Technologies for Energy Efficiency 4

Heavily subsidized energy prices and incentives to meet production goals regardless of costs have resulted in high levels of energy waste in Central and Eastern Europe (CEE). This has in turn contributed to environmental damage, high operating costs, loss of foreign exchange, and energy shortages. Fortunately, highly efficient technologies are available that can provide needed energy services (such as light, heat, and motor drive) while using less energy. In many cases these technologies are widely used in the West, and their use in CEE would have substantial benefits.

This chapter provides an overview of energy efficient technologies. How energy is used, the relative efficiency of that use, technologies for improved efficiency, and what would be needed to implement these technologies in CEE are reviewed for each of the three major energy-consuming sectors—industry, buildings, and transport. It is shown that there are numerous opportunities for significant energy savings through the use of simple, low-cost, retrofit technologies. In many cases these technologies offer paybacks (the amount of time required for the value of the energy savings to exceed the initial cost) of less than 1 year.

The use of coal for residential heating is common.

INDUSTRIAL ENERGY USE

Beginning with the first 5-year plan in the former Soviet Union (FSU) in the late 1920s, and in the former East Bloc countries in Central and Eastern Europe in the late 1940s, the centrally planned economies focused on large-scale industrial developments in basic materials production and fabrication. The former Soviet economy achieved rapid growth in the 1930s, largely due to construction of numerous industrial complexes concentrated around several iron ore and coal mining areas. Similar, though less rapid, growth took place in Central and Eastern Europe after

Table 4-l—Energy Use by Sector in Selected Countries, 1989

	FSU		Former CSFR		Hungary		Poland		West Germany		U.S.A.	
	PJ	Percent	PJ	Percent	PJ	Percent	PJ	Percent	PJ	Percent	PJ	Percent
Industry.	18,620	49	1,060	49	360	40	1,240	40	2,800	35	17,520	31
Transport.	6,180	16	170	8	120	13	400	13	2,050	25	20,470	37
Agriculture.	3,850	10	140	7	60	6	130	4	100	1	660	1
Commercial Buildings. . .	3,910	10	290	13	70	7	220	7	1,010	13	6740	12
Residential.	5,570	15	380	17	270	30	1,100	35	1,900	23	10,500	19
Other.	240	1	140	6	30	4	0	0	240	3	170	0
Total.	38,390	100	2,180	100	900	100	3,090	100	8,100	100	56,050	100

NOTES: Excludes conversion losses. Data are uncertain. FSU refers to the Former Soviet Union. Former CSFR refers to the former Czechoslovakia. West Germany refers to the former West Germany. Data for West Germany are for 1988. PJ-petajoule - 10^{15} joule.

SOURCES: OTA estimates, based on International Energy Agency, Energy Statistics ***and Balances of OECD Countries 1987-1988,*** **OECD (Paris,** 1990; International Energy Agency, ***Energy Statistics*** **and Balances** ***of non-OECD Countries 1988-1989,*** **OECD (Paris, 1991**); International Energy Agency, ***Energy Statistics and Balances of OECD Countries 1989-1990,*** OECD (Paris, 1992); World Bank, “Greenhouse Gas Strategy for Eastern Europe and the Former Soviet Union,” August 1992, draft.

the end of World War 11. Heavily subsidized energy supplies, lack of market incentives, and the importance given to fulfilling quotas and state plans resulted in little attention to energy efficiency. The result today is a technically outdated and energy inefficient industrial infrastructure.

Industry is currently the single largest energy-consuming sector, accounting for almost half of energy use in the FSU and the former CSFR, and about 40 percent of energy use in Hungary and Poland (see table 4-1, and box 4a).

Box 4-A-How Does the Industrial Sector Use Energy?

At present the industrial sector in **CEE, as in the United States, covers thousands of different products,** processes, and technologies. Several specific industries, however, account for the bulk of industrial energy use. The iron and steel industry is the single largest industrial energy user in CEE, accounting for 20-25 percent of all industrial energy use. This industry uses most of its energy in two forms: coal is used as a feedstock (meaning the coal is used as a raw material input) to produce coke (which is then used to form steel), and coal and other fuels are used to produce heat. The second largest industrial energy user in CEE is the chemical industry, which produces a wide range of products including plastics, rubber, paint soap, fertilizers, and pesticides. Feedstocks account for about half the energy used in the chemical industry-for example natural gas is a principal feedstock for the production of ammonia, which is used as a fertilizer. The remainder is used for process heat motor drive, and a variety of other uses. Machinery and transport equipment is generally the third largest energy user, largely for motor drives. Other significant sectors include the minerals industry, whose principal products are cement and glass, and the non-ferrous metals and food and tobacco industries.

An alternative perspective on industrial energy use is in terms of services rather than industries (table 4-2 shows such a breakdown for the United States, as data for CEE are not available). Steam is used for lower-temperature heating, such as in cooking and various chemical processing systems. Process heat, typically produced from coal or natural gas, is used for a variety of purposes including heating, drying, curing, and melting. Motor drive is used in every industry for pumps, fans, compressors, and other purposes. Finally, **energy is** used as **a** feedstock **in many industries**, notably natural gas for fertilizer production and coal for coke used to make steel.

Table 4-2—Breakdown of Industrial Energy Use by End-Use in the United States, 1985

Service	Percent Of Industrial Energy Use
Steam	33
Process Heat............,...	**27**
Motor Drive	**22**
Feedstocks.	13
other.	*5*

SOURCE: Office of Technology Assessment, 1993.

How Efficient Is Industrial Energy Use in CEE?

Industries in CEE typically require much more energy to produce one unit of output than do industries in Western Europe, Japan, or the United States. For example, ammonia production in Central Europe uses 25 to 75 percent more energy to produce one ton of ammonia than is used by U.S. or Japanese ammonia plants (see table 4-3). Similarly, the iron and steel industry in the FSU requires about 50 percent more energy per ton of iron output than is required in the United States (see box 4b).

There is also case-study evidence documenting the low energy efficiency of many industries. A series of industrial energy audits in Czechoslovakia found that, ''obvious energy wastes (such as steam leaks) are present in most plants, and simple low-cost improvements have not been implemented."[1] The FSU still uses energy inefficient open hearth furnaces to produce the bulk of its steel,[2] although these furnaces require about 60 percent more energy per ton of output than do oxygen converter furnaces.[3] A study of eight industrial facilities in Hungary found that basic equipment such as boilers, turbines, and pumps was often old, obsolete, and in need of repair.[4]

The potential for industrial energy efficiency improvements in CEE is in some ways analogous to the situation faced by U.S. industry in the early 1970s. From the late 1950s to 1970 industrial energy prices in the United States were flat (or decreasing in real terms[5]), and during this time aggregate energy intensity in U.S. manufacturing (defined as energy use in manufacturing per unit of production) was essentially flat as well.[6] However beginning in 1972 energy prices in the United States generally increased, and due both to these price increases and to technical advances, aggregate energy intensity in manufacturing dropped by about one-third from 1972 to 1985.[7] By one estimate, about two-thirds of this sharp drop in intensity was due to changes in the output mix—a shift away from energy-intensive products, such as iron and steel; and towards more material-intensive products, such as computers and electronics.[8] The remaining one-third was due to improved technical energy efficiency.

Table 4-3-Approximate Energy Intensity of Ammonia Production in Selected Countries

Country	Energy Intensity of Ammonia Production (GJ/tonne)
Former CSFR*	51
Hungary	47
Poland	36
United States	29
Japan	28

" The former Czechoslovakia.

SOURCE: S. Kolar, "Industrial Energy Efficiency in Central and Eastern Europe," contractor report prepared for the Office of Technology Assessment, September 1992, p. 7.

[1] RMA (Resource Management Associates, Inc.), ''Final Report, Phase Four: Industrial Energy Efficiency Component, Policy and Institutional Analysis of Industrial Energy Efficiency in Czechoslovakia," contractor report for U.S. AID, May 30, 1992, p. 19.

[2] In 1986, 54% of steel made in the FSU made use of open-hearth furnaces. M. Sagers and A. Tretyakova, "Fuel and Energy Use in The Soviet Metallurgy Industries," Center for International Research Staff Paper No. 28, U.S. Bureau of the Census, July 1987, p. 14.

[3] Ibid, p. 33.

[4] RCG/Hagler, Bailly, Inc., ''A Profile of Energy Efficiency in Hungarian Industry,' contractor report for U.S. AID, Dec. 20, 1991, p. 7.

[5] Energy prices to manufacturers were generally dropping, in real terms, from 1945 to 1970. See R. Marlay, "Trends in Industrial Use of Energy," *Science,* vol. *226,* Dec. 14, 1984, p. 1,279.

[6] M. Ross, "Improving the Efficiency of Electricity Use in Manufacturing, " *Science,* vol. *244,* Apr. 21, 1989, p. 311. Others have argued, however, that manufacturing intensity, adjusted for structural change, dropped consistently from 1958 to 1985. See for example R. Howarth, "Energy Use in U.S. Manufacturing: The Impacts of the Energy Shocks on Sectoral Output, Industry Structure, and Energy Intensity, " *The Journal of Energy and Development, vol. 14, No. 2. The* discrepancies between these two results are due in part to whether or not structural change is controlled for, and in part to the use of different definitions and data sources to measure intensity.

[7] M. Ross, supra note 6, p. 311.

[8] R. Marlay, supra note 5, p. 1,282.

Box 4-B-The Iron and Steel Industry

Iron **and steel is the single largest energy consuming** industry in CEE, accounting for about 20-25 percent of industrial energy use.[1] This industry is quite inefficient. The FSU, for example, uses about 50 percent more energy to produce 1 ton of iron than is used in the United States (table 4-4). Much of this difference is **due to the use of outdated and inefficient technologies.**

Table 4-4-Energy Intensity of Selected Iron and Steel Processes (GJ/ton, 1989)

Process	FSU	Czech	Hungary	Poland	USA	Japan
Iron Making	21	15	21	17	14	15
Steel Refining	4	8	4	7	3	NA
Aluminum Production	59	NA	53	58	45	NA

NA. Not available.

SOURCES: S. Kolar, Industrial Energy Efficency in Central and Eastern Europe," contractor report prepared for the Office of Technology Assessment September 1992, p. 7; Energetic, Inc., "Industry Profiles: Final Report-Steel," contractor report for the U.S. Department of Energy, December 1990, pp. S-9.

The U.S. steel industry, in response to rising steel imports and other pressures, went through a drastic downsizing and moderniza-tion in the 1980s. In just 8 years the U.S. steel industry reduced its energy intensity by over one third by shutting down inefficient plants and **investing in new technology** (table 4-5). A further improvement of over one-third, relative to current levels, is thought possible with use of advanced technology. The steps that permitted the U.S. steel industry to sharply reduce its energy intensity are, for the most part applicable to CEE. These include dosing down of older inefficient plants, retrofitting of existing plants with improved technologies and practices, and building new, highly efficient plants. Improved technologies include dry coke quenching, heat recovery, continuous casting, direct steelmaking, and increased scrap recycling.[2]

Table 4-5-Energy Intensities of Steel Production

Description/Method	Intensity (GJ/ton)
1. U.S. average, 1980	38
2. U.S. average. 1989	24
3. 2010 'State-of-the-Art'	15

Includes **conversion losses for electricity.**

SOURCES: Energetics, ho., "Industry Profiles-+inal Report: Steel," contractor report for U.S. Department of Energy, December 1990, p. *6;* **Office of Technology Assessment, 1993.**

1 International *Energy* **Agency,** *Energy Statistics and Balances of non-OECD Countries 1988-1989,* **OECD** (Paris, 1991).

2 For a **more complete discussion of these technologies see U.S.** Congress, **Office of Technology Assess-ment,** ***Fueling Development,*** OTA-E-516 (Washington, DC: U.S. Government Printing Office, April 1992), pp. 117-123.

The industrial sector in CEE has long paid little attention to energy costs and energy efficiency. Seemingly overnight, however, there has been an abrupt change in the operating environment. Energy prices are rising rapidly, and will probably contirme to rise until they reach world levels. This makes numerous energy efficiency improve-ments, long neglected, suddenly very attractive. In addition, industries are moving towards a market economy, and must now make allocation and production decisions based on financial analysis rather than on externally imposed quotas. In responding to these new market pressures, CEE industries can utilize the considerable tech-nical and operational advances that have been discovered and fine-tuned in the West in the last 20 years.

The following section reviews just a few of these industrial technologies. A more comprehensive review of industrial technologies can be found in other OTA reports.[9]

Energy Efficient Technologies for Industry

This section reviews generic technologies that could be used to improve energy efficiency in industry. These include housekeeping, improved measurement and control, improved steam systems, and improved motors.

HOUSEKEEPING

There are many simple, low cost measures such as insulating pipes, plugging leaks, turning off equipment when not in use, and maintaining equipment that can result in large energy savings in industry. For example, a study of energy efficiency improvements in Canadian industry estimated that 40 percent of the improvements in industrial energy efficiency occurring from 1973 to 1985 were due to low or no-cost housekeeping measures.[10] Energy savings and paybacks will vary depending on the specific measures and applications, however case studies are illustrative of the savings potential. An audit of a metalworking plant in Budapest, Hungary found that 40 percent of compressed air was lost through leakage; locating and patching these leaks was predicted to save 135 kW with a payback of less than one year.[11] Low cost/no cost measures, notably steam trap maintenance and leak repair, reduced energy consumption per ton of product by 15 to 20 percent at a pharmaceutical plant in Czechoslovakia.[12] A series of industrial audits in Hungary found the level of maintenance to be below Western levels,[13] suggesting that many such opportunities remain.

IMPROVED MEASUREMENT AND CONTROL

Improved measurement and control of industrial processes using electronic sensors and monitors, switches, and computers offers large potential energy savings. Examples include combustion analyzers for furnaces and boilers, energy management systems to automatically operate energy-using equipment, and improved sensors and controls to allow for fine-tuning of temperatures and controls. Savings are site-specific, but generally considerable. For example, the installation of an energy management and control system at a chemical plant in Budapest, Hungary was predicted to reduce energy consumption by 15 to 20 percent, with a payback of less than 6 months.[14] Similarly, thermostatically controlled valves for a hot water system at a machining plant in Czechoslovakia offered considerable savings with a payback of less than 3 months.[15]

STEAM SYSTEMS

Steam is probably the single largest industrial end-use (as shown in table 4-2, steam accounts for about one-third of all industrial energy use in the

9 U.S. Congress, Office of Technology Assessment, *Fueling Development, OTA-E-516* (Washington, DC: U.S. Government Printing Office, April 1992); U.S. Congress, Office of Technology Assessment, Industrial *Energy Use, OTA-E-198* (Washington DC: U.S. Government Printing Office, June 1983).

10 Marbek Resource Consultants, ''Energy Demand in Canada, 1973-1987; Volume 1,' contractor report for Energy, Mines and Resources, March, 1989 (Revised August, 1989), p. B-34.

11 RCG/Hagler, Badly, Inc. and EGI Contracting and Engineering, "Energy Efficiency Audit Report: Csepel Muvek Femmu Metalworks Plant,'' contractor report for U.S. AID, March 1992, pp. 30-31.

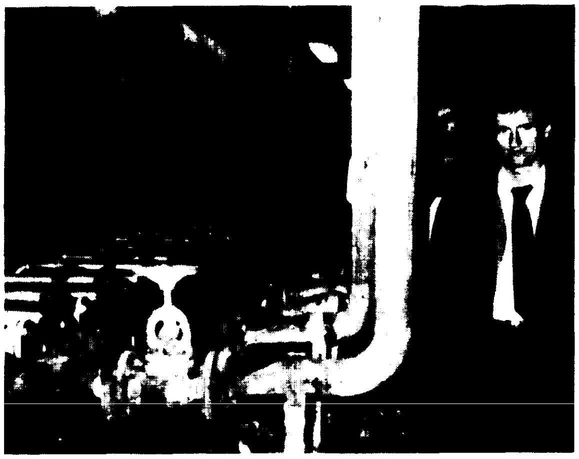
12 RMA (Resource Management Associates, Inc.), supra note 1, p. 20.

13 RCG/Hagler, Bailly, Inc., supra note 4, p. 20.

14 RCG/Hagler, Bailly, Inc. and EGI Contracting and Engineering, "Energy Efficiency Audit Report: Budapest Chemical Works, " contractor report for U.S. AID, March 1992, pp. 18-19.

15 Resource Management Associates, Inc. and Energoprojekt, "Energy Efficiency Audit Report: Prazske Pivovary Branik, Prague, Czechoslovakia,'' Contractor report for U.S. AID, January 1992, p. 16.

U.S.AID



***Steam traps, indicated by the arrow, save energy** in industrial steam systems. One American company has successfully exported these devices to the region (see the appendix of this chapter).*

Table 4-6-Age Distribution of Boilers (1989)

	Fraction of Capacity	
Age	Former CSFR	United States
50+ years.	11	5
30-50 years	26	30
10-30 years.	52	52
0-10 years	11	13

SOURCE: S. Kolar, "Industrial Energy Efficiency in Central and Eastern Europe," contractor report prepared for the Office of Technology Assessment, September 1992, p. 29; RCG/Hagler, Bailly, Inc., "Combustion System Technology and Application Assessment: ndustrial Boiler Combustion Systems," contractor report for the Gas Research Institute, October 1988, p. 26.

United States; the fraction in CEE is probably larger). There are several technologies that can improve the efficiency of steam systems. The first, discussed above, is housekeeping-insulating tanks and pipes, repairing steam leaks, installing and maintaining steam traps (see app. 4-l), operating boilers at optimal temperatures and pressures, and general tune-up and cleaning of burners. By one estimate, increased insulation alone can reduce boiler fuel use by 8 Percent.[16] Higher first cost-but typically very cost-efffective--options include adding electronic temperature controls and installing improved burners (which alone can increase efficiency 3 percent[17]). Installation of a new high efficiency burner with automatic controls on a 20-year old boiler in a fabric plant in the former CSFR was estimated to increase efficiency by 3 to 6 percent, with a payback of 7 months.[18]

Many boilers in CEE (and in the United States as well, see table 4-6) are quite old, and may soon need replacement. Fluidized-bed boilers are a particularly promising advanced boiler technology. Many boilers, particularly in Poland, are fueled by coal. Fluidized-bed coal-fired boilers can increase efficiency, reduce emissions, and increase tolerance to low quality coal.[19] Tests of fluidized bed boilers have shown that they can operate with very high ash coal-up to 40 percent.[20] This could be a significant advantage in the former CSFR, where wide-spread use of coal with high water and ash content contributes to the low operating efficiency of boilers.[21]

The use of cogeneration systems can also yield significant gains in efficiency. Cogeneration refers to the simultaneous production of heat (typically steam) and electricity. In industries with an onsite need for both steam and electricity, the overall efficiency of a cogeneration system is

16 Energetics, Inc., "Industry Profiles—Final Report: Steam Generation and Cogeneration," contractor report for U.S. Department of Energy, December 1990, p. 11.

17 United Nations, *East-West Energy Efficiency*, ECE Energy Series No.1O, New York, 1992, P. 101.

18 Resource Management Associates, Inc. and Energoprojekt, "Energy Efficiency Audit Report: Cemy Dul Fabric Plant, Horice, Czechoslovakia," contractor report for U.S. AID, January 1992, pp. 14-15.

19 U.S. Congress, Office of Technology Assessment *Fueling Development,* OTA-E-516 (Washington, DC: U.S. Government Printing Office, April 1992), pp. 191-192.

20 Ibid, p. 192.

21 S. Kolar, "Industrial Energy Efficiency in Central and Eastern Europe, ' contractor report prepared for the Office of Technology Assessment, September 1992, p. 26.

typically much higher than that of a steam-only system.[22] By one estimate there is a potential to provide 6 percent of the former CSFR's electricity needs with cogeneration systems.[23] The relatively low penetration of cogeneration in CEE is due in part to a history of low electricity prices (which have made self-generation less financially attractive) and to the difficulty faced by private power producers in selling electricity to the grid. These issues have been addressed in part in the United States by the Public Utility Regulatory Policies Act (1978), which requires electric utilities to purchase electricity from cogenerators at a reasonable rate. Since passage of the Act, cogeneration installations in the United States have grown rapidly, from 12 GW installed capacity in 1980 to 25 GW by the end of 1989.[24]

MOTORS

Electric motors consume the bulk of industrial electricity in CEE. In the former CSFR, for example, electric motors are responsible for over two-thirds of industrial electricity use.[25] These motors are used for pumps, fans, compressors, materials processing (crushing, grinding, etc.), and materials movement (cranes, elevators, etc.). Recent technical advances allow for significant improvements in motor efficiencies.[26] Standard motors typically operate at efficiencies of 77 to 94 percent, while high efficiency motors operate at 84 to 96 percent. These high-efficiency motors make use of both better design and better materials to reduce internal electric and magnetic losses. High-efficiency motors typically cost about one-third more than standard motors, but depending on usage, electricity rates, and other factors, this investment often pays back rapidly. Another technical improvement in motors, adjustable-speed drives, allows for better matching of motor speed and load and thereby can provide electricity savings of 30 to 50 percent in fans.[27]

Industrial Energy Use: Conclusions and Implementation

Industry is the single largest energy user in CEE. Although data are scarce, it is fairly clear that much of this energy is wasted, and that there are many cost-effective opportunities for improved energy efficiency. In the past, industry neglected energy efficiency as energy costs were low and the focus was on meeting production goals. Now, however, energy costs are rising rapidly and economies are moving towards a market-based system. When faced with rapidly rising energy prices, U.S. industry responded by retrofitting industrial facilities with simple housekeeping and maintenance measures, closing down old inefficient facilities, and investing in new technologies. Most of these actions could be applied in Central and Eastern Europe; furthermore, industry can make use of the many imroved technologies discovered and refined in the West in the last 20 years.

In the short term, the first priority for industry is to implement the numerous low and no-cost retrofit measures described above. These include insulating pipes, installing steam traps, installing simple electronic meters and controls, and providing basic maintenance. These measures offer very short paybacks (usually less than 2 years, and in some cases less than 6 months) and significant energy savings.

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22 Cogeneration is discussed in detail in U.S. Congress, Office of Technology Assessment *Industrial and Commercial Cogeneration, OTA-E-192* (Washington DC: U.S. Government Printing Office, February 1983).

23 S. Kolar, supra note 21, p. 29.

24 Energetic, Inc., supra note 16, p. 2.

25 S. Kolar, supra note 21, p. 21.

26 For a detailed discussion of high efficiency motors see U.S. Congress, Office of Technology Assessment, Fueling *Development, OTA-E-516 (Washington* DC: U.S. Government Printing Office, April 1992), pp. 107-115.

27 Ibid, p. 113.

Implementing these low cost measures will require all of the following:

- awareness of their availability and energy savings potential;
- incentives to take the time and effort to install them;
- hardware, or the capital to buy them; and
- knowledge of where and how to use them.

A recent study of industrial energy use in Poland found, ''most responsible personnel lacked awareness of the specifics and extent of energy wasted and of the measures necessary to use energy more efficiently. ''[28] The frost step in implementing energy efficiency is to make sure those who can make investment decisions are aware of the opportunities. *Awareness* of availability and energy savings potential can be spread through professional journals, training, word-of-mouth, demonstration programs, exhibitions and trade fairs, and other informal communication channels.

One complicating factor is determining just who to target for new information. Many industries are in transition from public to private ownership, and the responsibility and authority to make investments of any type may be spread among the government (which in many cases retains part ownership), the new part-owners, the plant manager, and the energy manager (if there is one). Furthermore in many Hungarian industries, for example, decision making is very hierarchical and centralized,[29] requiring energy efficiency to compete with many other issues for the attention of senior management.

Technology transfer from the United States to Central and Eastern Europe to date has been largely in the form of private sector efforts to sell U.S. technologies (see app. 4-l). These efforts have benefited from U.S. programs to build awareness and understanding of energy efficiency through meetings, trade fairs, and audits. Although these efforts are difficult to evaluate, their relatively low costs and case-study evidence of their benefits suggest that they are worthwhile.

For an individual or an industry to take the time and effort to focus on efficiency requires some *incentive* to do so. For the simple low-cost measures discussed above, it might seem that the rapid paybacks (corresponding to financial returns of well over 100 percent in many cases) should be sufficient. However if the energy savings do not flow to the plant or to the individual making the decision, then there is little incentive to invest. In Russia, for example, there is some concern that reducing energy consumption may lead to reduced energy allocations in the future. Similarly, profits in Russia (e.g., those resulting from energy savings) are taxed at a 50 percent rate.[30] Providing decision makers with the correct price signals, and allowing the benefits (and costs) of efficiency to flow to those making the decisions, will help provide the needed financial incentives.

The countries of CEE must make their own decisions on price reform and abolition of production quotas. However the United States can play a role by sharing information on the effectiveness of alternative pricing structures (e.g., off-peak electricity rates), providing foreign aid during the difficult time of adjustment to new price levels, and making it clear that appropriate financial incentives are absolutely necessary for a market to function properly. This is conceptually straightforward but quite difficult in practice. In the face of rapidly increasing energy prices, some industries are forced to either not pay their utility bills (causing financial problems for the utility) or

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28 International Resources Group, Ltd., "Poland: Policy and Institutional Analysis, Final Report, " contractor report for U.S. AID, May 1992, p. 11<

29 RCG/Hagler, Baitty, Inc., supra nOte 4, p. 16.

30 E. Martinet, "Energy Efficiency in Russia, Belorus, and Estonia: programs, Perspectives, and Western Assistance," contractor report prepared for the Office of Technology Assessment, Dec. 9, 1992, p. 17.

simply pile up debt with suppliers, banks, and others. Calls for price reform must be tempered with the reality that, at least in the short term, the money just may not be available.

The use of low-cost retrofit technologies is, in many cases, straightforward. One does not need a highly trained engineer to install steam traps and insulation. What is needed, and is presently in short supply, is the required *hardware.* There are already some efforts being made by U.S. companies to export these devices to CEE (see app. 4-1). Many of these efforts, however, are hampered by lack of *capital.* CEE industries may recognize the energy-savings potential and have a financial incentive to make the investment, yet not have the needed capital.[31]

Several innovative financing schemes could be used to supply capital to CEE industries for energy efficiency investments. Performance contracting, in which the company supplying the hardware shares the financial savings resulting from the decreased energy use, is being investigated (see app. 4-1). One project is even considering payment in the form of natural gas. This avoids problems of currency convertibility, which have hampered several projects.

In the United States, utilities sometimes supply the capital for efficiency when it is less expensive than new electricity generating facilities. Some have argued that CEE utilities could supply capital for efficiency. However these utilities are generally overcapacity due to the economic recession, and therefore cannot easily justify short-term efficiency investments in terms of avoided new supply. Furthermore, many of the short-term retrofit options save primary fuels rather than electricity. If, however, a utility is considering investing in capital equipment to reduce pollution from an existing plant-such as retrofitting scrubbers to a coal-fired plant-it is certainly worth investigating whether it would require less capital to invest in efficiency and thereby reduce electricity demand, which would in turn reduce coal consumption.

There are several ways the U.S. Government could assist efforts to provide capital and hardware for energy efficiency. Joint ventures between U.S. and CEE industries could be encouraged through export promotion and risk-reduction programs.[32] The United States could provide low-interest loans directly to CEE industries for energy efficiency retrofits, to be repaid through the energy savings resulting from the retrofit .33 The Federal Government could institute a‘ Green Exports program, whereby U.S. companies transferring energy efficient technologies to CEE get positive publicity and technical assistance from the government. The multilateral banks could be encouraged to supply capital for energy efficiency retrofits.

Technical knowledge of how to evaluate, install, and maintain energy efficiency technologies is needed as well. Although most retrofit technologies are relatively simple, some expertise is needed to decide where and how to use them. Methods to provide this expertise include audits, general educational materials such as videotapes and books, technical courses, and exchange programs.

In the long term, major increases in energy efficiency will come not just from retrofits but from replacement of technically outdated industrial facilities with new facilities using modem technologies and practices. Investments in new industrial facilities most likely will be made for reasons other than energy efficiency (e.g., to reduce overall costs or to increase product quality), nevertheless large efficiency and environmental benefits will result from investments in new industrial equipment and processes.

31 In many cases capital is either unavailable, or available only at very ~@ interest rates.

32 Many such programs already exist—see chapter 5 of this report, also, The Alliance to Save Energy, "A Resource Guide for Exporting Energy-Efficient Products, " Washington DC, July 1991.

33 For example, a revolving loan fund is used by the state of Texas to supply capital for retrofits of state-owned buildings.

Larry Markel

Most people live in apartments. Single-family houses are less common than in the West.

The capital requirements for rebuilding industrial facilities will be enormous. Given the relatively constrained foreign aid budget in the United States, it would be difficult for the U.S. Government to cover a significant fraction of the costs to rebuild industrial facilities. An alternative role is for the U.S. Government to support and encourage private sector investment through information, risk-sharing and risk-reduction programs, and to encourage CEE country governments to provide an attractive investment climate.

BUILDING ENERGY USE

Energy used in buildings-to heat, cool, light, and provide other important energy services—accounts for about one-fourth to one-third of all energy used in Central and Eastern Europe. As with the industrial sector, there is great potential for increasing the efficiency of energy use in buildings through use of commercially available technologies already widely used and accepted in the West.

Physical Description

Most urban and suburban housing is in the form of large, multifamily apartment buildings. These buildings are considerably less expensive to build, per unit, than single-family buildings; and therefore provide basic housing services at a lower frost cost. Only in rural areas are single-family homes common. This is in contrast to the United States, where single-family homes are the dominant housing type (table 4-7). Apartment units are relatively small, providing about one-fourth as much floor space per person as housing in the United States (table 4-7). Appliance saturation is presently close to that of the United States for major energy uses such as refrigerators and washing machines (table 4-8); however, residential air conditioning is almost unknown, in contrast to the United States where over two-thirds of households have air conditioning.[34] (See also box 4c).

Commercial buildings (i.e., offices, stores, schools, and so on) are much less common in CEE than in the United States. By one estimate, the FSU has less than 1/5 as much commercial building floorspace per capita as does the United States.[35] There is very little information available

[34] U.S. Congress, Office of Technology Assessment, *Building Energy Efficiency, OTA-E-5 18 (Washington* DC: U.S. Government Printing Office, May 1992, p. 41); includes central and room units. Note that much of CEE lies north of the U. S., and therefore does not need air conditioning.

[35] L. Schipper and R.C. Cooper, "Energy Use and Conservation in the U. S. S.R.: Patterns, Prospects, and Problems, " LBL-29830 (Berkeley, CA: Lawrence Berkeley Laboratory, April 1991), p. 23.

Table 4-7-Comparison of Housing in the FSU and the United States, 1989

Indicator	FSU	United States
Percent of new units that are single family houses	15	72
Average floor space per person (all units, m^2/person)	16	61

SOURCES: U.S. Bureau of the Census, ***American Housing Survey for the*** United ***States in*** 1989, H150/89 (Washington, DC: U.S. Government Printing Office, July 1991), p. 38; U.S. Bureau of the Census, ***USA/USSR: Facts and Figures*** (Washington, DC: U.S. Government Printing Office, August 1991), pp. 2-7,2-8.

Table 4-8-Appliance Holdings in t he United States and in the FSU

	% of households having 1 or more	
Appliance	United States(1990)	FSU (1989)
Television (color)	96	44
Refrigerator and/or Freezer	99	92
Clothes washing machine	76	72

NOTE: About 15% of U.S. households have more than one refrigerator, and 50% have more than one color television set.

SOURCES: U.S. Bureau of the Census, ***USA/USSR: Facts and Figures*** (Washington, DC: U.S. Government Printing Office, August 1991), p. 8-4; U.S. Department of Energy, Energy Information Administration, ***Housing Characteristics 1990*** (Washington, DC: U.S. Government Printing Office, May 1992), pp. 104, 106.

Box 4-C--A Typical Residence in CEE

Residential buildings in Central and Eastern Europe are quite different from those in the United States. One way to illustrate these differences is by describing atypical residence in CEE-a unit in a large multistory apartment building. The design and construction of the building emphasizes low construction costs and simplicty. Steel and concrete are the principal materials, windows are poorly sealed and caulked, and building insulation is lacking or very thin. At present the building is publicly owned (that is, owned by a local or regional government agency), however the movement towards privatization has affected the buildings sector as well, and in the near future the units may be sold to the tenants. The building is in relatively poor shape; funds and parts for repair are limited, and only when components totally break down are they repaired or replaced. The apartment itself is quite small, providing only about 1/4 the floor space per person found in the typical U.S. residence. Within the apartment are a small refrigerator, a washing machine, and several small appliances including a sewing machine, a black and white TV, and a radio. Space heating is provided by radiators, which usually provide plenty of heat even on the coldest days-in face it is often necessary to open some windows, even in the winter, to keep from overheating. There is no thermostat or working valve on the radiators, and therefore no way to control the temperature other than by opening the windows. Hot water for washing is plentiful as well, winter and summer. Assummers are rarely hot, there is little need for air conditioning. Cooking is done on a natural gas-fired range.

SOURCE: Office of Technology **Assessment.**

on these buildings, but they are probably similar to residential buildings in that they offer only basic services--i.e. poorly controlled heat, few appliances, very little air conditioning, low lighting levels, and poorly insulated shells.

How Do These Buildings Use Energy?

Space heating is the single largest energy user in CEE buildings, accounting for over three-fourths of all building energy use in the FSU.[36] Of the energy used for space heating in the FSU, about 40 percent[37] comes as hot water from a

36 M. Sagers and A. Tretyakova, "USSR: Energy Consumption in the Housing and Municipal sector, " Center for International Research Staff Paper No. 30, U.S. Bureau of the Census, September 1987, p. 21. [Note: this figure may include some water heating].

37 Ibid, p. 21.

district heating plant-a large heat or combined heat and power plant providing hot water or steam to more than one building.[38]

The remaining 60 percent of energy use for space heating comes from onsite fuel use. Smaller buildings and those in rural areas without access to a district heating grid often use small coal-fried residential boilers, which typically are manually stoked and fired. These small coal burners have no emission controls and are extremely dirty, producing much more pollutants (notably particulate, CO, and SO_x) per unit of heat output than a well-controlled large boiler with pollutant controls. A variety of other space heating technologies, including those fired by wood, natural gas, and oil are found in some areas as well.

Water heating is a significant energy user as well. In those buildings served by district heat, hot water is often supplied centrally from the district heating system.[39] Buildings with access to natural gas service often use natural gas to heat water.

Significant energy uses after space and water heating include cooking, lighting, refrigeration, and various appliances. Over three-fourths of households in the FSU use natural gas for cooking,[40] the remainder use a variety of fuels including wood and electricity. Few data are available on lighting, but most household lighting is supplied by incandescent lamps; and lighting levels are often relatively low. Refrigerators in CEE are typically smaller and simpler than those in the United States—with an interior volume about half that of the typical U.S. model,[41] and manual rather than automatic defrost. As discussed below, their energy efficiency is quite low as well.

How Energy Efficient are Buildings in Central and Eastern Europe?

There are two ways to assess energy efficiency: relative to a standard or to other countries, and relative to opportunities for improvement. This section discusses energy use in Eastern European buildings relative to that in other countries, and the following section discusses specific technical opportunities for improvement.

Comparing aggregate energy use in buildings across countries can be misleading. Considering only, for example, building energy use per capita across countries fails to consider climatic differences (a country in a colder climate will of course use more energy to heat buildings, this does not mean it's less efficient) or service differences (U.S. households use more electricity than CEE households because they are larger and have more energy-intensive appliances such as air conditioners, similarly this does not mean they are less efficient). A better indicator that controls for some of these effects would be, for example, space heating energy use per square meter of floor space per heating-degree-day .42

Data for such a measure are difficult to obtain, however researchers at Lawrence Berkeley Laboratory have estimated that households in the FSU use about 190 kilojoules per square meter of floor space per heating degree-day. For comparison buildings in the United States use about 125; that is buildings in the FSU use about 50 percent more energy to heat one square meter of

38 District heating is rare but not unknown in the U.S. At present, about 1 1% of commercial building floor space in the U.S. is supplied heat from a district heating plant (U.S. Congress, Office of Technology Assessment, *Building Energy Efficiency, OTA-E-518* (Washington, DC: U.S. Government Printing Office, May 1992), p. 49). District heating of *residential* buildings in the United States is very rare.

39 The hot water from the district heating plant is not used directly, but rather fresh water is heated in a heat exchanger which uses the district heating system as a heat source.

40 U.S. Bureau of the Census, *USA/USSR: Facts* and Figures (Washington, DC: U.S. Government Printing OffIce, August 1991), p. 2-8.

41 L. Schipper and R.C. Cooper, supra note 35, p. 22; U.S. Congress, Office of Technology Assessment, *Building Energy Efficiency*, OTA-E-518 (Washington DC: U.S. Government Printing Office, May 1992), p. 61.

42 Degree-days are typically measured relative to a base temperature, usually 65 degrees F°. If the daily average temperature One day is 60 degrees F, then that day has 5 (65 minus 60) degree-days.

floorspace than buildings in the United States,[43] controlling for outdoor temperature. Furthermore, work by OTA and others has shown that considerable improvements in the energy efficiency of the U.S. building stock would be cost-effective,[44] therefore the U.S. energy intensity indicators should be seen as an achievable level and not an economic optimum. This suggests that a considerable potential exists to save energy in FSU buildings through increased efficiency. Furthermore, buildings in the United States are, in general, quite comfortable, and saving energy in FSU buildings does not require any loss of comfort-in fact, as discussed below, improved control can both save energy and *increase* comfort.

Electricity use in buildings tells a somewhat different story. Residential electricity use per capita in the FSU is about one-tenth that of the United States.[45] This is not an indication of efficiency, however, but rather a reflection of the low appliance saturation in the FSU. Although households in the FSU often have refrigerators, washing machines, and televisions (table 4-8); they generally do not have air conditioners, clothes dryers, electric ranges, and other electricity-intensive home appliances common in the United States. In addition, as shown in table 4-7, households in the FSU are significantly smaller and therefore have lower lighting requirements as well.

Refrigerators are probably the single largest electricity user in CEE residences. The energy efficiency of new refrigerators currently sold in CEE lags significantly behind that of new refrigerators sold in the United States. As shown in table 4-9 (page 69), refrigerators currently sold in Poland exceed the maximurn energy use allowed in the United States by 40 percent.

Technologies for Improved Efficiency

Technologies for increasing the efficiency of energy use in buildings include: improving the operation and control of space heating systems, fuel switching, improving the building shell, improving the efficiency of electrical appliances, and improving the district heating delivery system.

IMPROVED OPERATION AND CONTROL OF SPACE HEATING SYSTEMS

Space heating systems in multistory apartment buildings usually are operated very inefficiently. The chief "technology" for temperature control is usually an open window-a ''fortichka," a small window built within the frame of a surrounding larger window for the purpose of regulating temperature (see app. 4-1). This technology leads to tremendous energy losses (opening windows rather than turning down the heat is done in U.S. apartment buildings as well%).

There are a number of technologies, more effective and efficient than opening windows, that can reduce energy consumption while maintaining, or even improving, occupant comfort. The first is an *operating radiator valve,* which can be used to control the flow of steam or hot water through a radiator. Many radiators lack valves

43 Delivered (useful) energy only. Source: L. Schipper and R. Cooper, supra note 35, p. 58.

44 See U.S. Congress, Office of Technology Assessment, *Building Energy Efficiency*, OTA-E-518 (Washington, DC: U.S. Government Printing Office, May 1992), chapter 1; also P. Komor and A. Moyad, ''How Large is the Cost-Effective Savings Potential in U.S. Buildings?, ' *Proceedings of the ACEEE 1992 Summer Study on Energy Efficiency in Buildings* (Washington DC: American Council for an Energy-Efficient Economy, 1992), vol. 6, p. 6.125.

45 Residences in the FSU used about 400 kWh/capita-year in 1990 (residential electricity use only, OTA estimate based in part On M. Sagers and A. Tretyakova, supra note 36, p. 12), while U.S. residences used about 3710 kWh/capita-year in 1990 (U.S. Department of Energy, Energy Information Administration *State Energy Data Report* (Washington DC: U.S. Government Printing Office, May 1992), p.32; U.S. Bureau of the Census, *Statistical Abstract of the United States 1992* (Washington DC: U.S. Government Printing Office), p. 8).

46 J. DeCicco, 'Modeling, diagnosis, and implications for improving the energy-efficiency of centrally heated apartment buildings,' Report No. 225 (Princeton, *NJ:* Center for Energy and Environmental Studies, April 1988), p. 228.

altogether and those that are installed often become jammed due to corrosion. A case study of an apartment in a high-rise in Krakow found that all but one radiator had inoperative radiator valves.[47] In a study of a centrally heated apartment building in New Jersey, 34 percent of the radiator valves were stuck.[48] Without an operable valve there is no way, other than opening windows, to control the temperature.

Thermostats can reduce energy use and increase comfort by automatically regulating heat to provide a constant indoor temperature. A thermostat frees the occupants from the task of continually adjusting the radiator, and also controls the temperature when no one is home. Thermostatic radiator valves are available at a cost of $30 to $35 each;[49] these valves control room temperature by modulating the flow of hot water or steam through the radiator. These valves can be retrofit relatively easily to many space heating systems.[50]

One notable feature of multiunit apartment buildings with central space heating systems is that individual units are rarely metered; that is the energy use of the individual apartment is not actually measured. Energy costs are typically based on a flat rate proportional to apartment size. Therefore, there is no direct financial incentive for efficient operation (such as using radiator valves rather than windows to control temperature). The use of individual apartment *meters* would provide data from which tenants could be charged for their actual consumption, and could be financially rewarded for efficient operation.[51] In a study of the effects of metering in apartment buildings in the United States, energy consumption dropped 6 percent in one building and 13 percent in another after individual unit meters were added.[52]

There are numerous technologies that can improve the heat distribution system of a building. Examples include *resets,* which allow the hot water temperature to vary in response to outdoor temperature, *cutouts,* which shut off the hot water when the outdoor temperature is such that no space heating is necessary, and *night setback,* which reduces hot water temperature in late night hours. Installation of resets and cutouts yielded space heating energy savings of 10 to 26 percent in apartment buildings in Milwaukee.[53] Modeling of a centrally heated apartment building in New Jersey suggested that heating energy use could be reduced 63 percent by reducing steam pressure, changing various control settings, instituting night setback, and installing thermostats.[54]

In summary, improved operation and control of space heating systems in multifamily buildings are often cost-effective retrofits. A summary of

47 A. Hoggatt, ''Energy Efficiency in Krakovian Apartment Buildings: An Engineering and Economic overview," draft report for U.S. EPA, May 26, 1992, Appendix A.II by Steve Greenberg, p. 45.

48 J. DeCicco, supra nOte 46, p. 230.

49 These are approximate prices in the United States in 1993.

50 Systems piped in series—that is, where the output of one radiator is the input to another—will require the installation of a bypass pipe.

51 Metering must be combined with an enforceable billing system.

52 D. Palermini and D. Hewitt, "Economic and Social Impacts of Converting to Tenant Metering in Multi-Family Housing,' in Proceedings *of the ACEEE 1990 Summer Study on Energy Efficiency in Buildings* (Washington, *DC: American Council* for an Energy-Efficient Economy, 1990), p. 9.238. Of course the meters themselves did not save energy, but the metered data was then used to charge occupants for actual consumption.

53 M. Hewett and G. Peterson, ''Measured Energy Savings from Outdoor Resets in Modern, Hydropically Heated Apartment Buildings, in *Proceedings of the ACEEE 1984 Summer Study on Energy Efficiency in Buildings (Washington DC:* America nCouncil for an Energy-Efficient Economy, 1984), p. C-135; as referenced in G. Ewing et al., "Effectiveness of Boiler Control Retrofits on Small Multifamily Buildings in Wisconsin,'' in *Proceedings of the ACEEE 1988 Summer Study on Energy Efficiency in Buildings (Washington DC: American* Council for an Energy-Efficient Economy, 1988), p. 2.51.

54 J. DeCicco, "fier~ Conservation and Outdoor-Reset Control of Space Heating Systems,'' in *Proceedings of the ACEEE 1988 Summer Study on Energy Efficiency in Buildings* (Washington DC: American Council for an Energy-Efficient Economy, 1988), p. 2.33.

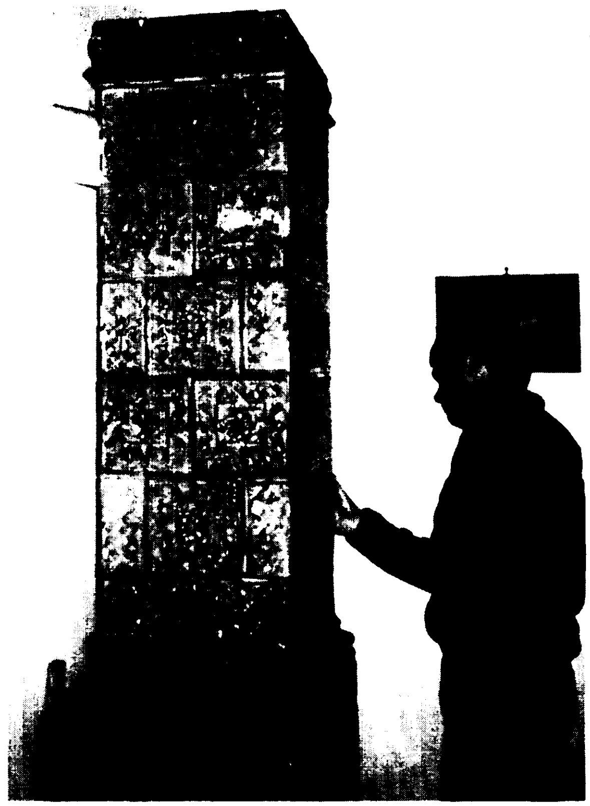
multifamily building retrofits in the United States and Europe found that heating system improvements offered significant energy savings and reasonable paybacks—typically 3 to 7 years.[55]

FUEL SWITCHING

Many buildings in CEE are heated with coal. In the case of multifamily buildings this heat is provided either by a coal-freed district heating plant or a small onsite boiler, while single-family buildings are often heated by a small coal-fired boiler.

Small onsite boilers in multifamily buildings typically lack any pollution control equipment, are fired with relatively low-quality (that is, high ash and sulfur content) coal, and are poorly maintained; the end result is very high air emissions (including particulate, CO, and SO_x) and low operating efficiency. One option is to connect these buildings to the district heating system, which although coal-fired often does have pollution control equipment. Such an effort is now being pursued in Krakow, Poland, funded in part by the U.S. Department of Energy. A second option is to convert these boilers to natural gas, which could dramatically reduce air emissions.

Many buildings using district heat for space heating also obtain their hot water from the district heating system. This requires the district heating system to operate year-round to provide hot water. Converting to individual natural gas-fired units for water heat would allow the district heating system to shut down during the summer. A second option is the use of a ' 'front-end" gas-freed boiler, a small onsite boiler sized to meet hot water needs. Retrofits of front-end boilers to multifamily buildings in the United States have led to significant energy savings,


Larry Markel

***Coal** stoves in residences are significant sources of pollution.*

although high frost costs resulted in long paybacks.[56]

Single-family buildings often are heated by small coal-fired stoves. For those buildings located in areas served by natural gas, conversion of coal-fried stoves to natural gas would have significant air quality benefits. However many single-family buildings are located in rural areas without natural gas service, Similar air quality benefits, however, could be gained through conversion to LPG (liquefied petroleum gas). Another option is to replace the traditional small coal stove with a high efficiency, cleaner-burning

55 J. Harris et al., "Comparing Measured Savings and Cost Effectiveness of Multifamily Retrofits in the United States and Europe," *Energy Systems and Policy*, vol. 13, 1989, p. 109.

56 M. Lobenstein et al., "Measured Savings and Field Experience from the Installation of Front-End Modular Boilers," in Proceedings *of the ACEEE 1990 Summer Study on Energy Efficiency in Buildings* (Washington, DC: American Council for an Energy-Efficient Economy, 1990), p. 9.189.

modem coal stove. Energy savings and emissions reductions from such a switch are thought to be considerable .57

SHELL IMPROVEMENTS

Energy use for space heating can be reduced significantly by reducing losses through the building shell. Several researchers have noted that buildings in CEE have relatively low insulation levels.[58] One study found that walls in a Polish apartment had an R-value[59] of about 3.6,[60] well below that of the R-value of 10 or higher commonly found in walls of U.S. houses.[61] Similarly, improved windows can reduce heat loss as well. Windows are typically double-pane with a R-value of about 2, but are often poorly fitted and sealed, which contributes to infiltration losses. Improved windows making use of low-emissivity coatings, low-conductance frames, and suspended reflective films are available with R-values up to 8.[62]

The cost-effectiveness of shell *retrofits* in multifamily buildings is sometimes questionable. Although increased insulation and improved windows do reduce energy use, their relatively high first costs often result in long paybacks. A review of retrofits of multifamily buildings in the United States and Europe found paybacks for shell retrofits (such as increased insulation, caulking, window replacements, and storm windows) to be relatively long-over 10 years in many cases.[63] In new construction and renovation, however, the use of high levels of insulation, high-R windows, and careful sealing and weatherstripping is almost always cost-effective.

IMPROVED APPLIANCES

Households typically have fewer and smaller appliances than do households in the United States or in Western Europe-however, there are still significant opportunities for improvement. For example, new refrigerators currently produced and sold in Poland exceed the current (1993) U.S. energy standard by 40 percent (table 4-9). A number of engineering improvements were used by U.S. manufacturers to allow for a 22 percent drop in refrigerator energy consumption from 1990 to 1993 (table 4-9). These include improved door insulation, improved compressors, redesign of heat transfer surfaces, and improved evaporator fans. These technologies could be used in CEE as well. The savings could be significant-for example, if FSU refrigerator manufacturers were to obtain equivalent savings, the FSU could reduce electric power capacity requirements by about 190 MW each year.[64]

Lights are a large consumer of electricity in buildings. Substitution of compact fluorescent lamps for incandescent lamps can reduce lighting energy consumption 75 percent.[65] The increased

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57 U.S. Department Of Energy, ''Krakow Clean Fossil Fuels and Energy Efficiency Project Statement of Work, ' Attachment B, p. 4. Modem residential coal stoves with automatic stoking (which reduces emissions caused by under- or over-fueling) and electronic temperature control are currently produced in the United States (for example, units produced by Harman Stove and Welding, Inc., Halifax, PA).

58 L. Schipper and R.C. Cooper, supra note 35, p. 22; M. Sagers and A. Tretyakova, supra note 36, p. 13.

59 "R" is a measure of resistance to heat flow, with units of hour-square feet-degree F per Btu. The higher the R-value, the better the insulating value.

60 A. Hoggatt, supra nOte 47, p. 44.

61 U.S. Congress, Office of Technology Assessment, *Building Energy Efficiency*, OTA-E-518 (Washington, DC: U.S. Government Printing Office, May 1992), p. 18.

62 Window R-values are measured at center-of-glass, and do not include losses through the frame.

63 J. Harris et al., supra note 55, p. 109.

64 Assumptions: annual sales of 6.5 million refrigerators and freezers in the FSU (U.S. Bureau Of the Census, supra note 40, p. 8-4), savings of 200 kWh/year per unit, capacity factor of 80%0 for electricity generation.

65 U.S. Congress, offic. of Technology Assessment, *Building Energy Efficiency*, OTA-E-518 (Washington, DC: U.S. Government Printing Office, May 1992), p. 52.

Table 4-9-Comparison of Energy Use of Different Refrigerators

Model/source	Energy use (kWh/year)
New unit currently manufactured in Poland, 1992.	**694**
U.S. maximum allowable by law, 1990.	**636**
U.S. maximum allowable by law, 1993.	**497**

NOTE: New unit is "partial automatic defrost" two-door 9.5 ft^3(adjusted volume) combination refrigerator-freezer manufactured and sold in Poland in 1992. U.S. standards are the maximum allowable energy use for a unit of that size with those features if offered for sale in the United States.

SOURCES: Literature from Polar, ul. Adolfa Warskiego 6, Wroclaw, Poland; Federal Register 47918 (Nov. 17, 1989).

frost cost of compact fluorescent lamps makes them economically attractive only in areas where lights are on for many hours per day—such as corridors, entrance areas, and other public spaces. There have been many improvements in commercial building lighting technologies as well. Electronic ballasts, improved reflectors, and reduced wattage lamps can reduce lighting energy use by over one-third.[66]

DISTRICT HEAT DELIVERY IMPROVEMENTS

The district heating systems that deliver hot water for space heating to apartments are often old, leaky, and inefficient. By one estimate, in Poland 15 percent of the energy contained in the original fuel is lost in the district heating delivery system.[67] These losses are both in heat (via conduction, convection, and radiation) and in direct water leaks. Many of the technical frees to reduce these losses are relatively straightforward, such as replacing leaky pipes, repairing leaky joints, and insulating pipes. By one estimate, pipe insulation typically has a payback of less than 1 year.[68] Improved controls to better regulate temperature, pressure, and flow can reduce energy use as well. An ongoing project to upgrade a district heating system in Moscow projects energy savings of 30 percent from improved boiler and distribution system controls (see app. 4-l). Another source estimates savings of 10 to 30 percent from improved control of distribution systems.[69]

Conclusions and Implementation

A number of factors will almost certainly lead to increased energy use in buildings in CEE in the long term, including:

- large increases in commercial building floor space;
- increases in the demand for energy-intensive services in the commercial sector (notably air conditioning, information technologies, and lighting);
- increases in the size (square meters of floorspace per person) of residential housing;
- growing population; and
- growing demand for energy-intensive residential appliances, such as color televisions, clothes dryers, and larger refrigerators.

The challenge for improved technologies, therefore, is to moderate the increase in energy demand below what it would otherwise be.

There are numerous examples of large opportunities for energy efficiency improvements in buildings. As discussed above, walls in a Polish apartment building were found to have less than half the insulating value of walls in typical U.S. houses. Space heating energy intensity in the FSU is about 50 percent higher than in the United States. New refrigerators in Poland use 40 percent more energy than is allowed by the 1993 U.S. standards. By one estimate, energy savings of 30

66 Ibid, p. 56.

67 L. Lipka, "District Hinting Systems in Poland, " in International Energy Agency, *Seminar on Energy in East and West: The Poland Case*, Copenhagen April 1990.

68 United Nations, supra note 17, p. 94. If pipes are buried, paybacks will be longer.

69 Ibid, p. 95.

to 45 percent are possible in the FSU buildings sector.[70] The data are spotty but consistent: clearly the savings potential is considerable.

The first priority for improving building energy efficiency in CEE is to make those changes with the highest returns and largest savings. Although much of the building stock is in relatively poor condition, the shortage of housing means that very few residential buildings will be replaced in the near term. Therefore low-cost investments can be economically justified, even in older buildings, without concern that the building will be torn down before the investment pays off.[71] The technologies providing these high returns include, for example, thermostatic radiator valves, district heat distribution system controls, resets, and cutouts. Although the financial attractiveness of these technologies will vary depending on the specific application, in most cases they offer rapid paybacks.

As in the industrial sector, implementing these low-cost measures requires several components:

- awareness of their availability and energy savings potential;
- incentives to take the time and effort to install them;
- hardware, and the capital to buy them; and
- knowledge of how and where to use them.

Much of the discussion above on implementing low-cost measures in industry applies to the buildings sector as well. To summarize, awareness of availability and energy savings potential can be spread through professional journals, training, word-of-mouth, demonstration programs, exhibitions and trade fairs, and other informal communication channels. Providing decision makers with the correct price signals, and allowing the benefits (and costs) of efficiency to flow to those making the decisions, will provide the needed financial incentives. Building designers, builders, and owners may recognize the energy-savings potential and have a financial incentive to make the investment, and yet not have the needed capital. Several innovative financing schemes could be used to supply capital to the buildings sector for energy efficiency investments, including performnance contracting, utility financing, and payment in energy rather than in currency. Technical expertise can be provided through audits, general educational materials such as videotapes and books, technical courses, and exchange programs.

The second priority is to improve the energy efficiency of new buildings and appliances. At present there is a shortage of residential housing in much of CEE, and if the service sector grows as rapidly as predicted there will soon be a shortage of commercial buildings (for offices, stores, restaurants, and so on) as well. The financial attractiveness of retrofitting *existing* buildings with insulation, high-quality windows, and other energy efficient features is often questionable; however for *new* buildings the incremental frost cost is much lower and therefore these investments are usually profitable.

There has been rapid growth in the building energy efficiency business in recent years in the United States, due largely to utility investments in energy efficiency and to changes in State and Federal regulations. Many smaller companies are producing energy efficient devices, such as commercial lighting reflectors and high-R windows. Larger appliance companies are investing considerable R&D resources into meeting Federal energy efficiency standards. Numerous consulting and marketing companies are assisting utilities in their auditing and demand-side planning efforts. And new building design and construction firms have paid increasing attention to energy efficiency, due largely to the growing use of State building energy codes.

Transferring these technologies and practices could be aided by CEE adoption of some of the

70 L. Schipper and R.C. Cooper, *supra* note 35, p. 60.

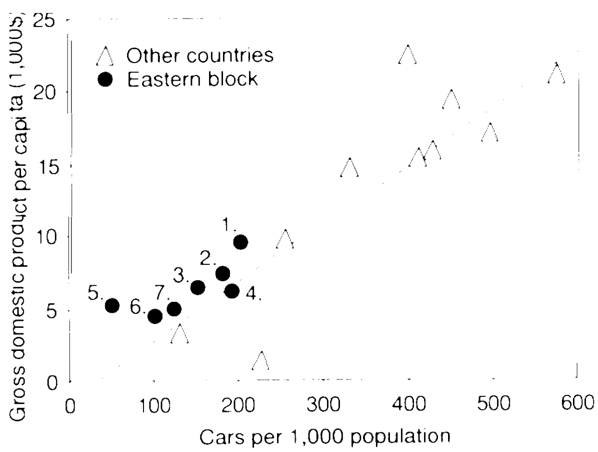
71 This is in contrast to industry, where one faces the decision of whether or not to invest in a facility that may close due to lack of demand.

same incentives used in the United States—notably utility investment combined with regulatory change. In the United States, various market issues such as high information and transaction costs, separation between owners and tenants, and high consumer discounting have led to a greater reliance on regulation in the buildings sector than in the industry or transport sectors.[72] For example, in the United States appliance standards and building codes set minimum energy efficiency levels, and recent legislation (the Energy Policy Act of 1992) increases the coverage of both codes and standards. If CEE countries were to adopt similar provisions, the affected industries would have to adopt the appropriate energy efficient technologies and practices. Russia's building code, for example, is currently being revised.[73] Communication with code revision bodies in the United States, such as the Council of American Building Officials (CABO) and the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), could help pinpoint useful and effective technologies and practices.

TRANSPORTATION

Economic and social activities depend on movement of goods, services, and individuals from one location to another. The effectiveness of this exchange depends on the availability and efficiency of a nation's transportation network. As a nation's economy develops, its demand for raw materials, food, labor, goods and services, and personal mobility develops as well; resulting in an increased need for more extensive, reliable, and affordable transportation. These trends have been observed in Western industrialized nations and in less developed nations with growing economies. It is likely that the economies of Central and Eastern Europe will experience similar demands (figure 4-1).

Figure 4-1—Income and Vehicle Ownership



1. Former E. Germany
2. Former Czechoslovakia
3. Hungary
4. Yugoslavia
5. Former Soviet Union
6. Poland
7. Bulgaria

NOTE: Data are approximate. Line shown is for reference only.

SOURCE: *The Economist*, Mar. 10, 1990, p. 71.

Along with the increased demand for transportation services could come an increase in the amount of energy required by the transportation sector. Three elements shape transportation energy use:

- Activity—measured in passenger-miles and ton-miles;
- Modal mix—the contribution each transportation mode (such as road, rail, air, and pipeline) makes to the total transportation sector; and
- Modal energy intensities--a combination of vehicle fuel intensity (energy per vehicle-mile) and utilization of vehicle capacity (number of passengers or tons of freight per

72 This issue is discussed in more detail in U.S. Congress, Office of Technology Assessment, *Building Energy Efficiency*, OTA-E-518 (Washington DC: U.S. Government Printing Office, May 1992), p. 131.

73 RAS, Inc., "Tkchnologicat Potential of Energy Conservation in Transport and Construction Sectors of Economy of the Russian Federation" contractor report prepared for the Office of Technology Assessment, December 1992, p. 29.

Table 4-10-Transport Systems and Energy Use, 1989/1990

		Road				Rail			Air		
Country	Transport energy use as a % of Total	Road energy use as a % of Total	Length of road Network (1,000km)	Pass.-km by road (bil)	Freight tonne-km by road (bil)	Rail energy use as a % of Total	Pass.-km by rail (bil)	Freight tonne-km by rail (bil)	Air energy use as a % of Total	Pass.-km by air (bil)	Freight tonne-km by air (bil)
former CSFR....	7	3.2	75	40	13	0.8	20	66	0.4	2.6	<1
Hungary....	13	10.6	30	22	8	1.6	13	20	0.7	1.6	<1
Poland.....	12	9.4	NA	58	9	1.8	61	111	0.7	4.9	<1
FSU........	16	7.1	970	480	143	2.8	411	3,852	3.2	229.0	3.3
US.........	27	19.8	6,280	5,182	1,269	0.6	40	1,798	2.3	561.0	16.2
OECD Europe....	27	22.2	NA	NA	NA	0.7	NA	NA	2.9	NA	NA

NOTE: Data are uncertain. NA = not available. Energy data exclude conversion losses.

SOURCES: OTA estimates, based in part on World Bank, "Greenhouse Gas Strategy for Eastern Europe and the Former Soviet Union," August 1992, draft, Appendix III, pp. 3-20; Eurostat, "Country Reports: Central and Eastern Europe 1991," Statistisches Bundesant, Luxembourg, 1991, pp. 116-125; Oak Ridge National Laboratory, "Transportation Energy Data Book: Edition 12," ORNL-6710 (Oak Ridge, TN: March 1992), pp. XXIII, 6-9; U.S. Department of Transportation, "National Transportation Strategic Planning Study," Washington, DC, March 1990, p. 10-1; International Energy Agency, *Energy Statistics and Balances of non-OECD Countries 1988-1989, OECD (Paris, 1991).*

vehicle) which yields energy use per passenger-mile or per ton-mile.[74]

To decrease the amount of energy used by the transportation sector one can work to alter each of these elements. The primary methods for achieving this goal are:

1. moderating demand by changing behavior (e.g. by changing prices so as to reflect all relevant social costs) or decreasing the need for transportation via improved urban planning and communications;
2. influencing modal mix; and
3. improving the efficiency of each transportation mode.

Implementing options 1 and 2 relies heavily on internal government policies and the establishment of appropriate market forces. Option 3, although possibly requiring the government to provide the impetus, is most dependent upon the availability and application of technology, and is therefore the major focus of this section.

The following discussion briefly examines how energy is used in the transportation sectors of the former CSFR, Hungary, Poland, and the Former Soviet Union; what potential strategies exist to improve the efficiency of transportation in these nations, and the potential role of the United States in improving the transportation energy efficiency of these nations.

Energy Use

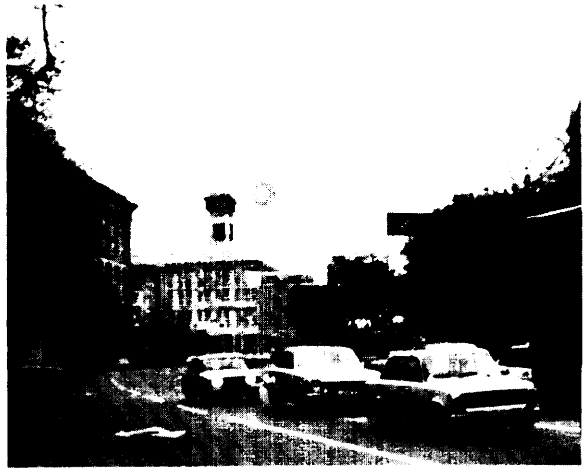
In 1989, transportation comprised a large portion of the total energy consumed in the Western countries-nearly 27 percent in the United States, and 25 percent in former West Germany. In contrast, the FSU used only 16 percent of its energy for transportation; Hungary and Poland 13 percent, and the former CSFR only 7 percent (table 4-10). These significantly lower numbers correspond to the more limited economic development of these nations as compared to Western countries, i.e. they have lower industrial output and lower GNPs per capita which are

[74] L. Schipper and S. Meyers, "Trends in Transportation Energy Use, 1970-1988: An International Perspective," LBL-32384 (Berkeley, CA: Lawrence Berkeley Laboratory, May 1992), p. 1.

Table 4-1 1—Comparison of Auto Ownership Levels (cars/1000 **people)**

Country	1950	1960	1970	1980	1987
FSU.	3	3	7	31	45
Poland.	1	4	12	66	104
Hungary.	1	2	10	83	157
Czechoslovakia. . . .	8	14	46	152	174
France.	39	130	233	355	393
East Germany.	NA	9	61	149	207
West Germany. . . .	13	82	208	375	470
U. S. A..	268	345	428	537	555

SOURCE: J. Pucher, "Capitalism, Socialism, and Urban Transportation: Policies and Travel Behavior in the East and West," ***A PA*** Journal, Summer 1990, p. 281.



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Relatively few people own cars, but the number is growing rapidly.

directly linked to factors such as automobile ownership (table 4-1 1).

From 1980 to 1989 the centrally planned economies of Central and Eastern Europe exhibited modal shifts in transportation use. The most prominent of these shifts was the increasing reliance of each region on automobiles and trucks. These changes occurred because of shifts in industrial output and the types of goods being produced, as well as the desire of individuals for enhanced personal mobility as indicated by a general increase in the amount of passenger travel. The area of largest growth was in the use of automobiles, although passenger travel on planes generally increased as well. A shift to road transport portends that the transportation sector, if not managed effectively, will consume an increasing amount of energy and a larger fraction of each nation's total energy use.

Automobiles often are one of the fastest growing energy segments in a developing market economy. Industry analysts project that demand for automobiles in CEE will grow by 133 percent during the 1990s. This compares to an OECD rate over the same period of just 10 percent.[75] According to one estimate, it is predicted that Eastern Europe will account for 60 percent of all growth in the automobile industry over the next 20 years.[76]

An increase in automobile use increases demand for gasoline unless fuel economy increases faster. For example, in Poland private gasoline use rose by 17 percent from 1990 to 1991.[77] Because private use for gasoline has been historically low, new demand will require additional refining in those nations with such capability, or the expenditure of more capital for the import of gasoline. Thus, the average efficiency of automobiles in these nations, particularly newly acquired vehicles, is critical. It is estimated that if the FSU's car fleet was used under Western conditions, the energy intensity would be approximately 9 liters/100 km (26 miles per gallon [mpg]). The actual on-the-road energy intensity of cars is estimated at 11-12 liters/100 km (20-22 mpg) due to poor fuel quality, vehicle maintenance, and road conditions.[78] A recent study

75 Y. Karmokolias, "Automotive Industry Trends and Prospects for Investment in Developing Countries, " International Finance Corporation, The World Bank, 1990.

76 J, Lindquistand C. Ackerman, ' 'Moving Into Overdrive," *Director,* November 1990, p. 125.

77 S. Meyers, "Economic Reform and Energy Efficiency in Eastern Europe, " contractor report prepared for the Office of Technology Assessment, December 1992, p. 4.

78 L. Schipper and S. Meyers, supra note 74, p. 11.

Table 4-12-Comparison of Modal Splits in Urban Transportation (percent of urban trips)

Country	Auto	Public transport	Pedestrian and bicyclist	Ratio of auto to public transport
FSU	12	88	NA	0.14
Poland	15	85	NA	0.18
Hungary	11	58	31	0.19
Czechoslovakia	13	52	35	0.25
France	47	11	35	4.30
East Germany	24	27	48	0.89
West Germany	48	11	40	4.40
U. S. A.	82	3	10	27.30

NOTE: Public transport includes bus, street ear, subway, urban ferries, cable cars, inclined planes, and automated guideway systems. Dates for the data are the most recent for each of the available countries.

SOURCE: J. Pucher, "Capitalism, Socialism, and Urban Transportation: Policies and Travel Behavior in the East and West," ***APA Journal,*** Summer 1990, p. 282.

indicates that new models such as the VAZ-2109 and the Moskvich-2141 are designed to get 5.9 L/100 km (40 mpg) and 6.6 L/100 km (36 mpg) respectively .79 Automobiles produced in Western nations that have attributes similar to the VAZ obtain 4-4.5 L/100 km (52-59 mpg), with significantly lower pollution. Replacing the existing fleet with new automobiles getting 20 per cent better fuel economy would save about 50 million barrels of oil per year.

Public transportation systems are extensively developed by Western standards because they have prospered under direct and indirect government policies. These include fare subsidization and the existence of planned centralized housing and industrial developments. The effects of these policies are dramatic. In the United States, 82 percent of all urban trips are made with the automobile, while only 3 percent use public transportation (bus, subway, street car, commuter rail). In the FSU 88 percent of urban travel is by public transport and only 12 percent by automobile.[80] Most European nations fall between these extremes, with Central European nations being most similar to the FSU (table 4-12). Automobile travel, given as passenger kilometers per capita per day, has universally increased (table 4-13). In contrast to West Germany and the United States, the use of public transportation in CEE increased between 1980 and 1985.

In addition to the extensive availability of public transportation networks in many Central and Eastern Europe nations, the relatively low cost of public transportation makes it attractive. Table 4-14 indicates how expensive automobile use is relative to public transport.

Even automobile owners in this region usually take public transportation to work. The reasons for this behavior are the high cost of fuel, high automobile operating costs, parking problems, and frequent inexpensive public transport service during peak hours.[81]

Rail systems for freight are extensive as well, although this system currently faces decreasing utilization as industrial output declines. Coal use for rail transport has been declining over the last decade throughout the region as the use of diesel locomotives and track electrification increases.

Air transportation, particularly in the FSU where greater distances necessitate air travel, is

79 RAS, Inc., supra note 73, p. 10.

80 J. Pucher, "Capitalism, Socialism, and Urban Transportation: Policies and Travel Behavior in the East and West," *APA Journal*, Summer 1990, p. 280.

81 Ibid, p. 281.

Table 4-13--Trends in Public and Automobile Travel (passenger kilometers per capita per day)

Country	Public transport 1970	Public transport 1980	Public transport 1985	Automobile transport 1970	Automobile transport 1980	Automobile transport 1985
FSU	6.1	8.6	9.3	NA	NA	NA
Czechoslovakia	7.5	9.3	9.6	6.2	15,2	15,8
France	3.6	4.7	4.9	16.8	23.2	24.6
East Germany	6.5	9.0	9.1	6.3	11.2	13.2
West Germany	4.0	4.8	4.4	16.5	21.2	22.1
U. S. A.	1.0	0.9	0.8	30.7	34.9	36.1

NA - Not available.

SOURCE: J. Pucher, "Capitalism, Socialism, and Urban Transportation: Policies and Travel Behavior in the East and West," ***APA Journal,*** Summer 1960, p. 284.

well developed. The energy efficiency of the system is below Western standards, primarily because of the use of less technically advanced equipment. The former Aeroflot appeared to be energy-efficient, but only on a per passenger basis. Unlike western airlines, most Aeroflot flights were full. Generally speaking, energy requirements per seat-kilometer of the former Aeroflot fleet are 50 percent higher than those in Western nations .82

Potential Strategies for Improved Efficiency

This section briefly examines possible methods to improve the efficiency with which energy is consumed in the transportation sector, while minimizing environmental pollution and improving transport services. These objectives can be accomplished by:

1. using existing technologies to improve the individual efficiencies of each transport mode;
2. using government policies to: change modal distribution or encourage the continuing use of a more energy efficient mode—for example public buses or subways; set minimum efficiency standards for individual transport modes; and more realistically approach true costing of fuel and land use;
3. improving infrastructure and communications; and
4. promoting overall system improvements, e.g., educating individuals to provide proper vehicle maintenance.

Table 4-14-Comparison of Gasoline Prices and Public Transport Fares, 1988

Country	Ratio of gasoline price per liter to public transit fare per trip
FSU	8.2
Poland	6.8
Hungary	11.7
Czechoslovakia	9.0
France	1.0
East Germany	9.0
West Germany	0.5
U. S. A.	0.3

NOTE: Fares are the regular one-way cash fare for a typical bus or subway trip within the central city,

SOURCE: J. Pucher, "Capitalism, Socialism, and Urban Transport: Policies and Travel Behavior in the East and West." ***APA Journal,*** Summer 1990, p. 287.

Each of these methods can yield significant improvements in the energy efficiency of the transportation sector.

The task of improving efficiency in Central and Eastern Europe should be less daunting than promoting energy efficiency in less developed

82 L. Schipper and E. Martinot, "Energy Efficiency in Russia, Ukraine, and Belorus: Opportunities for the West,'' Lawrence Berkeley Laboratory, draft report prepared for the U.S. Department of Energy, January 1993, pp. 4-5.

nations. This region's technologically well educated population, existing transportation infrastructure, and industrialized character are all assets which augment the capacity of the region to enhance its transportation energy efficiency.

SPECIFIC TECHNOLOGIES TO IMPROVE INDIVIDUAL EFFICIENCIES

The efficiency of automobiles and trucks in CEE is lower than that of OECD nations. Table 4-15 provides a summary of commercially available technologies which could improve transportation energy efficiency. Modem automobiles usually incorporate these technologies. Technology transfer could involve integrated overall design packages or specific elements.

Technologies to improve aircraft efficiency are also available, e.g., improved airframe design, lighter weight materials, and improved jet engine design. Similarly, ships could benefit from known technologies that improve hull and engine design. Pipelines could be improved by optimization of pipe diameter and inner wall materials for the specific substances being transported, improved compressor technology, and automated leak detection.

Table 4-15-Selected Technologies To Improve Transportation Energy Efficiency

Automobile Specific
- Electronic control of spark timing
- Throttle body and multipoint fuel injection
- Improved vehicle drive trains and transmissions
- Accessory improvements
- Overhead cam engines as opposed to push-rod engines

Truck and Bus Specific
- Improved fuel injection pumps
- Electronic engine controls
- Cab mounted front air deflectors
- Turbochargers

For Autos, Trucks, and Buses
- Improved tire design
- Weight reduction
- Reduced aerodynamic drag
- Reduced engine friction
- Improved fuels

Rall Specific
- Diesel- electric locomotives
- Weight reduction
- Low friction bearing technology
- Computer directed operations
- Improved load factors
- Improved railway junctions
- Flange lubricators
- Mechanized/automated yards

SOURCE: Office of Technology Assessment, 1993.

Infrastructure, operations, and training also have the potential to save energy. Specific options include:

- improved design of roads, rails, river locks, airports, servicing facilities, filling stations, etc;
- computer controlled transport management systems where appropriate (stop light timing/traffic control systems, train scheduling and operation, freight distribution);
- improved mechanized freight loading; and
- additional training of individuals responsible for the maintenance of various aspects of the transportation sector, e.g. those responsible for individual vehicle maintenance or traffic control.

Western companies have established several ventures that could result in rapid diffusion of applicable technologies. Examples include Pratt and Whitney commercial engine/airframe venture with Russia's Ilyushin Design Bureau; Volkswagen's investment in former Czechoslovakia's auto maker Skoda ($6 billion); Fiat's manufacturing facilities in Russia and Poland, and its sales networks in Hungary and the former CSFR; GM's efforts to initiate joint ventures in Eastern Europe; and Citibank's financing of Germany's Hochtief to renovate Poland's Warsaw Okecie Airport ($200 million).

THE ROLE OF CEE GOVERNMENT POLICIES

The actual diffusion of technologies to improve efficiency will most likely result from increased international business. Thus it is the responsibility of the host nation to provide an environment that is conducive to private international enterprise and yet synergistic with regard to its domestic agenda. This includes providing a stable government, lowering trade barriers, establishing a reliable banking infrastructure, establishing a legal system that can provide foreign companies recourse and intellectual property protection, examining its rules regarding the repatriation of profits, and limiting restrictive technology import policies such as tariffs, quantitative restrictions, and licensing of imported technologies. It is essential that a nation's efforts be reflected in both law and in implementation of that law.

A host nation can also improve the efficiency of its transportation sector by implementing policies that encourage and reward energy efficient technologies and behavior. This might include policies that encourage:

- Land-use planning to better match residences with jobs, schools, shopping, and transport corridors.
- Truer pricing of fuel.
- Fuel efficiency standards for automobiles (similar to U.S. CAFE standards).
- Pricing of transport services to optimize modal distribution (and reflect land costs, road costs, parking, pollution, etc.).
- Retiring automobiles that are past their designed service life, (By one estimate 30 to 40 percent of the motor vehicle fleet in Russia qualifies as past its prime. Replacement of these vehicles with newer designed automobiles could save 10 to 15 percent of the fuel consumed by road transport.[83])
- Targeted research and development to improve the efficiency of the transportation sector.
- Assistance to domestic manufacturers to improve the design and manufacture of more energy efficient vehicles.

The Role of the United States

Opportunities to improve energy efficiency within the transportation sector include many that can be accomplished with commercially available technologies used widely in other industrialized nations. The rapid diffusion of these technologies could yield significant energy savings. It is quite likely that the most cost effective and rapid improvements in energy efficiency will result from the transfer of commercially available technologies.

The U.S. Government can assist in the transfer of specific technologies in numerous ways, most of which require expending capital either through direct assistance or loans. These include:

1. Providing funds to foreign nations to purchase/import specific equipment, such as automobiles, that will improve efficiency directly. This will result in immediate efficiency gains, but does not address the needs of a host nation to improve its domestic skills/manufacturing. It will however improve U.S. exports.
2. Providing funds to domestic corporations for overseas investment. These funds could be used to target foreign companies that would be appropriate recipients for energy efficient technologies. Possibilities include whole or partial ownership, joint ventures, licensing agreements where a specific technology or service is leased, or franchise agreements.
3. Providing funds for improvements in infrastructure that would contribute to more energy efficient transport services. Capital or specific technologies to improve roads, airports, railroad tracks and crossings, river locks etc. are all needed. Moneys targeted for the procurement of traffic management systems for road and air travel would also improve efficiency.
4. Providing funds for improvements in communication networks, which can alleviate the actual need for some transportation. Additionally, a better communication network would allow for improved logistics such as full loading, better routing, etc.

83 RAS, he., supra note 73, p. 1.

5. Providing funds for education and training, e.g., in the area of vehicle maintenance, would also contribute to more efficient transport services. Another area to target might be airport and rail operations. Specific training facilities could be set-up in host nations, within existing corporations in host nations, or through worker/student training in this country.
6. Scrutinizing domestic technology export controls, originally implemented because of strategic reasons, to allow for technology transfer.
7. Assisting with the development of foreign regulatory and government policies such as taxes, duties, true costing, and land use in urban areas to help promote those modes of travel which are the most efficient. The U.S. could provide direct government to government assistance in formulating legislation and in drafting and implementing regulations. This might be accomplished via the exchange of policy makers.

As with any effort to transfer technology, questions regarding applicability and sustainability need to be addressed. Market based industrial technology in the West has developed in a context where consumer behavior/demand and pricing schemes are unique. Higher wages and larger disposable incomes, as well as ideas of property ownership, have shaped technological development. Some high quality or high performance technologies that make sense in the West might not be appropriate for developing economies with limited capital.

Once the market has identified and implemented applicable technologies, it is important that the government continue to maintain an environment where energy efficiency is desirable via regulation and incentive based policies. An understanding of human behavior is also essential. Identifying what motivates or inhibits consumers, e.g., financial benefits, access to previously unavailable services, or discount rates, is needed as well. It also includes understanding what motivates or inhibits a company manager to use a specific technology made available as a result of a government energy efficiency program rather than to sell the technology on the market and use the proceeds for another need.

SUMMARY AND CONCLUSIONS

In the short term, there are numerous highly profitable opportunities for efficiency improvements through low-cost retrofits of existing facilities. Examples include thermostatic radiator valves for buildings, insulation and steam traps for industrial steam systems, and basic electronic controls for district heat distribution systems. In many cases these technologies offer paybacks of 1 year or less (that is, a return on investment in excess of 100 percent). Implementing these technologies requires four components: 1) awareness of their availability and energy savings potential, 2) incentives to take the time and effort to install them, 3) hardware or the capital to buy them, and 4) knowledge of how and where to use them.

There are numerous policy options that can encourage greater use of these technologies. Trade fairs, audits, and exchange programs can build awareness and technical knowledge, and various innovative financing programs (such as risk reduction and insurance programs) can encourage private sector provision of capital and hardware. As the financial returns are relatively high for these technologies, government support and encouragement of private sector efforts, rather than direct government assistance, may be appropriate. This also has the advantage of helping to build domestic capability for producing and utilizing these technologies, and avoids longer term dependence on foreign assistance.

Consideration of capital-intensive retrofits, or investment in new facilities, is more complex. These new facilities-industrial plants, buildings, appliances, automobiles, and so on—will in the long term determine energy efficiency. Most energy-using devices (such as cars and refrigerators) currently being produced in CEE are much less efficient than those presently being produced in the United States. The U.S. units, in turn, are much less efficient than is technically feasible. Clearly there are technical opportunities for improved efficiency.

Implementing these new technologies requires careful consideration of the long-term economic health of the sector, especially in the industrial sector. There are some likely trends, however, that can guide future investment. There will probably be growth in the service sector, which will require more stores, restaurants, and offices. Increasing consumer incomes will lead to increased demand for private automobiles, consumer appliances, and single-family housing. Some argue that the present system has excess capacity for heavy industry such as steel and ship-building,[84] suggesting that these industries will shrink.

Two key points should be considered when contemplating policy options to promote longer term investments in energy efficiency. First, investments in new industrial facilities and buildings will depend on expectations of future demand, availability of capital, and the overall economic climate; and not on energy considerations. Energy is typically a small fraction of total operating costs in both industry and buildings, and therefore is usually not a primary consideration when making investment decisions. Nevertheless, new equipment usually is more energy efficient than old equipment, especially in industry. The policy relevance is that efficiency will be well served by overall economic development. The second and related point is that U.S. experiences show that energy efficiency often lags what appears to be economically justified due to a separation between buyers and operators, environmental externalities, information and transaction costs, and other reasons.[85] That is, market forces and economic development alone will not lead to optimal levels of energy efficiency, and policy intervention may be needed.

84 See for example J. Sachs, "Building a Market Economy in Poland," *Scientific American, March* 1992.

85 For a discussion of these issues in the buildings sector see U.S. Congress, Office of Technology Assessment, Building *Energy Efficiency*, OTA-E-518 (Washington, DC: U.S. Government Printing Office, May 1992).