an organization with advanced technical, financial, and organizational capacity. But financial and organizational capacity is usually in very short supply in municipal utilities. If district heating is to survive without continuous government subsidies, at a minimum, the heat supply companies need to be commercialized. This means a streamlined organizational structure, efficient operation (rationalization) based on contractual obligations, full cost recovery through enforcement of payment and no undertaking of "social" obligations.

District heating is often protected from competition by outdated norms and inappropriate regulations being applied to less centralized heat supply options. Old norms are often still in place that require enormous reserve capacity (say, 100 percent), making it extremely costly to provide heat from building boilers. There is a tendency to apply the regulatory supervision, especially tariff setting, in place for district heating also to non-district heating. However, these smaller-scale heating systems are much more open to competition and could be provided entirely by the private sector on the basis of commercial contracts. An appropriate enabling framework would consist of arrangements to protect consumers from monopolistic pricing and enforce safety and environmental standards, and provide for some support mechanisms to ensure access to heating services for poor households. In addition, if consumers associate, for example in condominiums, these may act either as suppliers or contract on behalf of their members for heating services. This would provide more bargaining power vis-à-vis any heat supplier.

Community development

Collective action at the building or community level offers one promising approach to bringing down the costs of heat supply. Groups of households acting together can produce significant economies of scale in consumption, reduce transaction costs in collections, and provide guarantees to service providers. In fact, such collective interface is indispensable for any central heating option, since individual connections and disconnections are technically difficult and expensive.

While promising, collective action is not as commonly observed as one might expect. People are often observed collaborating on a reactive rather than proactive basis. For example, they organize the repair of an elevator when it breaks or a roof when it leaks, but rarely do they gather money from residents to arrange service contracts, such as heating, in advance. When asked why they do not engage in more collective behavior residents typically indicate that it is not their responsibility to get involved in the running of the heating system and that free riding will encourage the state to supply heat.

Community development activities that will encourage effective collective action include building trust between community members, increasing organizational and management skills, and promoting transparent procurement and implementation. These activities can be supported through investments in training in collective decision-making, conflict resolution and financial management as well as development of standard by-laws for cooperative organizations and codes of conduct for managers.

In addition, financial issues are key concerns in organization of collective action. People do not want to handle the difficult task of managing non-payment, nor do they want to be responsible for depriving their neighbors of heating. Collective actions that focus on labor contributions rather than financial participation may be more successful, especially in poor areas. Where financial participation is required (for example, via the collection of user fees or repair charges), it is important to recognize potential implementation problems in buildings where there are many poor households and a great variation in household incomes.

Conclusion

There is a broad range of policy and investment instruments available to encourage poor households to make clean heating choices and improve cost recovery. If the focus is on promoting clean non-network fuels, then targeted vouchers for equipment and possibly fuel may be promising instruments. If the focus is on promoting access and use of network energy then lifeline tariffs, as long as the size of the blocks is set to minimize leakage to the non-poor and the government explicitly compensates utilities for any social transfers they are asked to provide, may offer a promising alternative.

In terms of investments, earlier chapters indicate that there is a role for public sector intervention in either increasing access to low-cost clean non-network energy or extending clean energy networks into poor areas. Network investments must be coupled with investments in metering and control options and with consumption-based billing, allowing users to choose the amount of heat and levels of comfort and spending. Particularly promising, especially in areas where large increases in clean fuel prices are expected, are investments in efficiency improvements and insulation that can produce substantial reductions in consumption. These investments must be coupled with innovative financial instruments that enable consumers, particularly the poor, to distribute capital costs over a longer period.

In addition to policy and investment instruments, there is considerable room to increase the institutional efficiency of heating service delivery. This can be achieved through a combination of enterprise commercialization and training of heating service providers, promoting effective collective action at the community level, and encouraging participation of private sector service providers.

Note

1. Probably in 1998 (about 2.3 percent of GDP); since then reduced considerably to US$7–8 million through privatization.

ANNEXES

Annex 1. Purchasing power parity and exchange rate conversions

To provide consistency in comparison of poverty rates according to the same standards across the countries, US$2.15 per capita-day and US$4.30 per capita-day, household consumption in local currencies were brought to 1999 values by using PPP adjusted rates.

Country	Survey Period	1996 PPP Exchange Rate*	CPI 1996 Average	CPI Survey Reference Period	PPP Exchange Rate Adjusted to the Survey Period**
Armenia	Nov 99 – Jan 00	128.54	118.7	146.3	158.47
Kyrgyz	Sept – Dec 99	3.47	130.4	303.3	8.07
Croatia	Oct 97	4.16	104.3	117	4.66
Moldova	Feb – May 99	1.16	120.9	191	1.83
Tajikistan	May 99	56.94	100	411.5	234.29
Lithuania	Sep 98	1.55	124.6	142	1.77
Latvia	Sep 97	0.26	117.6	133.2	0.29

* The rates that were used in World Bank 2000b.

** 1996 PPP exchange rates were adjusted for domestic inflation by multiplying the 1996 PPP exchange rate by the ratio of CPI (Consumer Price Index) in the country in the survey period (average for the period) to the average CPI in 1996. The exchange rate was used to convert the expenditures reported in the surveys from local currency to PPP USD.

In calculation of expenditure on energy or other monetory values such as unit prices of different fuel types, we used inflated exchange rates rather than PPP adjusted values. There are two reasons for that. First, we wanted to see the differences in energy policies by looking at the differences between unadjusted values. Second, the comparison among countries, such as the rate of energy expenditure in household budget, did not require such adjustment. Nevertheless, after converting variables to US dollars by using the rates within the survey period, they were inflated to 1999 levels for consistency.

Country	Survey Period	Local Currency	Survey Year US$ Rate	Inflation	US$ Rate, Inflated to 1999
Armenia	Nov 99 – Jan 00	Armenian Dram	525.48	•	525.48
Kyrgyz	Sept – Dec 99	Kyrgyz Soms	43.84	•	43.84
Croatia	Oct 97	Croatian Kunas	6.101	0.97	5.877
Moldova	Feb – May 99	Moldovan Lei	9.99	•	9.99128
Tajikistan	May 99	Tajik Rubles	1128.00	•	1128.00
Lithuania	Sep 98	Lituanian Litas	4.00	♦	4.00
Latvia	Sep 97	Latvian Lats	0.58	0.97	0.558

• Survey period is the same as baseline year.

♦ Lithuania uses "fixed currency rate" policy.

Poverty in Eastern Europe and Central Asia
(1996 U.S. dollars adjusted for purchasing power parity)

Country (survey year)	National head count at $2.15 a day (percent)	Urban mean per capita spending (dollars a day)	Urban head count at $2.15 a day (percent)	Urban mean per capita spending among the poor (dollars a day)
Armenia (1999)	38	2.6	41	1.6
Croatia (1997)	<1	16.2	<1	-
Kyrgyz Rep. (1999)	47	2.9	44	1.4
Latvia (1997)	7	5.9	6	1.6
Lithuania (1998)	2	8.8	1	1.8
Moldova (1999)	35	5.6	13	1.6
Tajikistan (1999)	69	2.2	63	1.4

[1] The seven countries included in the analysis were selected based on the availability of recent (1997 or later) household survey data with sufficient survey questions about energy expenditure patterns. Studying household energy consumption patterns requires data on prices, quantities, and expenditures. Because these data are not available from all the household surveys, some assumptions are required. These assumptions and summary statistics for the data presented in this paper are provided in Annexes 2 and 3.

Source: Author's calculations based on household survey data.

Annex 2. Data Assumptions

Variables and their definition

Fuel	Abbr.	Unit	Use*	Price	Quantity	Expenditure
Liquid Gas	LPG	kg	useLPG	pLPG_kg	qLPG_kg	expLPG
Kerosene	KER	l	useKER	pKER_l	qKER_l	expKER
Coal	COL	kg	useCOL	pCOL_kg	qCOL_kg	expCOL
Wood	WOD	kg	useWOD	pWOD_kg	qWOD_kg	expWOD
Electricity	ELE	kwh	useELE	pELE_kwh	qELE_kwh	expELE
Central Heating	CH	gc	useCH	pCH_gc	qCH_gc	expCH
Central Gas	CG	m^3	useCG	pCG_m3	qCG_m3	expCG

* Use is defined as positive consumption of fuel

Legend:
√: Reported in the survey
c: calculated means dividing expenditure by either quantity or price. Thus calculated prices are actually average costs.
*: from outside source
•: missing / not available
M: Monthly
S: Seasonal
A: Annual

Armenia

Fuel	Use	Price	Quantity		Expenditure	
			Source	Period	Source	Period
LPG	√	√	√	A	c	
KER	√	√	√	A	c	
COL	√	√	√	A	c	
WOD	√	√	√	A	c	
ELE	√	*	√	M	√	M
CH	√	*	c		√	S
CG	√	*	c		√	M

Kyrgyz

Fuel	Use	Price	Quantity		Expenditure	
			Source	Period	Source	Period
LPG	√	√	√	S	c	
KER	√	*	c		√	S
COL	√	c	√	S	√	S
WOD	√	*	c		√	S
ELE	√	*	c		√	M
CH	√	*	c		√	S
CG	√	c	√	M	√	S

Croatia

Fuel	Use	Price	Quantity		Expenditure	
			Source	Period	Source	Period
LPG	√	*	√	A	√	A
KER	√	•	√	A	√	A
COL	√	*	√	A	√	A
WOD	√	*	√	A	√	A
ELE	√	*	√	M	√	M
CH	√	•	•		√	M
CG	√	*	√	A	√	A

Moldova

Fuel	Use	Price	Quantity		Expenditure	
			Source	Period	Source	Period
LPG	√	*	•		•	
KER	•	•	•		•	
COL	√	*	√	S	c	
WOD	√	*	√	S	c	
ELE	√	*	√	M	c	
CH	√	*	c		√	M
CG	√	*	√	M	√	M

Tajikistan

Fuel	Use	Price	Quantity		Expenditure	
			Source	Period	Source	Period
LPG	•	•	•		•	
KER	√	*	c		√	M
COL	√	*	•		•	
WOD	√	*	•		•	
ELE	√	*	c		√	M
CH	√	*	c		√	S
CG	√	*	c		√	S

Lithuania

Fuel	Use	Price	Quantity		Expenditure	
			Source	Period	Source	Period
LPG	•	*	•		•	
KER	•	•	•		•	
COL	√	*	C		√	A
WOD	√	*	C		√	A
ELE	√	*	C		√	A
CH	√	*	C		√	A
CG	√	*	C		√	A

Latvia

Fuel	Use	Price	Quantity		Expenditure	
			Source	Period	Source	Period
LPG	√	*	c		√	M
KER	⊙	⊙	⊙		○	
COL	√	*	c		√	S
WOD	√	*	c		√	M
ELE	√	*	c		√	M
CH	√	*	c		√	S
CG	√	*	c		√	S

Annex 3. Household Energy Consumption Summary Statistics

Armenia

Variable	Obs	Mean	Std. Dev.	Min	Max
useLPG	1350	0.24963	0.432959	0	1
useKER	1350	0.117778	0.322464	0	1
useCOL	1350	0	0	0	0
useWOD	1350	0.491852	0.500119	0	1
useELE	1350	0.985926	0.11784	0	1
useCH	1350	0.137037	0.344014	0	1
useCG	1350	0.140741	0.347883	0	1

Variable	Obs	Mean	Std. Dev.	Min	Max
pLPG_oe	331	0.589047	0.059046	0.44925	0.7188
pKER_oe	133	0.400775	0.107283	0.230949	0.692848
pCOL_oe	0				
pWOD_oe	573	0.164662	0.047353	0.050612	0.278368
pELE_oe	1350	0.559712	0	0.559712	0.559712
pCH_oe	900	0.180348	0.053126	0.147419	0.265964
pCG_oe	1350	0.116512	0	0.116512	0.116512

Variable	Obs	Mean	Std. Dev.	Min	Max
qLPG_oe	1340	18.16422	38.66249	0	211.8
qKER_oe	1336	3.540856	13.90509	0	123.6
qCOL_oe	1350	0	0	0	0
qWOD_oe	1341	151.6617	195.8701	0	1128
qELE_oe	1347	136.2212	103.6615	0	611.065
qCH_oe	0				
qCG_oe	1317	111.1877	363.6023	0	2744

Variable	Obs	Mean	Std. Dev.	Min	Max
expLPG	1337	10.74096	23.26625	0	137.0176
expKER	1313	1.104202	4.847675	0	57.09066
expCOL	1350	0	0	0	0
expWOD	1255	22.4295	30.83066	0	159.8539
expELE	1348	65.7214	54.71257	0	342.0682
expCH	1296	6.066617	19.36755	0	102.7632
ExpCG	1317	12.21801	39.99641	0	274.0352

Kyrgyz

Variable	Obs	Mean	Std. Dev.	Min	Max
UseLPG	2344	0.367321	0.482178	0	1
UseKER	2342	0.190009	0.392391	0	1
UseCOL	2345	0.352239	0.47777	0	1
UseWOD	2346	0.252344	0.43445	0	1
useELE	2352	0.992347	0.087165	0	1
useCH	2348	0.498722	0.500105	0	1
useCG	2351	0.301999	0.459223	0	1

Variable	Obs	Mean	Std. Dev.	Min	Max
pLPG_oe	859	0.219054	0.049807	0.080773	1.220566
pKER_oe	2364	0.470876	0	0.470876	0.470876
pCOL_oe	705	0.006539	0.002238	7.03E-06	0.021082
pWOD_oe	2364	0.078325	0	0.078325	0.078325
pELE_oe	2288	0.051957	0.003561	0.048841	0.063651
pCH_oe	2364	0.040267	0	0.040267	0.040267
pCG_oe	224	0.070621	0.058126	0.005532	0.79069

Variable	Obs	Mean	Std. Dev.	Min	Max
qLPG_oe	2063	13.94205	25.47925	0	148.26
qKER_oe	2326	0.558355	1.522229	0	11.6261
qCOL_oe	2228	392.1522	653.3833	0	3246
qWOD_oe	2343	67.46366	152.391	0	1164.898
qELE_oe	2311	202.7521	144.6981	0	1321.714
qCH_oe	0				
qCG_oe	1862	8.281684	26.06614	0	183.26

Variable	Obs	Mean	Std. Dev.	Min	Max
expLPG	2068	8.977586	16.18402	0	93.0657
expKER	2348	0.26292	0.717712	0	5.474452
expCOL	2362	10.65464	17.48504	0	91.24088
expWOD	2361	1.74794	3.966445	0	30.41363
expELE	2311	10.96501	8.970309	0	82.11679
expCH	2347	5.603208	8.929994	0	63.86861
expCG	2332	1.838003	3.652303	0	24.63504

Croatia

Variable	Obs	Mean	Std. Dev.	Min	Max
useLPG	1726	0.445539	0.497169	0	1
useKER	1726	0.067787	0.251453	0	1
useCOL	1726	0.011008	0.104371	0	1
useWOD	1726	0.303013	0.459694	0	1
useELE	1726	0.998841	0.034031	0	1
useCH	1726	0.352839	0.477992	0	1
useCG	1726	0.284473	0.451294	0	1

Variable	Obs	Mean	Std. Dev.	Min	Max
pLPG_oe	1726	0.878676	0	0.878676	0.878676
pKER_oe	0				
pCOL_oe	1726	0.2064	0	0.2064	0.2064
pWOD_oe	1726	0.113133	0	0.113133	0.113133
pELE_oe	1726	0.938337	0	0.938337	0.938337
pCH_oe	0				
pCG_oe	1726	0.248947	0	0.248947	0.248947

Variable	Obs	Mean	Std. Dev.	Min	Max
qLPG_oe	1721	41.47822	57.79245	0	317.7
qKER_oe	1709	85.66804	387.821	0	2472
qCOL_oe	1713	0.189492	3.197121	0	54.1
qWOD_oe	1720	274.6549	498.1277	0	2368.8
qELE_oe	922	298.5378	224.3949	0	1591.2
qCH_oe	0				
qCG_oe	1455	192.3617	641.2096	0	4198.32

Variable	Obs	Mean	Std. Dev.	Min	Max
expLPG	1719	31.34008	43.2622	0	340.8491
expKER	1713	40.60634	179.6126	0	1274.475
expCOL	1713	0.420034	7.128711	0	136.3396
expWOD	1719	6.685913	16.20486	0	101.948
expELE	1720	303.4076	198.7088	0	1255.688
expCH	1707	15.99929	84.84733	0	615.5378
expCG	1715	86.78488	224.2414	0	1546.539

Moldova

Variable	Obs	Mean	Std. Dev.	Min	Max
useLPG	1051	0.0647	0.246113	0	1
useKER	0				
useCOL	1051	0.055186	0.228451	0	1
useWOD	1051	0.091342	0.288231	0	1
useELE	1051	0.856327	0.350925	0	1
useCH	1051	0.506185	0.5002	0	1
useCG	1027	0.652386	0.476445	0	1

Variable	Obs	Mean	Std. Dev.	Min	Max
pLPG_oe	1051	0.4093	0	0.4093	0.4093
pKER_oe	0				
pCOL_oe	1051	0.093242	0	0.093242	0.093242
pWOD_oe	1051	0.097159	0	0.097159	0.097159
pELE_oe	1051	0.447449	0	0.447449	0.447449
pCH_oe	1051	0.150131	0	0.150131	0.150131
pCG_oe	1051	0.111262	0	0.111262	0.111262

Variable	Obs	Mean	Std. Dev.	Min	Max
qLPG_oe	0				
qKER_oe	0				
qCOL_oe	1037	7.51557	39.39946	0	324.6
qWOD_oe	1049	35.59276	128.02	0	1278.4
qELE_oe	1049	69.98328	67.69999	0	428.4
qCH_oe	0				
qCG_oe	1044	309.6949	851.0945	0	4998

Variable	Obs	Mean	Std. Dev.	Min	Max
expLPG	0				
expKER	0				
expCOL	1037	0	0	0	0
expWOD	1050	3.162615	11.84604	0	124.2083
expELE	1045	52.55473	41.62928	0	240.2095
expCH	497	87.65471	44.8206	8.006982	240.2095
expCG	1047	25.07784	46.62881	0	399.9488

Tajikistan

Variable	Obs	Mean	Std. Dev.	Min	Max
useLPG	0				
useKER	544	0.011029	0.104536	0	1
useCOL	544	0.165441	0.37192	0	1
useWOD	544	0.347427	0.476591	0	1
useELE	544	0.998162	0.042875	0	1
useCH	544	0.012868	0.112807	0	1
useCG	544	0.056985	0.232028	0	1

Variable	Obs	Mean	Std. Dev.	Min	Max
pLPG_oe	0				
pKER_oe	544	0.110119	0.018012	0.096829	0.134485
pCOL_oe	544	3.41E-05	0	3.41E-05	3.41E-05
pWOD_oe	544	0.0002	0	0.0002	0.0002
pELE_oe	544	0.026074	0	0.026074	0.026074
pCH_oe	535	0.133536	0.061392	0.027944	0.400684
pCG_oe	544	0.060024	0	0.060024	0.060024

Variable	Obs	Mean	Std. Dev.	Min	Max
qLPG_oe	0				
qKER_oe	517	14.25632	49.50227	0	439.4666
qCOL_oe	0				
qWOD_oe	0				
qELE_oe	534	258.7201	371.0144	0	2325.6
qCH_oe	0				
qCG_oe	520	32.35328	71.87463	0	472.6241

Variable	Obs	Mean	Std. Dev.	Min	Max
expLPG	0				
expKER	517	1.432569	4.909651	0	42.55319
expCOL	0				
expWOD	0				
expELE	534	6.745936	9.673927	0	60.6383
expCH	519	0.035564	0.439801	0	7.092199
expCG	520	1.941974	4.314203	0	28.36879

Lithuania

Variable	Obs	Mean	Std. Dev.	Min	Max
UseLPG	0				
UseKER	0				
UseCOL	5179	0.003862	0.062029	0	1
UseWOD	5179	0.022398	0.147989	0	1
UseELE	5179	0.928172	0.258229	0	1
UseCH	5179	0.430006	0.495124	0	1
UseCG	5179	0.546438	0.497887	0	1

Variable	Obs	Mean	Std. Dev.	Min	Max
pLPG_oe	5179	0.263279	0	0.263279	0.263279
pKER_oe	0				
pCOL_oe	5179	0.130776	0	0.130776	0.130776
pWOD_oe	5179	0.106782	0	0.106782	0.106782
pELE_oe	5179	0.588235	0	0.588235	0.588235
pCH_oe	5179	0.000327	0	0.000327	0.000327
pCG_oe	5179	0.208884	0	0.208884	0.208884

Variable	Obs	Mean	Std. Dev.	Min	Max
qLPG_oe	0				
qKER_oe	0				
qCOL_oe	20	11249.16	8122.379	607.6788	35786.29
qWOD_oe	116	6400.556	5219.525	140.4732	25285.18
qELE_oe	4785	113.8147	74.71105	1.122	586.5
qCH_oe	0				
qCG_oe	2800	179.4595	266.6966	8.760862	2626.822

Variable	Obs	Mean	Std. Dev.	Min	Max
ExpLPG	0				
ExpKER	0				
ExpCOL	20	1471.124	1062.215	79.47	4680
ExpWOD	116	683.4636	557.3509	15	2700
ExpELE	4785	66.94982	43.94768	0.66	345
ExpCH	2221	347.5222	183.1078	4.8	1276.53
ExpCG	2800	37.48614	55.70853	1.83	548.7

Latvia

Variable	Obs	Mean	Std. Dev.	Min	Max
UseLPG	5269	0.292086	0.454765	0	1
UseKER	0				
UseCOL	5269	0.001708	0.041298	0	1
useWOD	5269	0.018789	0.135793	0	1
useELE	5269	0.998292	0.041298	0	1
useCH	5269	0.805276	0.396026	0	1
useCG	5269	0.664832	0.472094	0	1

Variable	Obs	Mean	Std. Dev.	Min	Max
pLPG_oe	5269	0.345334	0	0.345334	0.345334
pKER_oe	0				
pCOL_oe	5269	0.121209	0	0.121209	0.121209
pWOD_oe	5269	0.166873	0	0.166873	0.166873
pELE_oe	5269	0.600867	0	0.600867	0.600867
pCH_oe	5269	0.353782	0	0.353782	0.353782
pCG_oe	2432	0.764921	0.123135	0.761839	6.606911

Variable	Obs	Mean	Std. Dev.	Min	Max
qLPG_oe	4218	37.59387	114.6067	0	622.9412
qKER_oe	0				
qCOL_oe	3915	690.3813	553.7428	1.774803	4449.432
qWOD_oe	100	2392.791	1639.365	0	7734.857
qELE_oe	3924	138.947	111.7738	0	897.557
qCH_oe	0				
qCG_oe	4169	40.87255	53.1887	0	531.4257

Variable	Obs	Mean	Std. Dev.	Min	Max
expLPG	5253	10.3426	35.61531	0	206.5179
expKER	0				
expCOL	5261	0.020445	1.482935	0	107.5614
expWOD	5217	1.677232	18.96123	0	322.6841
expELE	5249	62.1124	67.57205	0	498.6546
expCH	5255	55.28749	87.49977	0	548.563
expCG	5235	8.120874	12.07784	0	121.9029

Annex 4. Social Costs of Heating Options

Health and productivity costs of not having enough heat

In many recent surveys in Eastern Europe, households have complained about insufficient heat from dilapidated district heating systems and the resulting increases in illnesses. For example, in Sevastopol, Ukraine, it was reported that in 56 percent of households somebody had gotten sick because indoor temperatures were too low. A better heat supply would significantly reduce the number of sick days and so increase productivity.

Moldova's heat supply is also severely constrained, with many households subjected to indoor temperatures of just 5-10° Celsius during the heating season. Nearly three-quarters of survey respondents connected to district heating said that they were too cold last winter. Among the 40 percent of urban households surveyed that are not connected to district heating, the average household heats only two rooms for less than five hours. About a third of urban households reported that at least one family member got sick during the winter, and many believed that low indoor temperatures were the reason. These families lose income and have to bear the costs of treating the illnesses. National productivity and GDP also suffer.

Health costs of burning dirty fuels

Air pollution, particularly indoor air pollution, is an increasingly important environmental and public health issue. A number of studies have established the possible effects of wood stoves and other dirty fuels on respiratory illness, particularly in young children and the elderly (Honicky and others, 1991; Xu and others, 1989). Airborne particulate matter from the burning of wood and coal is associated with chronic obstructive pulmonary disease, acute respiratory diseases in children, low birth-weight, higher infant and perinatal mortality, pulmonary tuberculosis, naso-pharyngeal and laryngeal cancer, and even lung cancer. Because the poor are more likely to burn wood and coal in their homes, they are also more likely to be exposed to higher levels of particulate matter.

Indoor air pollution has both direct and indirect costs. Direct costs include time spent visiting doctors, sick leave for patients and individuals caring for them, and spending on medicine and health care. Indirect costs include pain and suffering. Treating an episode of respiratory illness in Armenia, including the doctor's visit, medicine, food, and lost labor costs, runs an average of $9. An individual in a wood-burning household is 2.5 times more likely to report an episode of respiratory disease than is an individual in a household that does not use wood—suggesting that poor people bear the brunt of the social cost from the burning of dirty fuels. Indoor air pollution levels may not result solely from heating, but may also be due to cooking with dirty fuels. Policies to improve indoor air quality must take that into account as well.

It was also calculated that in Armenia indoor urban exposure to smoke causes the annual loss of 3,467 life years per 100,000 children under five and 120 life years per 100,000 women (Environmental Resources Management, 2001). The resulting economic cost to these women and children is estimated to be $3.2 million a year. Details of these calculation can be found in Environmental Resources Management 2001.

Environmental costs of deforestation

Forests are a valuable resource for their timber, watershed protection functions, and biodiversity values, and for sequestering carbon. Yet they are one of the most mismanaged resources in developing countries because they are often seriously undervalued. Many of their environmental benefits do not enter markets, and poor governance has often encouraged illegal activities. Moreover, many policies and investments aimed at addressing problems in one sector, such as energy, may affect forests in ways that are not well understood or are disregarded. In almost all countries wood is among the least expensive fuels, so when the price of another fuel increases, wood may be substituted. For example, in January 2000 the government of Armenia eliminated the increasing block tariff for electricity in favor of a single price, leading to a 47 percent increase in the price of electricity for residential consumers. When households were asked how they responded to this change, 80 percent reported that they substituted away from electricity—and more than 60 percent said that wood was the primary substitute. The increased reliance on wood is particularly common among the urban poor, who now use wood for heating and cooking.

Although deforestation is likely to continue even with good economic management and governance, in Eastern and Central Europe and the former Soviet Union over the past 10 years it may partly be the result of sector policy spillovers coupled with lack of governance. Energy policies have often led to rapid increases in electricity prices in countries with more or less open access to forest resources.

Opportunity cost of collecting wood

The poor often must spend time collecting wood and other materials to keep themselves warm. This is time that they could spend earning money or that their children could spend in school. The decision of whether to collect wood or to buy it depends on the opportunity cost of one's time and the price of wood. Thus collecting wood is a substitute for buying wood—when the price of wood rises, the poor will spend more time collecting it.

In Armenia only 20 percent of poor urban apartment dwellers buy wood, while more than 27 percent use it. The difference is that many households collect and cut their own wood rather than purchasing cut wood. Poor households spend nearly twice as much time collecting wood than do nonpoor households. Over the course of a year a poor household might spend more than 10 person-days collecting and cutting the 200 kgoe of wood needed for heating. Assuming a daily wage for unskilled labor of $2-3, this is equivalent to $20-30 a year in heating costs, which is consistent with the spending data presented above.

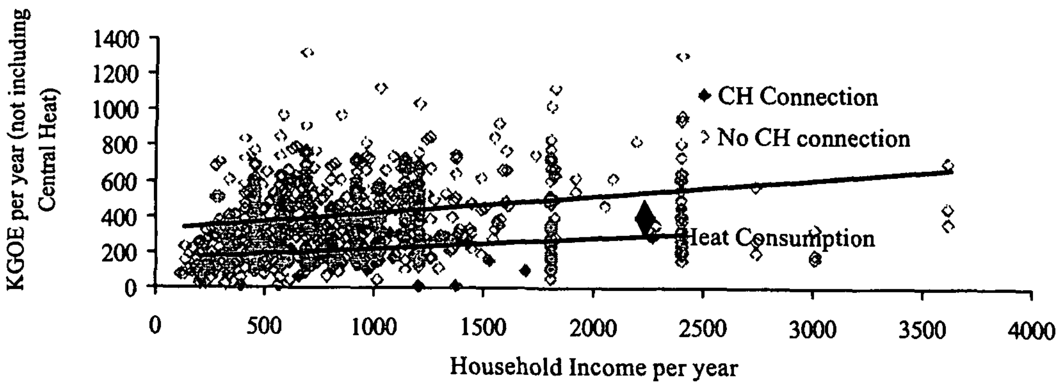
Annex 5. How to Estimate the Demand for Heat

Separating the demand for heat from nonheat energy is difficult in survey data because households consume a mix of fuels for a variety of purposes. For example, one household may use wood for heating and cooking in the winter and LPG for cooking in the summer. Another may use electricity for heating and gas for cooking in the winter and electricity for air conditioning and gas for cooking in the summer. One approach to identifying heat consumption is to use norms to net out basic needs, then study the residual. But that approach obscures the variations in consumption and spending patterns that are of interest here.

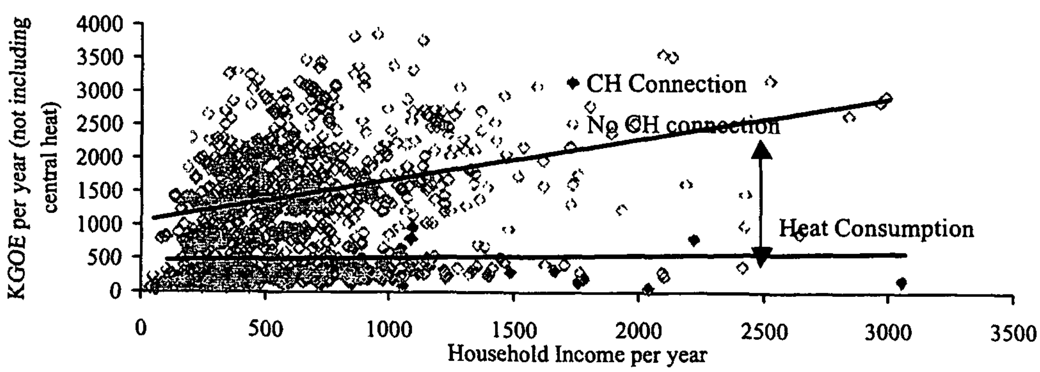
To solve that problem, we developed a new approach to estimating heat demand. The approach relies on two subsamples: households that are connected to the central heating network and report that central heating is their only source of heat, and households that have no central heat. For the first group, all non-central heat energy consumption is for nonheating purposes such as lighting and cooking. Comparing the total energy consumption (not including central heat) of these two groups of households makes it possible to isolate the energy used for heating. A scatter-plot illustrating this relationship for the three countries is presented below. We exploit this natural experiment in our data to develop and estimate a nested heat demand model. The model specification and interpretation of the coefficients is presented in the box below.

Energy Consumption Scatterplots

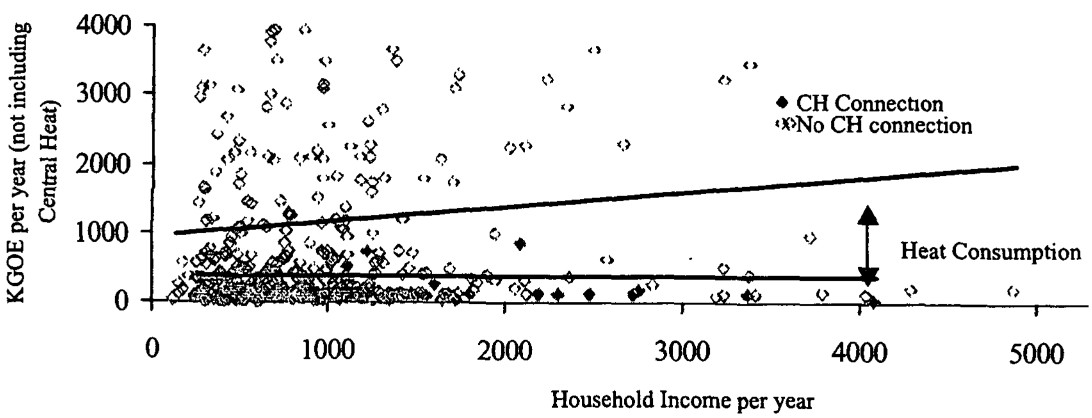
A. Armenia



B. Kyrgyz



C. Moldova



Source: Author's calculations.

Household heat demand specification

We start with the following reduced form equation:

$$qOE_i = \alpha_0 + \alpha_1 income_i + \alpha_2 p\_nh_i + \alpha_3 hhsize_i + \alpha_{4i} CH_i \quad (1)$$

where energy consumption (qOE) for household (i) is a function of income, price index of non heat energy (p_nh), and central heat (CH). For households with central heating (CH_i=0) the equation becomes

$$qOE_i = \alpha_0 + \alpha_1 income_i + \alpha_2 p\_nh_i + \alpha_3 hhsize_i \quad (2)$$

and for households without central heating (CH_i=1) the equation becomes

$$qOE_i = \alpha_0 + \alpha_1 income_i + \alpha_2 p\_nh_i + \alpha_3 hhsize_i + \alpha_{4i} \quad (3)$$

Since households with central heating do not consume other fuels for heating purpose, the difference between the two equations, or α_{4i}, can be interpreted as a measurement of heating consumption for households without central heating. Therefore,

$$qOE\_heating_i = \alpha_{4i} \quad (4)$$

Suppose, restricting i to be households without central heating, the demand function for heating can be specified as

$$qOE\_heating_i = \beta_0 + \beta_1 income_i + \beta_2 p\_h_i + \mathrm{X'B} \quad (5)$$

where p_h is the price of heat and X'B is a vector including number of rooms, housing type, and temperature.

substituting $qOE\_heating_i = \alpha_{4i}$ into (5) yields

$$\alpha_{4i} = \beta_0 + \beta_1 income_i + \beta_2 p\_h_i + \mathrm{X'B} \quad (6)$$

Since we don't know α_{4i} equation (6) can not be estimated directly. However, the coefficients for equation (6) can be estimated by linking (6) with (1) through α_{4i}. Substituting (6) into (1) leads the following new equation

$$\begin{aligned} qOE_i = {} & \alpha_0 + \alpha_1 income_i + \alpha_2 p\_nh_i + \alpha_3 hhsize_i + \beta_0 CH_i + \\ & \beta_1 CH_i income_i + \beta_2 CH_i p\_h_i + \mathrm{X'B} \end{aligned} \quad ....(7)$$

which can be estimated directly, and the coefficients for demand function for heating are coefficients for $CH_i, CH_i income_i, CH_i p\_h_i$ and $\mathrm{X'B}$, respectively.

The variables included in the model are explained in the box. The nested heat demand model fits the data well in all three countries. F-statistics are highly significant and the R-square is in the range of 0.4 to 0.5. All of the variables, except temperature, have the expected sign and are statistically significant at the five percent level, increasing confidence in the model. Energy consumption increases with both income and household size and it decreases with energy price. Households with central heat consume less energy than those without. Heat consumption increases with income and decreases with price.[9] Households with more rooms consume more heat. Households living in apartments consume less heat than in houses. Standard diagnostic tests were performed to verify the validity of the Ordinary Least Squares procedure. These tests, outlined in detail in Annex 6 of this chapter, indicate the empirical results are reliable.

The main disadvantage of this approach is that we are measuring the demand for energy for heating rather than for heat itself. But we cannot measure the demand for heat directly because we do not have data on indoor temperatures or the efficiency of heating appliances. This lack of data prevents us from directly exploring how much variation there is in actual heat consumption between the poor and nonpoor.

Heat demand estimation results

	Armenia		Kyrgyz		Moldova	
Description	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat
Per capita exp. Quintiles	17.59	2.91	54.03	2.01	17.52	0.36
Non-heat energy price index	-125.73	-2.42	-3485.13	-6.01	-1291.20	-13.04
Household size	17.69	4.20	69.14	4.23	18.87	0.48
Central heat(0) otherwise (1)	196.88	5.27	377.37	2.65	576.25	3.03
CH x per capita expenditure	0.06	3.87	0.31	3.51	0.14	1.45
CH x price of primary heat fuel	-445.03	-9.62	-6123.74	-6.87	-1443.27	-3.49
CH x number of rooms	34.64	5.27	166.18	8.45	74.75	2.19
CH x apartment (1), other (0)	-67.33	-4.89	-512.62	-6.63	-40.52	-0.12
CH x monthly temp. (Nov-Feb)	3.74	1.34	13.84	0.69	-108.37	-2.83
Constant	146.07	2.98	317.35	1.89	730.01	2.74
Rsquared	0.50		0.47		0.41	
Fstatistic	F(9, 734) = 81.69		F(9, 904) = 90.24		F(9, 399) = 30.72	
N	744		914		409	

Source: Author's calculations.

We can, however, use a fixed effects model on 2001 Armenia data to capture average differences in the total energy consumed by households using different heating technologies—electric heaters, gas stoves, kerosene stoves, and wood stoves (see annex 4). Surprisingly, the analysis reveals that households using electric heaters consume 87 kgoe less energy a year than the average, while those using wood consume about 100 kgoe more. These findings suggests that, contrary to popular belief, electricity might be the most environmentally friendly form of heating for users, and it may be more efficient from the perspective of private consumers.

This unusual result has several possible explanations. People using electric heaters may maintain a lower indoor temperature because electricity is more expensive. Or they may consume less energy because electric heaters are more efficient. Finally, it may be easier to manage energy consumption with electric heaters because, unlike wood stoves, they can be turned on and off and moved from room to room.

Annex 6. Validity of Heat Demand Model

A nested OLS model is used to identify the heat demand for households. To verify the validity of the OLS assumptions of this model, a series of statistical tests have been conducted.

Basically, for an OLS model, we assume the following conditions to be held:

- Linearity of the regression model
- The matrix of regressors is full-rank
- Homoscedasticity

The linearity assumption is not as narrow as it might first appear. In the classic OLS regression, linearity suggests that the parameters and the disturbance enter the equation is a linear fashion. Therefore, the relationship among the regressors does not have to be linear. A typical verification of this assumption is to use other alternative function forms to test the robustness of the linear specification. A log-linear regression model has been specified and estimated. The point estimates are very similar to those of our OLS specification. Therefore, we have no particular reason to distrust the validity of linearity.

Several multi-collinearity tests have been conducted and they unanimously reject the hypothesis that the regressors in the model are collinear. Hence, the matrix of our regressors is shown to be full-rank.

Homoscedasticity is not particularly restrictive in the context of our analysis. Even if the homoscedasticity is violated, i.e. the error terms in the regression are heteroscedastic, the point estimates obtained are still consistent. In other words, given a large sample, our estimates based on heteroscedastic OLS regression are still valid and unbiased. In this study, Cook-Weisberg test for heteroscedasticity using fitted values of dependent variables have revealed heteroscedasticity problems. This might cause inefficiency but the estimates are still unbiased given that other OLS assumptions are not violated. In addition, alternative specifications have to be used to test the robustness of the OLS estimates, and the point estimates cross different specification are very consistent to the ones we obtained from OLS regression. Particularly, this shows that our estimates on price elasticity and income elasticity are valid.

Annex 7. Fixed Effects of Different Heating Techniques

Model: $y_{ij}=a+\mathbf{x}_{ij}b+v_i+e_{ij}$

, where i is the heating device index and j is the household index. $a+v_i$ stands for the different intercepts of demand function across different heating techniques. Obviously, this term measures the average of the households who use a specific heating device, i.

. xtreg qOE_oe welf p_nh hhsize CH CHxe CHxp CHxs if h_dev~=2, fe;

Fixed-effects (within) regression Number of obs = 822
Group variable (i) : h_dev Number of groups = 4

R-sq: within = 0.1532 Obs per group: min = 43
between = 0.5014 avg = 205.5
overall = 0.1454 max = 349

F(7,811) = 20.96
corr(u_i, Xb) = 0.0881 Prob > F = 0.0000

qOE_oe	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
welf	-73.54967	12.59018	-5.842	0.000	-98.26285	-48.83648
p_nh	-.1238701	.0404127	-3.065	0.002	-.2031959	-.0445442
hhsize	18.80239	3.083842	6.097	0.000	12.74914	24.85564
CH	-89.51655	28.22341	-3.172	0.002	-144.9161	-34.117
CHxe	.0000478	.0000172	2.771	0.006	.0000139	.0000816
CHxp	.1129281	.084609	1.335	0.182	-.0531504	.2790065
CHxs	1.848796	.5355006	3.452	0.001	.7976657	2.899927
_cons	294.9749	18.84356	15.654	0.000	257.987	331.9628
sigma_u	94.457774					
sigma_e	137.78127					
rho	.31972649 (fraction of variance due to u_i)					

F test that all u_i=0: F(3,811) = 45.80 Prob > F = 0.0000

Annex 8. Key Technical Characteristics of District Heating Systems and Housing Stock in Eastern Europe and Central Asia [1]

Box 1: What is district heating?

Usually, the term describes a system supplying heat produced centrally in one or several locations to a non-restricted number of customers. It is distributed on a commercial basis by means of a distribution network using hot water or steam as a medium. Often, the heat is also used for provision of domestic hot water and industrial purposes, such as process heat. Although most people understand district heating to be large centralized urban heating systems, many national statistics also include very small heating systems. Furthermore, systems that supply only steam for industrial purposes are usually also called district heating systems. In fact, the term *district heating system* is usually linked with the activities of the respective district heating company. Such a company usually operates larger centralized district heating networks, smaller isolated "block" heating systems (supplying only a small number of buildings), and even individual boilers in single buildings.

Source: ESMAP 2000.

Heat production. In the Russian and Eastern European schemes, district heating is supplied from cogeneration plants and/or heat-only-boiler (HOB) plants. Where cogeneration is used, the peak and reserve capacity requirements are covered by HOBs. Typically, large district heating systems have from one to three cogeneration plants and several hundred HOBs. A CHP plant is a technically more efficient way to produce heat and power than separated power generation and heat production. In Eastern Europe, the typical CHP plant efficiencies are around 70-75 percent as compared with 80-90 percent in Western Europe. The efficiency of the older HOBs in Eastern Europe are only 60-80 percent. However, with the introduction of modern automation and control systems, replacement of burners and cleaning of boiler surfaces, the efficiency can be typically increased to 85 percent. The efficiencies of new boilers are even higher, over 90 percent.

District heating transmission and distribution networks. Typical factors leading to poor efficiency and various other operational problems in the DH networks in Eastern Europe include high levels of leakages, due to external and internal corrosion of pipes as well as insufficient pipe insulation, and the use of constant flow technology.

Network leakages are common due to both internal and external corrosion of pipes. It is not uncommon for water to infiltrate pipeline channels from the outside and high ground water to cause external corrosion when pipe insulation material becomes wet and ventilation in pipeline channels is poor. In systems with high water losses, make-up water has to be added. In the worst cases, the networks may have to be refilled a hundred times a year or more, as compared to one or two times per year in well-maintained Western DH systems. Where water treatment is not adequate, poor quality of make-up water corrodes the pipes from the inside. Heat losses are also typically high due to inadequate insulation. The thickness of insulation is less than in Western countries. In DH systems where pipelines run above ground, e.g., in Armenia, theft of insulation material has become a problem.

[1] This section is based on ESMAP 2000, Gochenour 2001, and Martinot 1997.

The dominant mode of network operation in Eastern Europe has been constant flow regime. Basically, constant flow means that heat supply and heat demand are being adjusted by manually varying the flow temperature, typically in the range of 70-130°C, based on the ambient outdoor temperature. The adjustment of heat supply (and thus consumption level) in the typical constant flow DH system is carried out centrally at the heat production plants. Heat distribution to individual buildings depends entirely on the hydraulic balance of the network, leading to inaccurate heat distribution to buildings, e.g., too high indoor temperatures, particularly during spring and fall. In a constant flow system, each hydraulic section of the DH network system can be supplied typically by heat from only one location, which does not generally allow for the heat load to be dispatched from the least-cost production source.

Since the early 1990s, renovation and modernization of DH systems has started in Eastern Europe. The achievements of the World Bank financed investments project in Estonia (see endnote 1 in chapter 4) or in Poland (see Box 2 below) are quite representative.

Consumer installations. Hot water, usually both for space heating and domestic hot water, is transported through pipeline networks to substations from where heat is distributed to consumers. The substations may be located within the individual buildings or, larger ones, serve a group of buildings through secondary networks, which typically involve four 4 pipes – two for space heating and two for domestic hot water. Those secondary networks usually experience high losses, and the technical lifetimes of those networks is short. In the typical Eastern European schemes, the larger substations traditionally dominate, while in Western Europe, most substations are installed in individual buildings.

Both direct and indirect consumer connections are used in Eastern Europe. Indirect connection means that heat or domestic hot water is transferred by heat exchangers from the primary to the secondary network; the systems are thus hydraulically separated. Direct connection means that the water circulating in the DH network is introduced directly to the consumer installations, i.e., building pipes and radiators. In systems with direct domestic hot water connections, the hot tap water is supplied directly from the DH pipes and needs to be made up at the point of supply. There are about 300 cities in the FSU which utilize direct domestic hot water systems. The advantages of indirect heat and hot water transfer include, for example, more efficient network regulation, better protection against corrosion and reduced need for make-up water.

Metering. Virtually no heat or hot water metering existed before 1990 in residential, commercial and public sector buildings in most countries in Eastern Europe. There was very little point in installing meters because consumers could not regulate the heat supply. The lack of regulation and metering resulted in too low or too high room temperatures and further losses of heat from the opening of windows to cool the sometimes overheated rooms. Since 1990, many countries have made substantial progress in installing regulation and metering equipment. Many countries (Poland, Hungary, Bulgaria) have introduced mandatory metering at the building level, and in many cities in the Czech Republic, Hungary and Poland, for example, the metering rate is now close to 100 percent. In many countries of the FSU (excluding the Baltics), however, very few (under 1 percent) residential buildings have meters.

Box 2: Experiences with heating metering and billing reform in Poland

With partial support from a World Bank loan over 1991–99, the four Polish cities of Warsaw, Kracow, Gdansk and Gdynia undertook renovations of their heat supply systems, disseminated building-level heat meters for existing buildings, and reformed the heat tariff from a square-meter based tariff to a two-part tariff charged at the building level.

Results in Four Cities

	1991/92	1999	Change (percent)
Household heat bill subsidy (%)	67	<5 (1994)	na
Heat bill charged to households (1999 US$/m²)	13.7	6.2	-55
Heated floor area (million sq m)	63.8	68.6	7
Heat energy sold (gcal/sq m)	0.27	0.22	-18
Energy savings	na	na	22

The Government of Poland implemented energy sector reforms under which payment for heat gradually became the responsibility of households, and they began to use heat more efficiently. Households (or companies operating as their agents) invested in radiator valves (TRVs), heat allocation meters, better windows and some insulation. The internal piping systems of buildings generally were not changed—single-pipe vertical systems are still in place, but radiator bypass pipes have been added where not already in place. A key result was that the costs of heating a given apartment area fell by 55 percent, due to efficiency improvements by consumers, and to technical, operational and management improvements in the heat supply companies. This reduction in costs helped to make the removal of the subsidy less burdensome to households.

Nationwide, household heat subsidies, provided by municipal governments, have been reduced from 78 percent in 1991 to zero by the end of 1997. Installation of building-level heat meters has been mandatory for all buildings since 1999. Use of heat allocation meters has become a popular way to allocate heat bills within buildings—a total of 5.5 million were installed as of 1997 in about 30 percent of the dwellings nationwide. (Apartment-level heat meters are generally considered too expensive.) More than 10 companies have been formed and compete in the market for billing services—including allocation meter installation, meter reading, billing and maintenance. Energy savings, reflected in customer heat bills, stemming from the reform (including savings from private investments spurred by the reform) typically range from 20 to 40 percent. Water quality improvements, however, were required before the metering could be effective. It also should be noted that apartment heat levels were generally adequate in Poland before the reform—in other cases (e.g. Lithuania), energy efficiency gains may be harvested more in terms of improved comfort level instead of energy savings.

Source: World Bank 2000c

Operation and maintenance. Maintenance in Eastern Europe has typically concentrated on repairing damage that has occurred and not on preventing it, although there are exceptions. Repair works of production plants and networks are usually carried out in summer, typically during a two to four week period. During this period, the water circulation in DH networks is totally shut off, with the result that consumers do not obtain even domestic hot water. In most Central and Eastern European and FSU systems, DH networks are tested by pressure once a year to reveal weak pipelines and leaks. For example, in Kyivenergo's systems (Kyiv, Ukraine), this has proven to be efficient because typically about ten breakages are repaired during the heating season while some four hundred are repaired outside the heating season.

Buildings and customer installations. Cities in CEE/FSU were designed with a central heat and hot water supply in mind. Multifamily buildings, which vary in height from three to more than 20 stories, provide the majority of total dwellings in urban areas: 73 percent in Estonia, 50 percent in Lithuania, and approximately 80 percent in the Russian Federation, for example, but only 35 percent in Armenia. Throughout the 1950s and 1960s, most multi-family buildings constructed were no more than five stories high. Later, in the 1970s and 1980s, more nine-story and 16-story buildings were constructed, often on the very outskirts of cities. This pattern of development has typically led to larger population densities further away from city centers than in the centers themselves. [2]

There are several types of multifamily residential building construction common to most CEE/FSU countries:

- *Brick.* These were mostly constructed from 1950 to 1975, with 4 to 12 stories, and have radiators for the heating system.
- *Large block.* These were mostly constructed from 1955 to 1970, with 4 to 12 stories, and have radiators for the heating system
- *Prefabricated concrete panel.* These have been constructed from 1960 to the present using both one-layer and three-layer panels. Building sizes range from 5 to 22 stories. Heating systems in older buildings of 5 and 9 stories used radiators while most 12-story buildings that emerged in the 1970s used heated wall panels; convectors were used in modern 17-story and 22-story buildings.
- *Wood.* These are single-family houses and multifamily buildings of two to four stories.

Low thermal requirements in construction standards, a historical lack of attention to quality in construction materials and practices, and a poor record of operation and maintenance have led to high thermal losses in residential buildings. The most recent Soviet norms (1984–87) permitted heat transmission values more than twice those of Germany and Great Britain, and about five times those of Sweden for the same period. Actual heat losses in residential buildings are estimated to be 25–40 percent higher than design values. Deficiencies found most frequently are leaky windows and doors, uneven heat supply within buildings, and missing or insufficient basement and roof insulation. Joints between panels consist of rubber molding and cement mortar have deteriorated and permit air and rain to leak through. Although building designs and methods are very similar throughout CEE/FSU, seemingly identical buildings display enormous differences in actual construction and consequently in thermal properties; for instance, up to 40 percent in the Russian city of Ryazan.

Radiator systems are either one-pipe or two-pipe vertical systems (one-pipe systems are most common).

[2] However, in the centers of the cities itself, the building density (and therefore the need for heat) can be extremely high (such as in Budapest), but as the buildings are quite old, they are equipped with individual heating systems. A later retrofit would have entailed high construction costs.

Most space heat for multi-family buildings built in the last four decades is supplied from DH systems. Buildings connected to DH or with other central heating facilities don't have chimneys. Typically, heating pipes supplying radiators within buildings are vertically arranged one- or two-pipe systems. In the more common one-pipe systems, the hot water flowing through one radiator continues through several more before returning to the source. Most radiators do not have control valves, or if they do, the valves have usually become broken or non-functional. The piping layout and the lack of control make consumption-based billing or individual cut-off of non-paying consumers very difficult.

In contrast, in Western Europe (at least in newer buildings), pipes are arranged horizontally, so that each radiator and DHW source in an apartment is supplied in one single loop; two-pipe systems are standard. Radiators are typically equipped with control valves, mostly of the electronic kind, and hot water consumption is always metered. In many countries, individual heat consumption and not only building heat consumption is metered, and consumers are charged partially on a square-meter basis and partially on a consumption-basis.

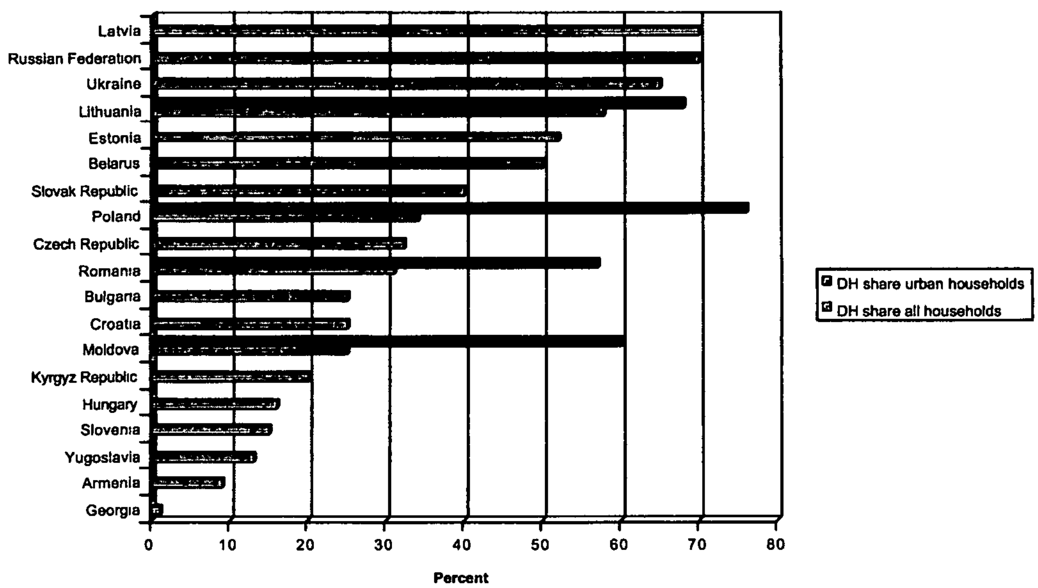
Technical measures for reducing heat losses in buildings include additional insulation on roofs, exterior walls, and basement ceilings; hot water and heat pipe insulation; window replacement, renovation, or simple weather stripping; improved caulking and sealing of building panel joints; new building entrance doors; and improvements to building ventilation systems. In particular, studies in CEE/FSU have highlighted the high thermal losses associated with building ventilation, leaky windows, and the low thermal insulation properties of exterior walls. Heat balancing valves for balancing the heat flows within the building also can reduce heat losses by eliminating overheated sections of a building.

Although many of the above retrofit strategies are straightforward (i.e., windows, insulation, and heating equipment renovation), heat metering and controls in buildings are of special importance, pose special problems, and deserve greater attention. Measures for metering and regulation of heat demand include both (1) building-level heat meters, valves, and automatic control systems for controlling the heat entering the building and (2) apartment-level heat meters and radiator valves for controlling the heat in individual apartments. Building-level meters for measuring total building consumption are an essential part of any retrofit strategy. The question of metering at the apartment level, however, is more complex. Based on experience in the Nordic countries, there is little doubt that households in collectively metered buildings (i.e., with building-level meters but not apartment-level meters) consume more heat per square meter than households in buildings with apartment-level meters. Occupants tend to be more responsive when they can see (and have to pay for) their individual consumption. Controls are equally important. If the occupants of each unit are to be responsible for their own consumption, they must have control over the amount of heat they actually use. [3]

[3] For a comparative analysis of heat metering and billing options in Western and Eastern Europe, Korea and China, see the report by JP-Building Engineering Ltd (2002), prepared for the World Bank and the Chinese Ministry of Construction.

DH coverage of urban households in the 1990s. Though DH is essentially an urban form of heating and needs relatively large heat loads and heat densities to be competitive (see Chapter 4), it can also be found in smaller towns and even villages. The highest shares of households connected to district heating can be found in the colder, more developed and more urbanized countries of the FSU, i.e., Russia, the Baltics, Ukraine and Belarus. Between 50 and 70 percent of all households in these countries are connected to DH systems (see figure below). If only urban households are taken into account, the share of households connected to DH goes up, and in some countries like the Baltics in bigger cities the share approaches 90 percent.

Percentage of Households Served by District Heating in the late 1990s

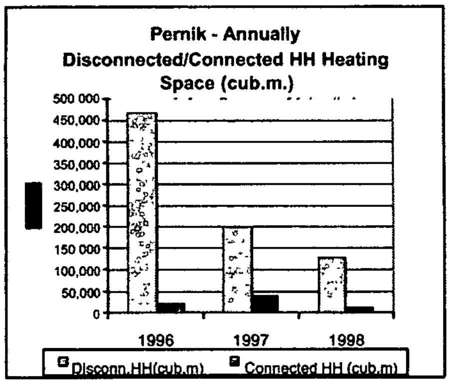


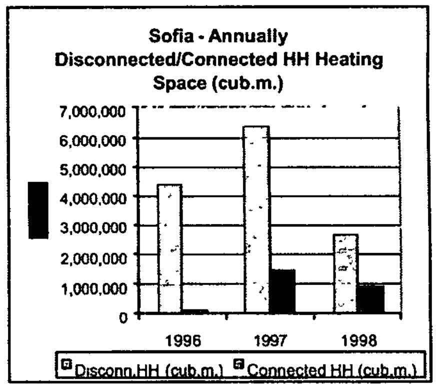
Source: Based on Euroheat&Power data (see www.euroheat.org), except author's calculation for Armenia, Kyrgyz Republic and Georgia.

In many countries the share of households provided with DH has actually gone down during the 1990s. It is well-known that this happened in Georgia and Armenia due to economic or natural disasters. And practically everywhere, the newly rich and many other families who can afford it, switch to individual heating systems, mostly on the basis of natural gas, because they are more reliable and can be controlled by the consumer. In Estonia, for example, this trend was particularly strong. Since the mid-nineties, many families, particularly in Bulgaria (see Box 3 below), but also in Romania and Moldova, elected to disconnect all or some of their radiators as a consequence of increasing tariffs for district heat, declining service levels and ability to pay. Instead, these households use mostly individual electric heaters or fuel stoves. In some instances, e.g., in Romania, households got together, managed to secure small loans and purchased boilers that would supply central heating to their building.

Box 3: Disconnections in Bulgaria

Declining affordability as operating subsidies are phased out faster than consumer's incomes are rising and coverage by the social safety net is inadequate resulted in over 30 percent of residential consumers opting to disconnect partially or completely from the DH systems. For Sofia and Pernik, which cover together 66 percent of all 578,000 Bulgarian households consuming DH, the two figures below show the disconnections and (re-)connections from 1996-1998. The disconnection rate in Sofia has steadily increased from 10 percent in 1996 to 26 percent of all DH consumers in the first half of 1999. During the same period, the disconnection rate in Pernik increased from 34 percent in 1996 to 49 percent of DH household consumers. In Sofia, average wages and the share of households eligible for targeted income support for energy consumption are lower than in Pernik which helps to explain that in Sofia, about equal shares of space were disconnected partially and totally, whereas partial disconnections dominated in Pernik.





Disconnections generate "free-rider" problems among consumers, since the disconnected premises still technically absorb heat and thus divert it from the neighboring apartments remaining connected to the system. In most cases the heat supply thus remains unchanged. The disconnections of heating space result in increasing the bill of the remaining connected customers who are metered. In cases where the heat supply to households is not metered, individual consumers pay in established proportions to their heated space. Disconnected heating space in this situation only increases the losses to the DH supplier since the bill for the heat, technically absorbed by the disconnected space, is not distributed among the remaining active consumers. Therefore, the government established the following disconnection rules: Consumers who disconnect their entire heating space do not pay anything for DH, whereas consumers who disconnect a portion of their heating space pay for heating the new reduced household space plus 25 percent of the regular heating expenditures for the disconnected section.

Source: Bulgaria 1999

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