PN-ACC-206
96959

POLAND'S INSULATION MARKET

Potential Demand
Business Opportunities
Policy Recommendations

Presented to:
U.S. Agency for International Development

Contract No. EUR-0028-C-00-2031-00

Prepared by:
ICF Kaiser International

June 1995

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EXECUTIVE SUMMARY

The insulation market in Poland has changed significantly in recent years in response to the privatization of the economy and the tightening of the thermal conductivity standards in the building code. In 1993 the overall market was 32,000 metric tonnes of polystyrene foam, 160,000 metric tonnes of rock wool, and 3,000 metric tonnes of fiber glass. Valued at world (U.S.) prices, the market size was 94 million U.S. dollars.

Almost 80 percent of the current insulation demand is met through the use of expanded polystyrene foam, which is the lowest cost insulation currently available in Poland. The polystyrene foam business is very competitive with 160 Polish suppliers and prices at world market levels. Rockwool and fiber glass production is less competitive with few manufacturers, and domestic prices for these fibers exceed world market price levels.

In 1993 about 94 percent of building insulation demand was associated with new construction, while 6 percent was associated with the government's building retrofit program. While privatization has caused a decline in building construction that has reduced demand for insulation, stricter building codes and higher energy prices will lead to an increase in demand once the economy has adjusted to privatization.

As virtually all new construction in Poland utilizes masonry walls, insulation demand is predominantly for insulation board. New building thermal conductivity standards often are met by installing 6-7 cm of board between a masonry wall and a brick facing. These standards are virtually identical to U.S. standards for masonry construction in similar climatic conditions, which suggests that the potential to economically increase insulation use in new buildings may be limited.

In contrast, most existing buildings are very poorly weatherized and insulated, with energy consumption per square meter up to double the U.S. average in comparable climates. Studies carried out through the U.S.-sponsored Krakow Demonstration Project indicate that weatherization and the installation of blown-in attic insulation are financially attractive and should be promoted. These energy conservation investments are applicable to residential, public, commercial, and industrial buildings.

The total potential for blown-in insulation in existing buildings is equal to 30-50 percent of annual insulation demand. At a realistic market penetration rate for this new application, however, the annual potential for incremental sales is only 2-5 percent of current market demand, which is well within the industry's current production capacity.

The principal institutional barriers to the adoption of the weatherization and blown-in insulation are 1) the lack of energy metering in Poland, 2) the lack of knowledge about the technical and financial benefits of energy conservation investments, 3) lack of financing for these investments, and 4) a lack of trained installation crews that can weatherize and install blown-in attic insulation correctly and efficiently.

INTRODUCTION

Poland is moving rapidly toward a market economy, and the construction and insulation industries are transforming in this process. Nevertheless, the existing building stock is not energy-efficient and exists in an institutional environment that does not facilitate the addition of optimal amounts of insulation. Consequently, government action to encourage the energy conservation investments in existing buildings may be appropriate in the near term.

Poland uses more energy to heat building space (per square meter) than OECD countries with similar weather patterns. This higher energy use is due in part to a lack of adequate building heating controls and the high level of air infiltration through the exterior walls, but a significant amount occurs simply because Polish buildings are underinsulated. Because Poland relies on coal combustion with limited environmental controls for 75 percent of its energy requirements, high heat losses from buildings relate very directly to environmental degradation.

The U.S. Agency for International Development (USAID) and the U.S. Department of Energy are promoting energy conservation in Poland as part of a strategy to reduce environmental pollution and the cost of energy-related services. In Krakow the U.S. Department of Energy has carried out a demonstration program related to reducing emissions from coal-fired boilers that includes building conservation components. Across Poland USAID is carrying out an extensive program of technical assistance related to energy conservation in numerous applications.

Given the relatively limited use of insulation in Poland historically, USAID commissioned this study to 1) analyze the current insulation market in Poland, 2) identify potential business opportunities for local and foreign firms, 3) identify institutional obstacles to the installation of optimal amounts of insulation, and 4) recommend policy changes to improve insulation use.

This report is organized to address these study requirements. Chapter I describes briefly the current insulation market in Poland. Chapter II addresses the potential for increased use of insulation consistent with insulation economics. Chapter III identifies some business opportunities for business activity. Chapter IV identifies the institutional obstacles slowing the increased use of insulation and provides some very specific recommendations to overcome these obstacles. The Appendix provides detailed information about Polish building code thermal conductivity standards.

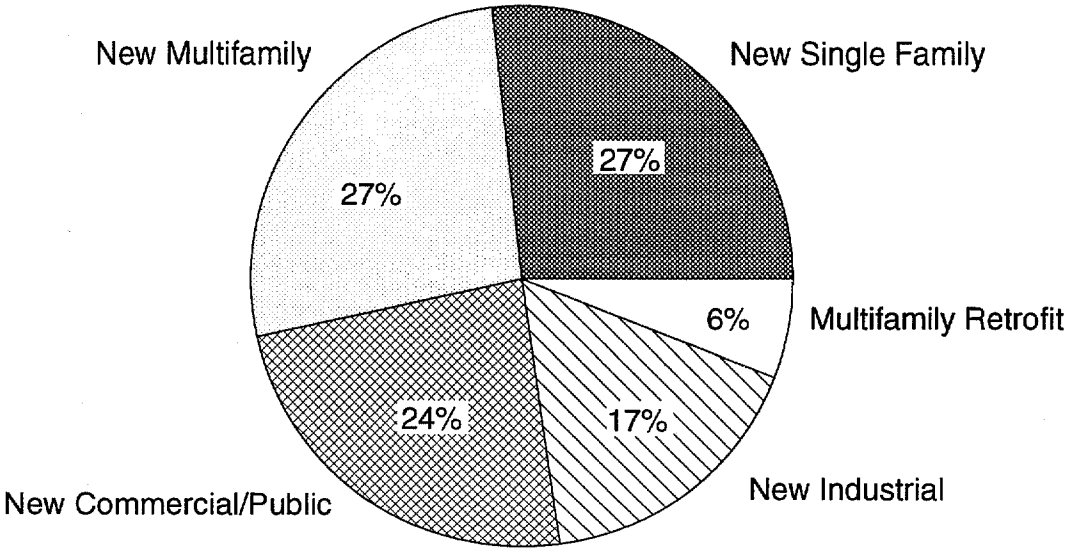
CHAPTER I
CURRENT INSULATION MARKET IN POLAND

The current Polish insulation market consists principally of the demand for rigid insulating board in buildings. Poland relies almost exclusively on masonry construction for all types of buildings, and insulation board is used between the structural concrete walls and a face brick or masonry layer to reduce heat losses. The current building code essentially has standardized the use of 6-7 cm of this board in walls and 12-14 cm in roofs. While either rockwool or polystyrene (foam) board can be used, expanded polystyrene is cheaper and much lighter than rockwool.

ICF Resources has estimated the size of the various components of the Polish insulation market based on construction statistics, the amount of insulation required in each new building, the size of the insulation retrofit subsidy program, and discussions with insulation manufacturers. These results are summarized in Figure 1.

New building construction is the principal market for insulation materials, with residential buildings the largest single market. Retrofit applications appear to be a small component of the market, supported almost exclusively by the government's limited, but very large subsidy for the installation of exterior insulation on existing, uninsulated apartment buildings.

Figure 1
Building Insulation Market in Poland in 1992



Source: ICF Resources

Insulation Prices

Insulation prices in Poland vary considerably between manufacturers/distributors. Figure 2 shows representative prices for polystyrene foam, rockwool, and fiber glass in Poland and in the U.S. in mid-

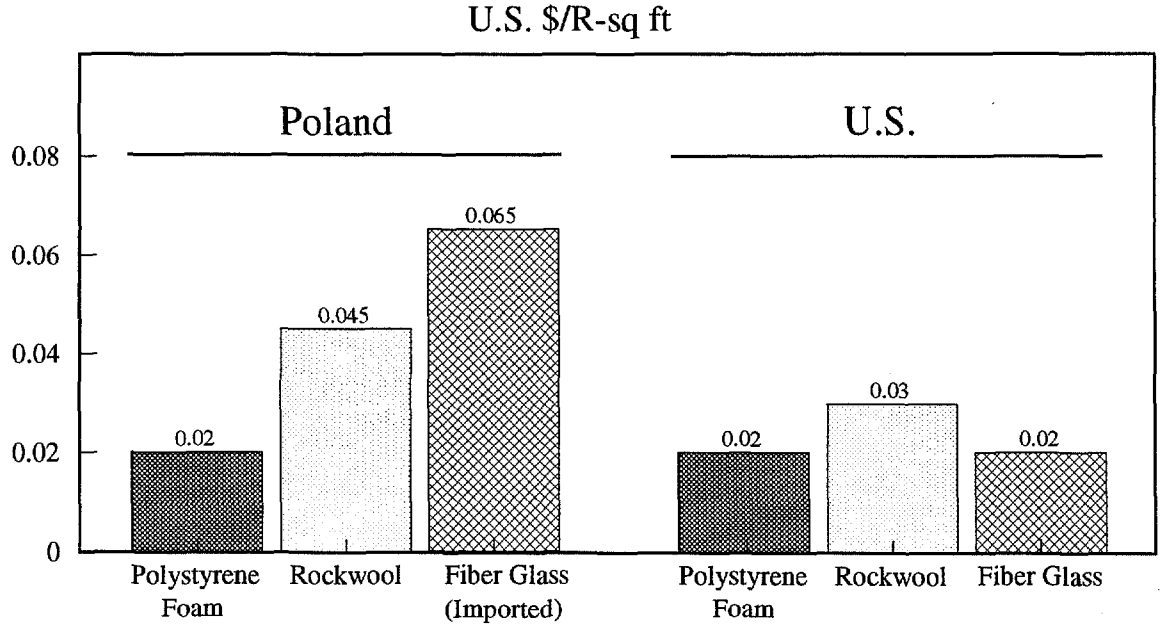
1994. U.S. prices are shown to indicate what prices can be with large scale, very efficient, competitive manufacturing facilities.

Expanded polystyrene foam manufacturing is clearly very competitive. It is the lowest cost insulation in Poland, and it costs roughly the same there as in the U.S. Rockwool (board) costs over twice as much as polystyrene foam in Poland on an insulation-equivalent basis. Rockwool costs 50 percent more in Poland than in the U.S., indicating that the Polish rockwool industry is not particularly efficient.

Fiber glass in the form of batts or loose fiber for blowing is competitive with polystyrene foam on an insulation-equivalent basis in the U.S., where it has significant market share. In Poland, where frame construction is uncommon, there is not a large enough market to support a world class fiber glass manufacturing plant. As a result, fiber glass is used little in Poland, domestic production is limited, and good quality, imported product is expensive.

Given the relative costs of polystyrene foam and rockwool board, rockwool market share seems likely to shrink over time. Polystyrene foam does have the disadvantage that it is flammable, which precludes its use in certain applications in Poland where safety is deemed of high importance (e.g., schools and hospitals). These applications, however, are a small portion of total demand.

Figure 2
Representative Mid-1994 Insulation Prices



Source: Robert Anderson & Associates

Insulation Supply

Rockwool[1)] is the traditional insulating material used in Eastern Europe, and this heavy material still accounts for the largest portion of the market on a tonnage basis. In recent years, however, as Poland has increased the level of insulation required in new structures, production of expanded polystyrene foam has increased to meet the growing demand. As shown in Table 1, polystyrene foam is by far the most important insulating product in terms of market share, with almost 80 percent of the market in 1993. Fiber glass is produced in Poland, but it has an insignificant share of the Polish market. Valued at world (U.S.) prices, the market for insulation in 1993 was 94 million U.S. dollars.

Table 1
Insulation Produced in Poland in 1993

Type	Production (Metric Tonnes)	Insulation Equivalent (R-value-sq.ft.)	Market Share (percent)	Insulation Equivalent (Cm-sq.m)
Expanded Polystyrene (foam)	32,000	3.39 billion	79	200 million
Rockwool (loose/board)	160,000	0.85 billion	20	50 million
Fiber glass (batts/board)	3,000	0.03 billion	1	2 million
Total	195,000	4.27 billion	na	252 million

Source: Robert Anderson & Associates

Information on insulation production capacity is available for the rockwool and fiberglass manufacturers, because they are few in number and were formerly state companies. Polystyrene foam, in contrast, is produced by 160 state and private manufacturers. The available data on 1993 capacity and capacity utilization are shown in Table 2.

There are currently four significant rockwool manufacturers:

- Danish Rockwool (formerly Cigacice)
- Izopol Trzemeszno
- Polinowa Ltd.
- Nidzica

Additionally, Izolacja Ogrodzieniec has a rockwool production line that is 95 percent complete, and Malkinia has a plant with four production lines that is 95 percent complete. Completion of these facilities would add about 80,000 metric tonnes per year to the industry's production capacity. Neither company has made any progress towards completion of these facilities for several years.

1) Rockwool is a glassy, fibrous material made by melting naturally-occurring rock (usually basalt) or smelting slags (usually iron) and spinning the molten material into fibers in a high velocity air stream. Rockwool is a very heavy fiber that tends to settle when used in low-density (non-board) applications.

The marketing and distribution activity of the principal rockwool manufacturers varies considerably. Danish Rockwool is aggressively marketing its product and now has the largest rockwool market share. Polinova is also active, particularly in the Silesia region.

Matizol is the only Polish fiberglass manufacturer with one small plant. Gullfiber, a Swedish manufacturer, is importing its fiberglass and successfully marketing it. The lowest-price fiberglass available in Poland is produced by Therwoolin in Hungary and imported.

Table 2
Insulation Manufacturing Capacity and Utilization

Insulation Type	Manufacturing Capacity (metric tonnes)	1993 Production (metric tonnes)	Utilization (percent)
Rockwool	195,000 (275,000)*	160,000	82 (58)*
Fiber glass	3,000	3,000	100
Polystyrene foam	unknown	32,000	unknown

* Including capacity under construction that is 95 percent complete.

Source: Andrzej Czyz, AJC Consulting

Future Insulation Market Outlook

The future demand for insulation will continue to be concentrated in new buildings, principally in the residential and commercial sectors. In the Communist system the commercial sector was small, with annual building construction rates about the same as the industrial sector. Looking ahead, the commercial sector will be growing, but it will remain considerably smaller than the residential sector.

Projections of future rates of construction in Poland are highly speculative at this time, given the transitional state of the economy. Figure 3 shows the official statistics on new building construction for the 1981-92 period. Although official statistics are not yet available, new building construction activity appears to have declined further in 1993.

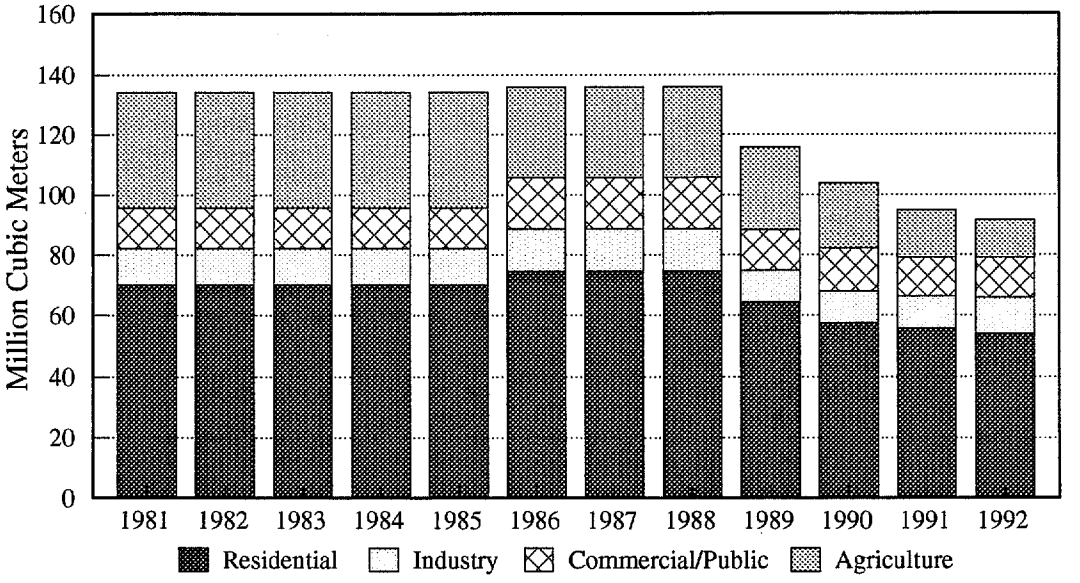
The housing market currently is in a revolutionary transition. Most Poles live in apartments and are shareholders of the cooperative which owns their apartment building. In conjunction with the privatization of the economy, the value of an apartment has appreciated almost to Western levels, while workers' salaries have remained very low. The price of an apartment is now about ten times a Polish worker's annual income, so workers not already in an apartment cannot afford to obtain one. As a result, construction of new apartments has declined significantly and is still falling. Eventually, workers' salaries will rise to a level more consistent with market housing costs, but this transition will take considerable time. New housing construction is likely to remain depressed over the near-term, with the emphasis on houses for successful entrepreneurs in the growing private sector.

Since the commercial sector was small under Communism, the commercial/public sector will expand very significantly from about 20 percent of residential space today to 30-40 percent in the future. Poland clearly will construct a lot of commercial space as it transitions to a private, market economy. In

the near-term, however, increased construction of commercial space will be offset by reduced construction of public facilities.

The industrial sector outlook is less clear. The sector has adequate building space, but much of it is in antiquated facilities. Foreign companies are building new structures for their greenfield operations, but the amount of this kind of investment is quite limited so far.

Figure 3
1981-1992 Building Construction in Poland



Source: Polish Government Statistics

Absent changes in building codes or a significant expansion of the insulation retrofit market, insulation demand will remain low over the next few years, in line with the rate of new building construction. Given this stable near-term projection of demand, there does not seem to be any immediate need for new investment in insulation board production.

There is growing interest in using blown-in fiber glass or rockwool insulation to insulate attics in existing commercial and residential structures. This insulating technique is new to Poland, and the market is very small currently, but it should grow and become significant.

If demand for insulation board or fiber increases, the two partially-constructed rockwool production facilities could be completed and incremental polystyrene foam production capacity could be installed very quickly. Longer term there will be a need for incremental fiber glass production capacity to insulate attics in existing buildings and to provide batts as construction design moves more toward wood or steel frame construction.

CHAPTER II
POTENTIAL FOR INCREASED USE OF INSULATION

Insulation, in conjunction with proper facility design, is used principally to improve living and industrial operating environments and to conserve energy. Accordingly, the economically optimal use of insulation depends on climate, factory operating conditions, and energy costs. Over time architects and engineers in the West have developed technologies and building designs that use insulation at a level that is appropriate for conditions and expected energy costs over the expected life of industrial facilities and building structures.

From both a technical and economic standpoint, the potential for greater use of insulation is different before and after a building has been constructed. Accordingly, this chapter examines the new and existing components of the building insulation market separately. The only other significant component of the Polish insulation market is steam and hot water pipe requirements. The potential insulation demand for pipe applications has not been examined in this study.[2)]

Economics of More Stringent Insulation Requirements in New Buildings

Although in theory a competitive market should ensure the installation of an optimal amount of insulation, in practice the economies of scale associated with standardization has led to the adoption of building codes and material standards. The process of specifying building material characteristics is both economic and political in nature. Once the debate enters the political arena, a variety of factors may be taken into account in setting standards, including environmental considerations, the desire to reduce energy dependence, and the interests of members of the construction and construction materials industries.

Poland has recently made its insulation requirements more stringent in new buildings, essentially adopting the German requirements. The current Polish building code requirements are summarized in the Appendix. For commercial and apartment buildings of masonry construction, the thermal conductivity standard can be met with 6-7 cm of polystyrene foam or rockwool board, which fits easily between the concrete support structure and the masonry facing, as shown in Figure 4.

The economics of increased insulation use depends on the (material and labor) cost of installing incremental insulation, the amount of energy saved, the cost of energy, and the financing cost. Adding wall and ceiling insulation in buildings is subject to decreasing returns. Doubling the amount of insulation cuts in half the rate of heat transfer, which means that each incremental unit of insulation saves less energy.

ICF Resources has not carried out a study of the economics of increasing wall or roof insulation in Poland, but such studies have been carried out in the U.S., in conjunction with the adoption of

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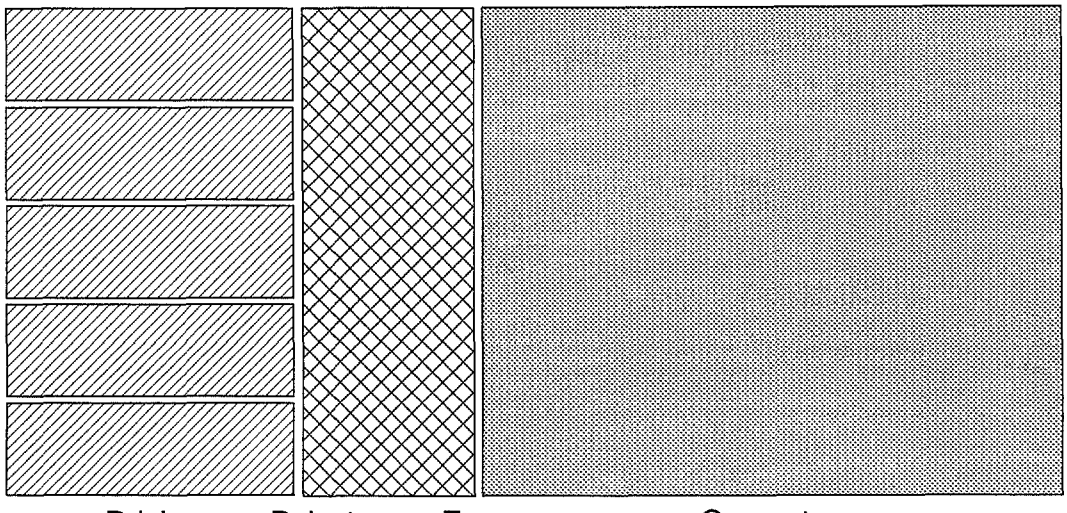
2) 28,000 km of district heating distribution pipe may be replaced with pre-insulated pipe over the next 10-20 years. Although various kinds of insulation could be used, currently polyurethane foam is considered to be the most appropriate material for this application because it protects the pipe from exterior corrosion.

ASHRAE (American Society of Heating, Refrigeration, and Air Conditioning Engineers) standards for buildings. These standards for parts of the U.S. with weather similar to Poland provide some insight into the adequacy of the Polish standards.

Figure 4
Masonry Building Wall Design in Poland



The national masonry standard in the U.S. allows cavity widths between support walls and masonry veneers of up to 11.4 cm (4.5 inches).[3)] If insulation board is used in this space, 2.5 cm (1.0 inch) of air space is recommended to provide drainage in the event water enters the wall. This means that 8.9 cm (3.5 inches) of polystyrene foam could be used while still meeting the U.S. national masonry standard. This simple analysis indicates that the 6-7 cm of insulation board required to meet the current Polish thermal conductivity standard for walls could be increased to 9 cm without requiring significant changes in building structural design. Some buildings in Poland are already constructed with up to 10 cm of insulation board in wall cavities, so this change seems quite feasible.

The Chicago area of the U.S. has approximately the same winter weather as Warsaw, Poland. Material, labor, and fuel costs are different there than in Poland, and Chicago buildings are designed to optimize heating and cooling economics, while Poland generally has only heating. Nevertheless, ASHRAE minimum standards for the Chicago area provide an indication of the approximate level of insulation that might be appropriate for Poland. The ASHRAE minimum external wall insulation standard for commercial and high-rise residential masonry construction in the Chicago area is an R-value of 9 to

3) National Concrete Masonry Association, "R-Values of Multi-Wythe Concrete Masonry Walls," NCMA-TEK 6-1, 1993, P. 1

10, depending on window area,[4] which corresponds to 6-7 cm of insulation board. The roof requirement is R-19,[5] which corresponds to 12-14 cm of insulation board.

This quick review indicates that the current Polish minimum insulation standards for new building construction are essentially identical to the U.S. standards for high-rise buildings of masonry construction in areas with climates like Poland's. While this finding is not definitive, it indicates that although there is some technical potential, the potential to economically increase the amount of insulation in new Polish buildings of masonry construction may be quite limited.

The economics of building insulation depends heavily on the type of construction used for the building. U.S. thermal conductivity standards for buildings with wood or steel frame construction are stricter than for masonry construction in both walls and roofs. Poland should consider a stricter standard for these kinds of building structures, which are likely to become more prevalent over time.

Potential for "Reinsulation" of Existing Structures

Although Polish and Western building codes are now similar, this is a recent development. In addition, the U.S. and Western Europe promoted "reinsulation" of older, existing buildings during the 1970s and 1980s. The net effect is that existing U.S. and Western European buildings are much better insulated than buildings in Poland.

Almost all of the existing buildings in Poland are based on standard Eastern Bloc designs for masonry construction. Many of these buildings have no wall insulation at all, since the current practice of using insulation board between the poured concrete slab and a face brick or masonry surface only began in 1974. Figure 5 shows the change in insulation standards in Poland over the last 30 years. The standards indicate that all buildings constructed since 1974 should have at least some insulation, but these standards were not enforced on a consistent basis. When insulation was not available, buildings were constructed without it. As a consequence, not all buildings have the insulation they should have.

ICF Resources could not find complete statistics on the size and condition of the existing building stock in Poland. Most of the space is in residential structures, which includes both apartment buildings and single family homes. According to Polish government statistics, there are about 11.6 million residential units in Poland, including 7.3 million apartments in multi-unit buildings and 4.3 individual homes. Of these individual homes, most are stand-alone units, while perhaps 20 percent (0.8 million) are "town houses" with common walls in urban areas. Almost all of these units are constructed with masonry walls, including the individual homes. Roofs are sloping concrete or wood-beamed over a small attic, with roof coverings composed of a variety of materials.

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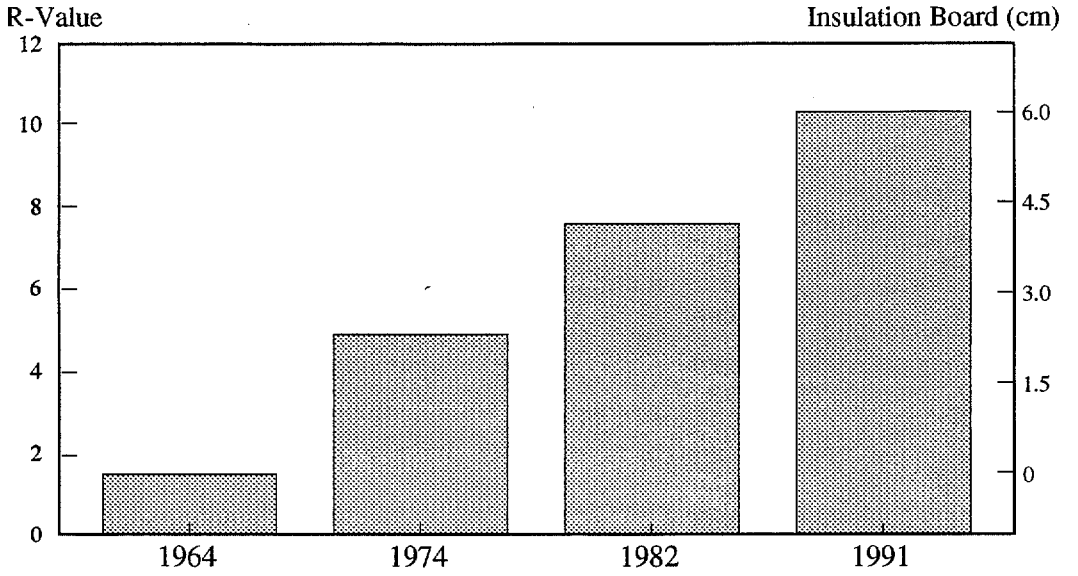
4) American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. and Illuminating Engineering Society of North America, *ASHRAE/IES Standard 90.1-1989, Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings*, 1989, Table 8A-26, P. 60

5) Ibid

Figure 5
Wall Insulation Required in New Polish Multi-family Masonry Buildings



Source: Andrzej Czyz

Individual apartments contain on average about 40 sq. meters of private heated space, or about 50 sq. meters including their share of public space within the building. Single family homes are much larger, averaging about 100 sq. meters of heated space. Overall this leads to 365 million sq. meters of heated space in apartment buildings and 430 million sq. meters of heated space in homes.

ICF Resources could not discover any statistics on existing commercial/public sector or industrial building space. Based on building construction statistics for the 1980s, however, these sectors each appear to have about 20 percent as much floor space as the residential sector, or perhaps 160 million sq. meters each. Figure 6 shows the estimated existing building space in the various sectors.

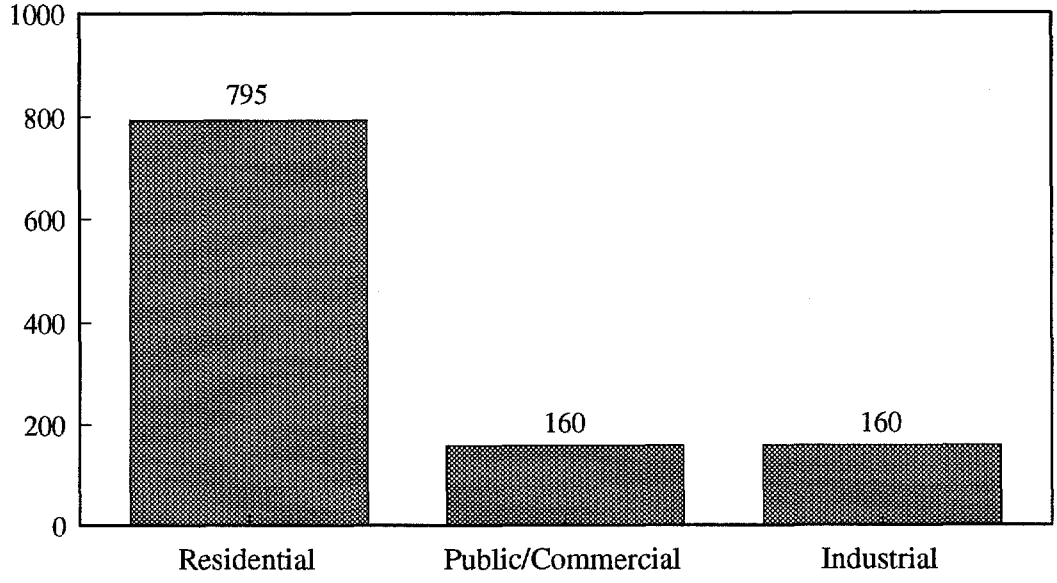
The condition of these buildings is not known with any degree of certainty. A simple extrapolation based on the 1980-92 construction data suggests that less than half of the existing apartments have been constructed since 1974, so there should be a lot of buildings without any insulation. A significant number of apartment buildings have been retrofit through the government's subsidy program for exterior insulation, but Polish officials believe that 10 percent of the apartment buildings are still in very poor condition, with serious interior moisture condensation and mold problems due to a complete lack of insulation in the masonry wall cavities. Relative to current Polish building standards, most buildings in Poland are underinsulated.

Energy Use in Existing, Uninsulated Buildings

Electrotek Concepts has carried out a building conservation demonstration project in Krakow, Poland under the direction of the U.S. Department of Energy. As part of this project, Electrotek Concepts 1) measured energy use in four existing, uninsulated apartment buildings, 2) installed a variety of energy-conserving technologies in the buildings, and 3) measured energy use again. The results of this

demonstration can be used to estimate the economic and financial feasibility of investments in these technologies.

Figure 6
Estimated Existing Building Space in Poland
(Million square meters)



Source: ICF Resources

The four buildings selected for the demonstration are centrally heated with hot water supplied through a district heating network. Prior to the demonstration many of the apartments were often cold and drafty, due to the uncaulked gaps between the window and door frames and the walls and to the lack of adequate temperature regulation. While an effort was being made to balance the flow of hot water to maintain proper temperatures in the apartments, there were no thermostats in the buildings. Cold areas often remained cold on cold days, and the tenants cooled overheated areas by opening the windows.

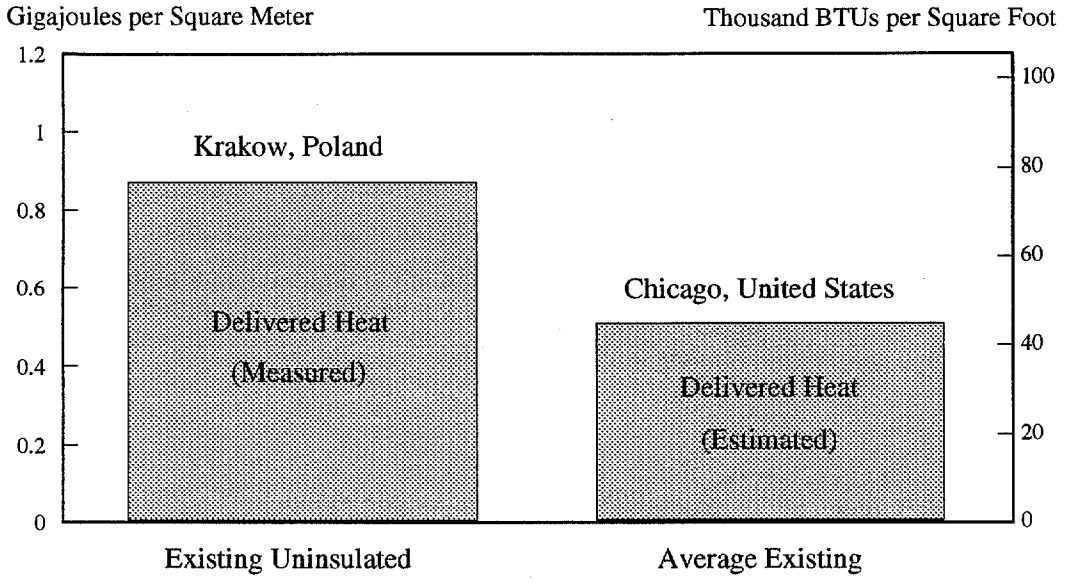
Heat was being provided to the buildings based in part on engineering estimates of heat requirements based on prior day forecasts of outside weather conditions. Actual heat consumption was not measured. As is the normal practice in Poland, apartment dwellers were being charged for heat based on the measured space in their apartment and the national district heating tariff. Consequently, to begin the demonstration Electrotek Concepts had to install heat meters in each building.

Figure 7 shows the estimated annual energy use/square meter for space heating in these apartment building in Poland and in multi-unit buildings in the U.S. Midwest, which has a climate similar to Poland (Warsaw and Chicago have almost identical winter temperature profiles.). The Polish energy consumption estimates are based on the measured heat delivered to the Krakow apartment buildings. The energy actually consumed depends on the heating system employed, which in most cases (perhaps 80 percent) is district heat. This heat may be produced in coal boilers or in combined heat and power (CHP) plants.

The U.S. energy consumption estimates are derived from U.S. government statistics collected in surveys of owners of existing, multi-unit, gas-heated buildings in 1990.[6] The energy consumption estimates implicitly include the waste heat from the gas boilers or furnaces used to heat the buildings. ICF Resources estimates that these boilers have average annual conversion efficiencies of 70 percent, so the delivered heat was estimated to be 70 percent of gas consumption.

The Polish and U.S. figures are not strictly comparable. The U.S. estimates are averages of all U.S. buildings. The Polish estimates are above the average for all Polish buildings since the buildings measured were uninsulated, while a significant share, perhaps 50 percent, of Polish buildings have some insulation. Nevertheless, these figures indicate that Poland uses up to twice as much energy to provide space heat to existing apartment buildings as does the U.S. in comparable climates.

Figure 7
Energy Use in Multi-Unit Apartment Buildings



Source: Electrotek Concepts/ICF Resources

Potential to Retrofit Insulation in Existing Buildings

Although most Polish apartment buildings are clearly underinsulated, this does not mean that the installation of additional insulation is necessarily feasible or economic. Once buildings are constructed, the feasible retrofit options are limited.

In the Krakow Demonstration Project, Electrotek Concepts examined the effectiveness of several insulation retrofit options, some of which were combined with weatherization and building heating controls. Weatherization included caulking of window and door frames, the sealing of cracks and gaps in walls and in basements, weatherstripping, and the installation of door sweeps and thresholds. The heat

6) EIA, *Housing Characteristics 1990*, May 1992, pp. 38-60; and EIA, *Household Energy Consumption and Expenditures 1990, Regional Supplement*, February 1993, pp. 96-141.

management controls included heat meters, heat exchangers, and outside air temperature reset controls in each building, and thermostatic control valves on each radiator in all apartments. The insulation options included:

- Exterior (wall) polystyrene foam insulation
- Blown-in fiber glass attic insulation
- Blown-in fiber glass basement ceiling insulation

Exterior polystyrene foam insulation is the standard retrofit option currently used in Poland. The use of blown-in fiber glass is common in the U.S., but it is not widely known in Poland, and neither the installation equipment nor high quality fiber glass are currently produced in the country. Rockwool fiber is produced domestically, but it is so much heavier than fiber glass that it cannot be blown into attics of apartment buildings over four stories tall using ground-level equipment. The attachment of insulation to the interior walls inside the apartments is technically feasible but was not attempted because it reduces the interior space available in the apartments and because of the interior wall moisture problems in some buildings.

Although numerous conservation options were demonstrated in the Krakow Demonstration Project, test data are not available for all of the options and combinations of options. The annual savings shown in Table 3 are based on the results of the Project, but in some cases they are estimated rather than measured individually. Even the tested measures provide only approximate results, since results depend on continued maintenance and proper rebalancing of heat loads after certain actions have been taken. Results for the same measures varied between buildings and between years (two years of data were collected for some options). A review of the estimated results reveals the following:

- Exterior insulation (after weatherization) can save about 10 percent of total energy use.

- Weatherization alone saves 7.5 percent of total energy use.

- Blown-in attic insulation provides significant savings, but not as much as the other options.

- Implementation of all the identified building shell conservation options could reduce energy use by 20 percent.

No results are shown for basement ceiling insulation, which did not produce any measurable savings.

Economics of Building Conservation Retrofit Options

Based on the energy savings results shown above, weatherization, exterior polystyrene foam installation, and blown-in attic insulation all appear to offer significant potential as building conservation retrofit options. The economics of the various options depends on the cost of installation, the expected life of the investment, and the cost of energy. The capital cost and annual energy savings cannot be used alone to evaluate their relative attractiveness because the expected life associated with each option is quite different. Some weatherization measures (e.g., caulk) may not last many years. Absent a more comprehensive study, the estimates of financial feasibility shown here should be considered approximate.

Table 4 shows the cost and performance data used and the results of the analysis of the three building retrofit options. The information about the capital cost, life, and energy savings was provided by Electrotek Concepts. Maintenance costs were not included since they are small and have not been estimated in the Demonstration Project.

Table 3
Estimated Annual Heat Savings from Conservation Investments in Uninsulated 66-Unit, 11-Story Apartment Buildings in Poland

Conservation Investment Option	Energy Saved (Gigajoules Per Apartment*)	Energy Saved (Percent of Baseline)
Weatherization**	3.75	7.5
Exterior Insulation (All Walls)**	5.0***	10.0***
Fiberglass Blown Into Attic**	1.25	2.5

* Apartments have 48 square meters of heated private space and 58 sq. meters including its share of heated public space. Baseline delivered heat is 50 gigajoules per apartment per year (implicitly for 58 square meters of space). Energy saved for attic insulation is averaged over all apartments in the building, but actual savings are 11 times greater in top floor apartments.
** Rebalancing of heat flow within the building is required after installation of this option to obtain these savings.
*** Incremental to weatherization alone.

Source: Electrotek Concepts

Table 4
Economics of 11-Story Building Retrofit Options (per Apartment)

Option	Capital Cost (USD)	Expected Life (Years)	Heat Savings (GJ/yr)	Heat Savings* (USD/yr)	Payback** (Years)	Return on Invest (%)
1. Weatherization	$45	10	3.75	$18.75	2.4	40
2. Exterior Insulation	$1352	25	5.0	$25.00	54.1	(5)
3. Attic Insulation	$37	40	1.25	$ 6.25	5.9	17

* Based on estimated delivered heat cost of $5.00/GJ
** Years of savings required to repay the investment (not including the interest that also must be paid).

Source: Electrotek Concepts

The energy cost savings shown are (conservatively) about equal to the current average price of delivered heat in Krakow. This price is less than the long run full cost of heat delivered through a fully-amortized system, but Electrotek Concepts believes that it is enough to cover the costs of operating and

maintaining the existing district heating systems and paying fuel costs/waste heat prices set equal to the coal price. Given that some proportion of the full cost of delivered heat is the fixed distribution cost (i.e. distribution pipes and administration), $5.00/GJ is a reasonable estimate of the true cost savings from heat conservation.[7]

A review of the table indicates the following:

- Weatherization and blown-in attic insulation are extremely cost-effective with an ROI (return on investment) of 40 percent and 17 percent, respectively

- Exterior insulation is a very poor investment from an energy conservation standpoint. It cost 36 times as much as attic insulation installed and only provided four times the savings. The energy savings alone cannot justify the insulation investment, so it must be justified based on improvements in living conditions, or as part of a renovation or repair of the building that is undertaken for other reasons.

Based on the Krakow Demonstration Project results, the viable retrofit market for insulation is blown-in attic insulation. Rockwool or fiber glass can be used in buildings under five stories, but only fiber glass in taller buildings, due to the difficulty of blowing heavy rockwool fibers long distances. Although the particular configuration of the building does not affect the financial return of the attic insulation investment, it does affect the amount of energy saved and the total cost of installing attic insulation. Table 5 shows the installation cost and annual energy savings and cost of attic insulation for two different buildings, each with 66 apartments.

Table 5
Energy Savings and Investment Cost of Attic Insulation
(Buildings with 66 Apartments)

Building Height	Capital Cost* (USD)	Heat Savings (GJ/yr)	Heat Savings** (USD/yr)	Return on Invest (%)
11-story	$2,500	82.5	$413	17
6-story	$4,600	151.3	$757	17

* Based on estimated installation costs of $7 USD/sq. meter and 58 sq. meters of private and public space per apartment.
** Based on estimated delivered heat cost of $5 USD/GJ.

Source: Electrotek Concepts

7) An alternative estimate of the values of heat cost savings can be based on the long run cost of gas delivered to an apartment building gas boiler. ICF Resources projects that gas supplied to Poland and delivered to a building will cost about $4.50/GJ. If the fixed cost of distribution is $0.50/GJ, then conservation saves $4.00/GJ. In a boiler with 80 percent efficiency, the value of heat saved would be $5.00/GJ.

Potential Demand for Blown-in Insulation

Although the Krakow Demonstration Project included only apartment buildings, the project results are also relevant for single family homes and public sector/commercial/industrial structures. Houses heating with low-cost coal will not find attic insulation a financially attractive investment, but for those houses heating with natural gas or district heat, attic insulation is an attractive option. Weatherization and blown-in attic insulation should also be a good investment for these structures.

Although a more detailed study should be carried out to estimate the potential demand for blown-in insulation in single-family homes, Table 6 provides a very preliminary estimate based on some crude assumptions about building height by building type and the share of existing buildings for which blown-in insulation might be appropriate. This estimate indicates that the total amount of blown-in insulation required is equivalent to 1.5-2.1 million metric tonnes of rock wool. As discussed earlier, fiber glass could be used in any of the structures, but rockwool can be used in the structures that are less than five stories. A review of the potential demand for insulation by category indicates that most of it is in structures that are less than five stories, so most of the demand could be met by rockwool. This total insulation requirement is about nine times current rockwool manufacturing capacity, so it represents a potential major new market for the industry.

Since fiber glass is much lighter, the insulation requirement also could be met with 330-470 thousand metric tonnes of fiber glass. At a potentially-realistic annual demand equal to 5-10 percent of the total requirement, however, the demand could not justify investment in a new, world-scale fiber glass plant.

The problem in converting this potential demand for insulation into sales is that 70 percent of the potential demand is in single family houses, and single family houses require many transactions to add up to significant sales of insulation. Given that there is little experience with blown-in insulation in Poland at the moment, the industry will require either a major marketing push, a government-sponsored promotional program, or both to turn this potential demand into sales.

Table 6
Preliminary Estimate of Potential Demand for Blown-in Insulation in Poland

Building Type	Building Space (mil sq.m.)	Attic/roof Space (mil sq.m.)	Share to Insulate (%)	Space to Insulate (mil sq.m.)	Rock Wool Insulation (M tonnes)*
Apartment Building	365	37	60-80	22-30	187-255
Single Family House	430	215	60-80	129-172	1097-1462
Public/Commercial	160	53	10-20	5-11	43-94
Industrial	160	160	10-20	16-32	136-272
Total	1,115	465	40-56	172-245	1463-2083

* Calculated for R-19 (kmax=.30), which requires 8.5 kg of rockwool fiber per square meter.

Source: ICF Resources and Robert Anderson & Associates

CHAPTER III
BUSINESS OPPORTUNITIES

The economic analysis in Chapter II indicated that two low cost building energy conservation measures potentially have an attractive return on investment. While weatherization and blown-in attic insulation appeared to pay for themselves over a very short period, the estimated cost did not include any marketing or selling costs. For a small building the overall investment is small, and an entrepreneur may find that the "transaction cost" to work out each deal may be high. Developing a marketing program that minimizes transactions cost will be critical to the development of a successful weatherization and "reinsulation" business.

Weatherization is the most financially attractive building heat management option, but it is also difficult to sell because it consists of such "low-tech" practices. The combination of weatherization and attic insulation into a package appears to be both more effective and likely to be more successful from a marketing standpoint. This combination of measures in an uninsulated structure can reduce overall energy use by 10 percent or more, which is significant from the building owner's perspective if energy is priced on a unit basis.

Given the estimate of potential demand for blown-in insulation in Chapter II, there is the potential for significant business activity related to the production of weatherization materials and blown-in insulation, the purchase of equipment, and the installation service business itself. Figure 8 shows the equipment and process used to blow insulation into attics.

Figure 8
Equipment Used to Blow Insulation Into Attics

Source: Electrotek Concepts

CHAPTER IV
INSTITUTIONAL BARRIERS AND POLICY RECOMMENDATIONS

Poland is making rapid progress in overcoming institutional barriers to more optimal use of insulation. Nevertheless, some barriers remain, which potentially could be addressed through government and non-governmental organization (NGO) programs. These barriers are related to both the demand and supply sides of energy conservation process, but the demand side is more important. If market demand for conservation develops, private entrepreneurs will eventually overcome the supply side problems.

Not all institutional barriers to conservation are equally important. The authors believe the key barriers, in their order of importance, are as follows:

- Non-metered energy pricing
- Lack of knowledge about weatherization/attic insulation benefits
- Lack of programs to finance weatherization and "reinsulation."
- Lack of trained technicians to weatherize and install insulation
- Continued slight subsidization of energy costs
- Lack of public oversight for insulation quality

Non-Metered Energy Pricing

The largest barrier to energy conservation is the common practice of billing based on estimated energy consumption rather than measured, actual consumption. Currently district heating bills are based on the area of living space supplied with heat and a national tariff, not actual supply costs and actual heat delivered. U.S. experience shows consumers have little incentive to reduce their energy consumption if it does not affect their energy bill. It will be difficult to interest consumers in energy conservation investments, such as insulation, unless they are charged for energy based on actual consumption.

Recommendation

As a matter of national policy, energy billing needs to be moved to an actual consumption basis as rapidly as possible. Energy meters should be installed wherever the installation costs are not prohibitive. Housing cooperatives utilizing district heat should make the installation of heat meters one of their priorities.

Lack of Knowledge About Weatherization/Attic Insulation Benefits

Perhaps the second greatest barrier to energy conservation is the lack of knowledge about the cost-effectiveness of the weatherization and attic insulation retrofit measures discussed in this report. Given the lack of historic experience with energy conservation and the lack of meters to document the savings, few potential customers realize that the potential for cost-effective savings is significant. Entrepreneurs can attempt to convince Housing Cooperatives and homeowners that the benefits exist, but at least at first, customers may be quite skeptical.

Recommendation

The best way to overcome the lack of knowledge about energy-saving opportunities in buildings is through government promotion of the weatherization/attic insulation options identified in this report, along with publicity about the energy savings that can be expected if these measures are properly implemented. At a minimum this report should be translated into Polish and provided to all Housing Cooperatives and District Heating Utilities in Poland.

Lack of Programs to Finance Weatherization and Reinsulation

The cost to weatherize a residential building and install attic insulation is $80-120 (USD) for an apartment and $300-600 (USD) for a single family house. Although these investments can provide a good return on investment, in the context of a country where an average worker currently makes $300/month, these investments require a financing mechanism.

Recommendation

The Ministry of Buildings should set up a weatherization/reinsulation cost-sharing revolving fund program with a 30-50 percent subsidy up to a maximum amount defined on a per apartment basis. The conservation package should be standardized to include weatherization and attic insulation only, and the guidelines for participation should be kept simple. Initially the program should be focused on apartment buildings with loans made to housing cooperatives. Meanwhile more analysis should be carried out to determine whether there is a standard cost-effective program for single family houses.

Lack of Trained Technicians to Weatherize and Install Attic Insulation

Given the lack of experience in Poland with building weatherization and blown-in attic insulation, once entrepreneurs begin to perform this work, there could be a long learning curve before consumers can be assured that they are getting the work done properly.

Recommendation

The Ministry of Buildings in conjunction with USAID could provide short training courses on building weatherization and attic reinsulation and provide a course certification program. This training program could be carried out by FEWE.

Continued Slight Subsidization of Energy Costs

Although energy prices have risen significantly in real terms, they are still somewhat below full long-run marginal costs. As a result, consumers do not see the complete financial benefits associated with energy conservation.

Recommendation

Public policy should continue to promote the implementation of long run marginal cost pricing of energy services as soon as it is socially possible.

Lack of Public Oversight of Insulation Quality

The insulation requirements for new construction are specified in the 1991 Polish Building Code in terms of permitted thermal conductance[8)] in walls, ceilings, and foundations. These limits are converted to insulation amounts using an estimate of a particular insulation's thermal conductivity per centimeter. If the effectiveness of the insulation is overestimated, then the calculated thickness of insulation required will be underestimated.

The current certification system requires that manufactures submit a sample of their insulation to the Polish Center for Testing and Certification or provide test data from recognized foreign laboratories. Once certification is received, it is valid for ten years. Unfortunately, there is no monitoring or enforcement program to ensure that material produced is consistent with the standard certified in the original sample. Purchasers who believe they have received substandard material must test it themselves and file suit to collect damages. In practice, purchasers must rely on visual inspection to ensure that material meets standards.

Rockwool manufacturers currently certify the thermal characteristics of their insulation, and these specifications are consistent with standard international standards for these materials.
There is no similar process for expanded polystyrene or fiber glass.

Robert Anderson of Robert Anderson & Associates visually inspected samples of rockwool board, styrofoam and fiberglass and concluded that the uniformity of some of these materials, particularly the expanded polystyrene and fiberglass, was clearly not up to international standards. Electrotek Concepts also found that the quality of the loose rockwool purchased for the Krakow Demonstration Project was uneven and often substandard. Some of the materials may have thermal conductance rates 10-20 percent above stated levels. While on average the additional heat loss associated with these substandard materials is not over 5 percent, over the life of the building this loss will be significant.

Recommendation

The Ministry of Building Industries has the authority to set material standards, but as of June 1994 it had not issued standards and had no capability itself to test materials for compliance with a standard. As soon as it is fiscally possible, the Ministry should issue material standards based on international practices and create a monitoring and enforcement program that can sample materials in the marketplace and levy significant fines when material quality falls below standards.

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8) Thermal conductance is the constant time rate of heat flow through unit area of a body induced by a unit temperature difference between the surfaces, Btu/(ft2.h.deg F) or W/(m2.K). It is the reciprocal of thermal resistance.

APPENDIX
POLISH BUILDING CODE THERMAL CONDUCTIVITY STANDARDS

Source: Robert Anderson & Associates

June 1994

As part of this study of the Polish building insulation market, Robert Anderson & Associates reviewed current Polish building standards and developed recommendations for bringing Polish practice up to Western levels. This Appendix summarizes this work.

Importance of Building Energy Codes in Determining Insulation Demand

Since the 1980's, Building Energy Codes have provided a large portion of the market demand for thermal insulation in the U.S., Canada, and many European countries. The Codes require minimum amounts of thermal resistance in new residential and commercial buildings and as an increasing trend for the resale of residential buildings. Originally, the Codes required minimum levels of R-value for walls, roof, foundations, etc. However, with the development of improved energy calculation methodologies, the Codes have adopted the concept of building envelope performance, that is, the total building envelope cannot exceed certain heating and cooling loads. The performance codes allow designers latitude in use of such measures as fenestration, building orientation, and use of solar heating, and adjust for different interior heat loads within buildings. The Building Energy Codes are based on life-cycle cost analyses to minimize the energy costs over the expected life of the building.

Methodologies for modeling and calculation of heating and cooling requirements of buildings have advanced rapidly and have been the basis for energy codes being "performance oriented" rather than "prescriptive" (the specification of given levels of R-value). Likewise the advancements have allowed fine-tuning, and in some areas, increasing of insulation requirements for specific climatic areas to maximize economic benefit while allowing building design flexibility.

Recent research in Western countries has identified factors that affect the performance and effectiveness of insulation materials. For example, air infiltration through insulated wall cavities and convective air currents within attic insulation under winter conditions can reduce the effectiveness (R-value) of insulation by 10-40%. The effect of air movement in fibrous insulation increases as the densities of the insulation decreases, hence the trend toward lower density fiber glass products mitigates the problem. Efforts are being made to change code requirements to reduce air infiltration through wall cavities by use of air barrier materials applied to the wall exterior. Remedial approaches for reducing convective air flow in attics under winter conditions are still under study.

Research has also shown that different insulation materials applied to a given level of thermal resistance (R-value) do not necessarily provide similar thermal performance in the field. For example, under winter conditions, a thermal resistance of R-20 of polystyrene rigid board would outperform R-20 of loose fill fiber glass. The reason being the low density fiber glass would have internal air movement which can significantly reduce the effective thermal performance. Although the differences in thermal performance of different insulation materials have been known and documented, these differences have not yet been recognized in the building energy codes.

In cold climates, moisture condensation in building insulation and other materials is a major problem. The conventional approach to this problem is proper thermal design and application of vapor barriers on interior surfaces. The application of vapor barriers is a secondary but significant cost in terms of material and installation that is often ignored in analyses of insulation cost/benefit.

Test data have shown that the thermal performance of thermal insulation can be degraded by faulty installation methods and inadequate maintenance during service. Although the mechanics of installing insulation are not difficult, quality workmanship and attention to detail is required.

Unfortunately, the quality of workmanship for installation of insulation is below standard in many cases, and once the insulation is covered with finishing materials, the faulty installation is difficult to detect. The most common maintenance problem is moisture leakage into the insulation in roof and wall applications and on hot water and steam piping. Under severe conditions, wet insulation loses almost all of its thermal resistance. Some insulation materials, such as fiberglass, will regain their thermal resistance when the material is dried out, but other materials, such as cellulose, will not regain their full thermal resistance. Materials such as polyurethane, can suffer rapid material decomposition and loss of thermal resistance under wet conditions. In contract, closed cell extruded polystyrene can withstand water immersion without serious effect.

In summary, it has been found that the performance of thermal insulation under various field conditions often does not provide the full benefits as may be predicted from laboratory test data and energy calculation analyses. To achieve full thermal performance and cost savings, attention has to be given to good thermal design, proper material selection, proper installation and continuing maintenance.

Status of Environmental Laws/Building Standards in Poland

Since reconstruction after World War II, Poland has had a Building Code that addressed thermal requirements of the walls and roofs of new building construction. In early years, these requirements were easily satisfied by use of massive construction techniques, such as solid masonry walls 2-2.5 feet thick for commercial and institutional buildings and somewhat thinner for residential buildings. More recently, the thermal requirements were increased and somewhat lighter masonry construction techniques were used; these newer buildings required the use of insulation to meet the requirements. However, during these times, insulation was often not available and many residential apartment complexes were built with little, if any insulation. The number and location of under-insulated buildings is not known, and they can only be identified by testing, e.g. infrared thermal imaging. It has been estimated that at least 70% if residential buildings are under-insulated with respect to the 1991 building code. The existing code requires that the thermal conductance of the opaque portions of most building envelope components (solid walls and roof) not exceed 0.55 watts/m^{2o}K. (For reference, the thermal conductance is equivalent to a thermal resistance R-value of 10.3 in U.S. units). Details of the current specific thermal requirements for different types of buildings are given in the tables at the end of this Appendix.

As of June 1994, an Energy Law has been drafted and enabling legislation has already passed the Parliament by a large majority. Of specific interest is that the new law will mandate updated material standards and certification program for insulation materials. The upgraded standards and certification for insulation materials will correspond with those of Western Europe. Consequently, products so certified will eventually be marked with the "CU" (Common Europe) stamp and will be marketable throughout the common market. The legislation has wide support form the building industry.

The existing building code does address fire safety and environmental issues, and the detailed materials requirements are given in the respective existing insulation standards. These issues do not adversely affect the manufacturers of currently used insulation products in Poland since the materials are already in compliance. For example, all polystyrene and other plastic foam insulation materials must meet fire safety standards, and the use of CFC's (chloroflurohydrocarbons) has been banned by the Montreal Protocol. The insulation manufacturers do not have problems with the environmental and safety aspects in the new building code or in the respective materials standards.

Future Building Codes and Insulation Standards

Government organizations responsible for promulgation of insulation materials standards report they are working on standards for new insulation products and plan to up-grade existing standards to be in accordance with international/western standards such as those developed under the International Standards Organization (ISO). Soon to be published are new standards for pre-insulated piping and the installation of the piping used primarily for District Heating hot water systems. However, there are no indications as to when updated standards for other insulation materials may be promulgated. Due to the lack of testing facilities in Poland, the standards organizations rely heavily on manufacturers' data, data supplied by foreign testing laboratories, and existing standards from other countries. It is not likely that any standards promulgated in Poland during the next five years will negatively impact the demand for currently used insulation products. Likewise, the introduction of new (to Poland) insulation materials should not be restricted by the lack of Polish standards since there are provisions for issuing temporary approval for new products based on test data from recognized foreign testing laboratories.

Certification for Insulation Materials

To demonstrate that a manufacturer's products meet existing standards and before the products can be sold in the marketplace, the product theoretically must be tested and certified by the Institute of Building Technique; however, since the Institute has very limited and antiquated testing facilities, test data from recognized foreign laboratories are often used. The certification process is often measured in terms of years, but a manufacturer is allowed to market product once certification has been applied for.

There are currently no formal materials standards for polystyrene foam products in Poland, even though it is the most used product. Since there is no standard, the government does not conduct any testing or certification of the products. However, if there were to be a standard for polystyrene foam products, the testing requirements would seriously overload the current capacity of the laboratory and new testing capacity is doubtful in the foreseeable future. The net result is that once the certification program and applicable insulation standards are in place, the certification program cannot be effectively implemented for lack of testing capabilities.

At the practical level, the certification process as a whole is ineffective at best, and as reported by architects, the steady flow of sub-standard products in the marketplace is of major concern in the building industry. When a builder suspects he has receive sub-standard materials from a supplier, he must then demonstrate that the material is sub-standard by laboratory tests and then enter the legal process to collect damages; this process often takes years to complete and is totally impractical to the builder. To maintain construction schedules the builder is then forced to use the sub-standard material. In other cases, builders may knowingly purchase sub-standard materials to gain lower costs without the knowledge of the building owner or investor. The result is that manufacturers of sub-standard materials pervade the marketplace with impunity.

Major deficiencies in the current certification process are:

1. Material samples supplied for certification are sent by the manufacturer; there is no assurance that the sample is representative of production grade material.

2. Once certification is received, it is valid for ten years without any form of retesting or checking of production quality.

3. The certification agencies are seriously limited in performing their mission due to the lack of adequate testing facilities to initially qualify products and to provide periodic checks of product quality.

4. There is no enforcement mechanism or system of penalties to assure quality levels specified in the standards. The only consumer recourse is through lengthy legal processes.

Enforcement of Codes and Standards.

The responsibility for enforcement of building codes and materials standards lies solely on the builder or investor. There are no enforcement mechanisms in either the building cods or material standards or associated with the enabling legislation for codes and standards. The approach is "consumer beware" and if there are problems, they must be resolved by lengthy legal processes. Sub-standard builders and materials suppliers are relatively safe from any form of reprisal, and if caught, can easily close the company and restart under a different name.

The Ministry of Building Industries has the authority to mandate requirements of insulation standards. Such mandates would then have the power of law and would be enforceable. However, as of June, 1994, the Ministry has not issued any such mandates, and as described above, the Ministry does not have the testing capability to determine compliance if it did mandate the standards.

Code Deficiencies/Needs for Strengthening:

Treatment of air infiltration and leakage. The past and current building code does not require the use of weather-stripping for doors and windows and does not limit the total air leakage in the building. Weather stripping is not commonly used in Poland (and most Eastern European countries) and heat losses are estimated to be up to 30% or more of the total heat load. The application of weather-stripping has been shown to be highly effective and has paybacks measured in terms of months. In terms of maximizing cost/benefit of energy conservation expenditures, weather-stripping is the priority measure.

Heating and thermostatic control systems. In most residential and commercial structures, occupants have no control over the heat inputs regardless of the need for heat. An insulated apartment would receive the same quantity of heat as an uninsulated one. It can be readily seen that much of the heat savings resulting from insulation could be lost by the occupants using the time-honored "open the window" method to reduce the temperature.

Prescriptive insulation requirements. The thermal requirements in the Building Code are prescriptive, that is, they specify given levels of insulation regardless of the use or design of the building. Western Building Codes have adopted a performance approach alternative that, in essence, limits the amount of energy required to heat or cool a building. This approach gives credit for passive solar heating, internal heat loads (people, lighting, and equipment) and infiltration control.

Moisture control. The Building Code does not provide for the control of the migration of internal moisture through walls and ceilings/roofs, e.g. the use of vapor retarders in insulated attics. In cold weather, such moisture can condense and freeze within the walls and ceilings and thereby reduce the insulation value of the insulation and under extreme conditions cause damage to the structure. Western codes alleviate this problem by use of "vapor barriers" and careful thermal design. Currently, high air

infiltration rates (due to lack of weather-stripping) minimize the buildup of internal moisture, but there are reports of moisture condensation on interior walls and accompanying growth of molds. The increased use of insulation and weather-stripping can be expected to increase problems of water condensation in the walls and attics. Unless the moisture issue is addressed concurrently with increased insulation requirement, the potential benefits due to the use of insulation will be offset by reduced thermal performance of wet insulation and future structural problems.

Obstacles to Optimal Insulation Use.

1. Lack of Production and Installation Capabilities for Loose-fill/Blown-in Insulation.

There is a need to develop a competitive market for blown-in thermal insulation, primarily for low cost attic installation. The cost/benefit of blown-in insulation has been demonstrated in western countries using loose-fill cellulose, fiberglass and to a lesser degree, rockwool. The advantages of this method are lower material and labor costs and more efficient thermal performance compared to application of batts or rigid board. Blown-in insulation is ideally for attic and cavity wall application.

At this time there is not the capability to produce or install blown-in insulation in Poland except as the result of a completed USAID sponsored pilot project based at the Polish Foundation for Energy Efficiency, Krakow. Also, there is a lack of designer, builder, and consumer awareness of the benefits of this form of insulation.

Attics in existing buildings are generally not reinsulated due to the high costs of batts or rigid board materials and the difficulties in installation. Blown-in insulation is ideally suited to meet this application. At this time, there is almost no awareness of blown-in insulation technology by the consumer and building industry; the benefits have not been marketed nor demonstrated.

Recommendation:

Stimulate the development for blown-in insulation market by conducting a wide-scale demonstration of blown-in technologies for attics and sloping walls through such agencies as the Polish Foundation of Energy Efficiency, the Association of Municipalities (the smaller town/cities), the Chambers of Commerce or a grouping of potential commercial insulation contractors:

- train 5-10 teams of commercial installers in different regions of Poland,
- conduct a wide scale demonstration project in 5-10 smaller cities throughout Poland,
- maximize the number of buildings insulated by minimizing administration costs and monitoring energy savings costs. Demonstrate the benefits through testimonials from occupants and public awareness campaigns, and,
- charge owners about 20% of cost so they appreciate effort and funds are collected for additional insulation.

2. Lack of Testing Facilities for Monitoring Insulation Quality Control

There is a need to strengthen/develop testing capabilities for insulation products to assure international level quality of product. Upgrading of insulation product quality is necessary for long term stability of the insulation industry, assurance of achieving expected energy savings, and the development of export sales. At this time there is not a modern testing capability for measuring the thermal properties

of thermal insulation capable of supporting the government certification program and this situation inhibits the effective enforcement of the materials' standards.

Recommendation:

Strengthen the testing capabilities of the Polish Government Centre for Testing and Certification (PCBC) by purchasing equipment and training professional staff. Of primary need is test apparatus for measurement of the thermal properties of insulation materials.

3. Lack of Modern Computer Tools for Designing Buildings With Optimum Insulation

There is a need to strengthen the capabilities of building professionals for calculating and analyzing the cost/benefits of thermal insulation and other energy conservation measures and to introduce these capabilities into the curriculum of technical universities. Architects, building system designers and technical universities do not have modern computer heat load calculation programs for optimizing thermal design and heating system design of buildings. Historically, designers use the prescriptive requirements of the Building Code, and consider the insulation requirements to be both minimum and maximum. Use of computer heat load calculation programs would lead to optimization of insulation usage and heating system design. Also, there is a need to develop the energy-related portions of the Building Code based on analyses of Polish requirements and climatic conditions.

Recommendations:

Strengthen the computer analyses capabilities of technical universities by introducing modern computer heat load simulation programs and support the training and initial research of university staff. A priority research project should be the development of optimal insulation requirements based on life-cycle costing methodologies for new and existing buildings. The findings should be used to support the development of Polish Building Code requirements.

POLISH BUILDING CODE, NEW CONSTRUCTION, RESIDENTIAL AND PUBLIC

	k (max) W/(m2*K)	R-value Btu units
External walls (in contact with external air)		
a) t(inside) > 16°C		
plain	0.55	10.3
with windows	0.60	9.5
with windows and doors	0.65	8.7
with balconies	0.70	8.1
b) t(inside) <= 16°C (any type of wall)	0.80	7.1
Internal walls between heated rooms and stairs or corridor	3.00	1.9
Walls in contact with projections of dimension		
a) up to 5 cm, filled with an at least 20 cm layer of thermal insulation	3.00	1.9
b) above 5 cm	1.00	5.7
Walls of unheated cellars	no code	
Roofs		
a) t(inside) > 16°C	0.30	18.9
b) 8°C < t(inside) <= 16°C	0.50	11.4
Ceilings of unheated cellars	0.60	9.5
Ceilings of heated cellars	no code	
Windows and balcony doors in residential buildings with t(inside) > 16°C		
a) In the I, II and III climatic zone	2.60	2.2
b) In the IV and V climatic zone	2.00	2.8
Windows in the internal walls between heated rooms and stairs or corridor	4.0	4.1
Windows in the public sector buildings of high hygienic requirements like: hospitals, kindergartens, etc.	2.30	2.5

Windows and balcony doors in public sector buildings		
a) t(inside) => 20°C	2.60	2.2
b) 12°C <=(inside) < 20°C	4.00	1.4
c) t(inside) <12°C	5.60	1
Windows of cellars and unheated attics	no code	
External doors to the building	3.00	1.9
Foundations, one meter wide/deep		
a) t(inside)>16°C	1.50	3.8
b) 8°C < t(inside) <=16°C	1.00	5.7

POLISH BUILDING CODE, NEW CONSTRUCTION, INDUSTRIAL

	k (max) W/(m2*K)	R-value Btu units
External walls (in contact with external air)		
a) t(inside) > 16°C		
plain	0.55	10.3
with windows and doors	0.65	8.7
b) 8°C < t(inside) <=12°C		
plain	0.75	7.6
with windows and doors	0.90	6.3
c) t(inside)<=8°C		
Internal walls		
a) t(internal) > 16°C	1.00	5.7
b) 8°C < t(internal) <=12°C	1.40	4
c) t(internal)<=8°C	no code	
Roofs		
a) t(inside) > 16°C	0.30	18.9
b) 8°C < t(inside) <=12°C	0.50	11.4
c) t(inside)<=8°C	0.70	8.1
Ceilings		
a) t(internal) > 16°C	1.00	5.7
b) 8°C < t(internal) <=12°C	1.40	4
c) t(internal)<=8°C	no code	
Windows in the external walls		
a) t(inside) > 16°C	2.60	2.2
b) 8°C < t(inside) <=12°C	4.00	1.4
c) t(inside)<=8°C	no code	
External doors and gates to the building		
a) t(inside) > 16°C	1.40	4
b) 8°C < t(inside) <=12°C	3.00	1.9
c) t(inside)<=8°C	no code	

BUILDING RENOVATIONS

	k (max) W/(m2*K)	R-value Btu units
External walls (in contact with external air)		
a) t(inside) > 16°C	0.55	10.3
b) 8°C < t(inside) <=12°C	0.80	7.1
c) t(inside)<=8°C	no code	
Internal walls between heated rooms and stairs or corridors		
Roofs		
a) t(internal) > 16°C	0.30	18.9
b) 8°C < t(internal) <=12°C	0.50	11.4
c) t(internal)<=8°C	no code	
Ceilings of unheated cellars with a t(inside)>16°C	0.60	9.5
Ceilings of heated and unheated cellars with a t(inside)<=16°C		no code

INDUSTRIAL

External walls (in contact with external air)		
a) t(inside) > 16°C	0.55	10.3
b) 8°C < t(inside) <=12°C	0.80	7.1
c) t(inside)<=8°C	no code	
Roofs		
a) t(inside) > 16°C	0.45	12.6
b) 8°C < t(inside) <=12°C	0.60	9.5
c) t(inside)<=8°C	no code	