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ESMAP
Energy Sector Management Assistance Program

Belarus: Scaling Up Energy Efficiency Retrofit of Residential and Public Buildings

Assessment of Investment Needs, Implementation Constraints, Financing Options and Delivery Models

December 2015

Energy and Extractives Global Practice
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List of Abbreviations

CAPEX	Capital expenditure
CEEF	Central and Eastern European Fund
CHP	Combined Heat and Power
DH	District heating
DSM	Demand-side management
ECA	Europe and Central Asia
EE	Energy Efficiency
EEO	Energy Efficiency obligation
EERF	Energy Efficiency Revolving Fund
EIB	European Investment Bank
EMS	Energy management systems
ERDF	European Regional Development Fund
ESA	Energy service agreement
ESCO	Energy service company
EMS	Energy-saving measure
ESMAP	Energy Sector Management Assistance Program
ESPC	Energy service performance contract
EU	European Union
EUR	Euro
Gcal	Gigacalorie
GDP	Gross domestic product
GEF	Global Environment Facility
GOB	Government of Belarus
GWh	Gigawatt-hour
HCA	Heat Cost Allocator
HESA	Housing Energy Saving Agency
HH	Household
HOA	Homeowners' Association
HoB	Heat-only boiler
HRF	Housing Retrofit Fund
HV	Heating and ventilation
IBRD	International Bank for Reconstruction and Development
IFI	International financing institution
JESSICA	Joint European Support for Sustainable Investment in City Areas
kWh	Kilowatt-hour
m	Meter
M&V	Monitoring and verification
MOF	Ministry of Finance
NGO	Non-governmental organization
OPEX	Operational expenditure
PFM	Public financial management
PIU	Project implementation unit
PV	Present value
R2E2	Renewable Resources and Energy Efficiency

RE	Renewable energy
RUE	Republican Unitary Enterprise
SNG	Sub-national government
TA	Technical assistance
TRV	Thermostatic Radiator Valve
UDF	Urban Development Funds
UNDP	United Nations Development Program
USD	United States dollars
ZhREO	State Unitary Enterprises of Housing Repair and Maintenance

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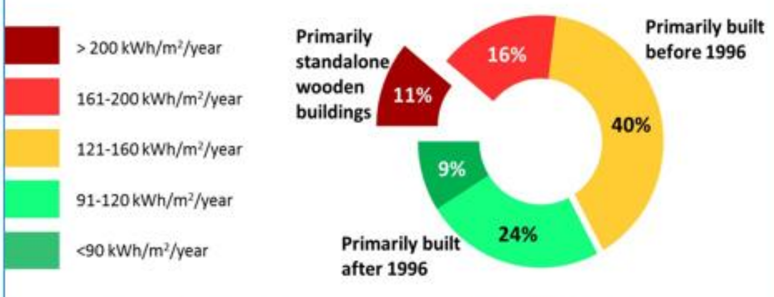
Executive Summary

Energy savings in Belarus' building stock is untapped

The buildings sector is a large potential source of energy savings for Belarus. More than 80 percent of the country's residential stock, and about 95 percent of the public building stock was built before 1996. Building thermal protection standards were significantly strengthened in 1993 and updated in 2010. Pre-1996 buildings consume, on average, nearly twice as much energy per square meter as buildings constructed in the last four years. Deep thermal retrofits in these residential and public buildings could result in dramatic energy savings.[1]



Estimated Specific Heat Consumption of Residential Buildings in Belarus by Percentage of Floor Area, 2014

National final energy consumption can be reduced by 6.7 percent with deep thermal retrofit

Deep thermal retrofit in all pre-1996 residential multi-family buildings could save more than 12,000 GWh per year, while improving comfort levels for residents. In the public sector, deep thermal retrofit of educational, health and administrative buildings could save 3,500 GWh of energy per year.[2] Combined, these savings equal about 6.7 percent of final energy consumption in Belarus in 2013.

Deep thermal retrofit would cost USD 17 billion and could largely be paid for by energy cost-savings

Substantial investments would be required to achieve these energy savings. A total of USD 14.2 billion would be required for deep thermal retrofit of residential buildings. An additional USD 2.7 billion is needed for public buildings. If heat tariffs are set at cost-recovery levels, the retrofits have simple payback periods ranging from 1 to 3 years, for

[1] 'Thermal retrofit' can include energy efficiency measures which reduce a building's heat load, such as thermal insulation of exterior walls, roofs and basements, thermal upgrade of windows and exterior doors, and other weatherization measures. In this report, deep thermal retrofit refers to a package of energy-saving measures that includes all of the aforementioned thermal upgrades and the installation of thermal radiator valves and heat cost allocators.

[2] The figures took into consideration (netted out the impact of) the measures already implemented in the residential sector within the capital renovation programs and by households themselves; and in public buildings sector by local authorities.

installation of end-user heat control measures, and up to 16 years for deep thermal retrofit, depending on the building type and considering the current conditions of energy supply.[3]

End-user Heat Control	Simple Thermal Retrofit	Deep Thermal Retrofit
TRVs and HCAs on all radiators in each apartment	End-user Heat Control Package, plus window replacement	Simple Thermal Retrofit Package, plus thermal insulation of exterior walls and roofs
International experience indicates that enabling end-user heat control together with consumption-based billing can result in 10-15 percent energy savings.	Total energy savings from the simple thermal retrofit Package can reach about 20 percent.	Total energy savings from the deep thermal retrofit package can reach 40 percent or more.

More expensive and more energy savings →

While having significant economic benefits such as sustaining jobs…

Several European studies have found that USD 1 million invested in energy efficiency (EE) can result in USD 3.5 – 4.4 million in benefits such as increased tax revenues, lower operating costs, and reduced unemployment and subsidies.[4][5] Building retrofits, in particular, can be labor-intensive and create mostly non-exportable jobs, with 16–21 jobs created for every USD 1 million invested.[6] Large scale investments in deep thermal retrofit, for example, at USD 1 billion per year, could sustain 16,000 jobs over a 17-year period.[7][8]

…and enhancing energy security.

Belarus relies heavily on imported natural gas to meet its energy needs. At 2015 import prices, deep thermal retrofit of pre-1996 residential and public buildings would result in at least USD 578 million of natural gas savings per year from reductions in heat consumption.[9] If the price of natural gas

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[3] Residential heat tariffs are well below the cost of service and some public entities currently pay a lower, preferential heat tariff.

[4] KfW, Impact on Public Budgets of the KfW Promotional Programs “Energy-Efficient Construction”, “Energy-Efficient Refurbishment”, and Energy-Efficient Infrastructure” in 2011. Frankfurt, KfW, April 2013.

[5] A study commissioned by Natural Resources Canada modelled the impact of EE programs on the economy and found a net increase in employment of 52 job-years per million dollars of program spending. For more information see: Energy Efficiency: Engine of Economic Growth in Canada, commissioned by Natural Resources Canada, Ottawa, March 2014

[6] Center for Climate Change and Sustainable Energy Policy, Central European University, 2012. Employment Impacts of a Large-Scale Deep Building Energy Retrofit Program in Poland: Executive Summary. Den Haag: European Climate Foundation.

[7] Calculations were made to convert estimates related to job creation from Euros to United States dollars using the average exchange rate from January to June 2015, where 1 USD = 0.896 EUR.

[8] Note that the estimate is likely to be conservative since it does not take into account lower wages in Belarus.

[9] Natural gas savings are calculated using the gas price charged to utilities of around 250 US/1000 m^3 in 2015 (by Resolution of the Ministry of Economy No.94) and assumes that 63 percent of heat fuel consumption is from natural gas.

imports were to increase to EU levels, import savings would amount to at least USD 799 million per year.[10]

To seize this economic opportunity GoB support is required to raise capital and facilitate financing…

Thermal retrofits are often financially unattractive (long payback periods for investments) even with full cost-recovery heat tariffs and require financing facilitation by government (table below). The Government of Belarus (GoB) can help raise the capital and facilitate financing required for investments by introducing sustainable financing and delivery mechanisms. A steady flow of funds, through a national program, will be needed to incentivize private borrowing and commercial lending for thermal retrofit in residential buildings. For public buildings, energy cost savings can be allowed to revolve and be used in future rounds of thermal retrofits. This will establish clear financial and performance accountability of EE investments in the public sector and stimulate the mobilization of commercial financing and the development of the EE service market, significantly increasing government fiscal space.

Belarus: Thermal Retrofit Investment Costs and Energy-Savings of pre-1996 Residential and Public Buildings, Based on End of 2014 Data and Information

		CAPEX (million USD)	Annual Energy Savings (GWh)	Simple Payback Period with Current Tariffs	Simple Payback Period with Cost-recovery Tariffs
End-user heat control	Residential	$378	3,152	16-21 years	1-2 years
	Public	$62	560	2-6 years	1-3 years
Simple thermal retrofit	Residential	$4,682	5,514	> 100 years	10-12 years
	Public	$1,174	1,293	20-30 years	10-16 years
Deep thermal retrofit	Residential	$14,215	12,057	> 150 years	15-16 years
	Public	$2,737	3,517	18-22 years	9-12 years

…and address implementation barriers…

Legal and regulatory, as well as incentive-related, technical and financial barriers must be addressed in order to achieve the savings potential. In the residential sector, important barriers include below-cost heat and electricity tariffs, a scarcity of well-developed homeowners' associations, low penetration of consumption-based billing for heat at the apartment level, and limited access to long-term, affordable consumer credit lines. In the public sector, strict, annual line-item budgeting and restrictions on public financing and procurement of energy efficiency services are critical barriers.

For residential buildings:

- ***Tariff reform***
- ***Consumption***

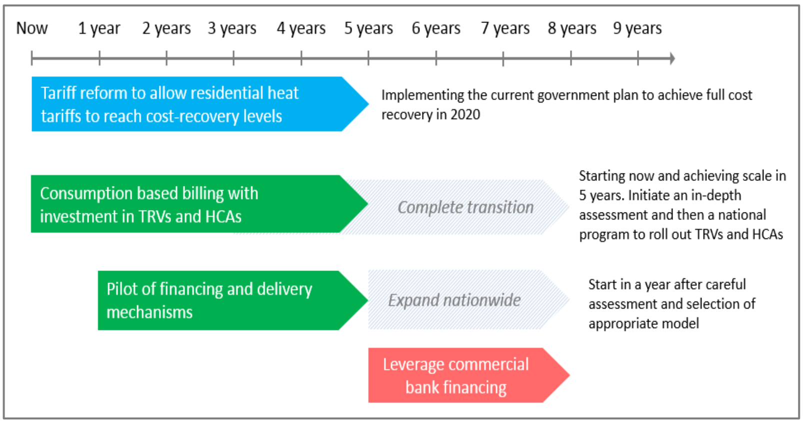
Several important measures can remove the implementation barriers described above, enable rational economic decision-making, and introduce sustainable financing and delivery models. For residential thermal retrofit, the GoB's plan to increase residential heat tariffs to cost-recovery levels by

[10] Natural gas savings are calculated using the weighted average price of natural gas exported by Gazprom to European markets at 345.37 US/1000 m^3in 2014.

based heat billing

- ***Access to low-cost and long-term financing***
- ***Pilots and demonstrations of financing and delivery models***

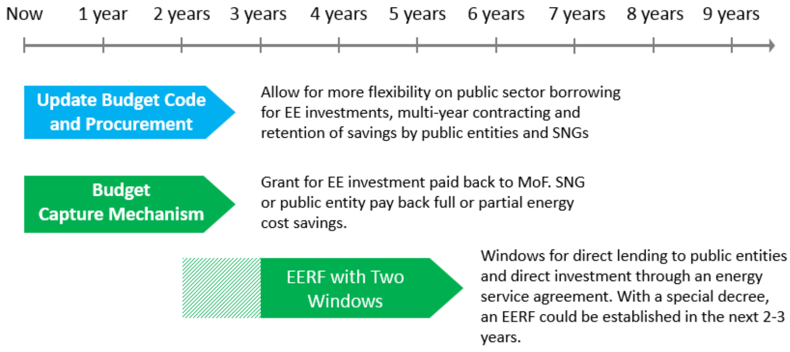
2020 is a first step to introducing sustainable financing and delivery models. Consumption-based billing for heating at the apartment level (requiring installations of thermal radiator valves and heat cost allocators) should also be introduced in parallel to support tariff reform. When consumers have the ability to adjust heat consumption and pay for what they use, they have stronger incentives to invest in EE. With these measures in place, a pilot program to test and put in place a scalable financing and delivery mechanism could be introduced in 3 years. The program can focus on the establishment of a transparent incentive scheme and operational model that engages homeowner associations, banks, and energy service providers. A system of acceptance (e.g., energy performance certification) for buildings which have undergone deep thermal retrofit should also be put in place. If the pilot program is successful, a national program could be rolled out within 5 years.



For public buildings:

- **Revolving public EE investment funds**
- **Enabling multi-year energy savings performance contracting**
- **Pilots and demonstrations of financing and delivery models**

In the public sector, the GoB could introduce regulatory changes to allow for greater flexibility in public sector budgeting and finance, specific to energy efficiency improvements. Such changes include allowing multi-year contracting for energy efficiency services, and allowing energy cost savings retention by subnational governments (SNGs) and other public entities. Adjustments in public procurement, to allow life-cycle cost considerations and facilitate energy performance contracting, would also improve the enabling environment. Making these legal changes in the next two years would pave the way for a pilot program to operationalize the revolving of energy cost savings in public sector EE investment projects and the establishment of scalable and sustainable arrangements for financing EE in the public sector, including a dedicated EE revolving fund and the use of energy savings performance contracting. This pilot can also be scaled up to a national program within five years, as with the pilot for residential buildings.


Now
1 year
2 years
3 years
4 years
5 years
6 years
7 years
8 years
9 years
Update Budget Code and Procurement
Allow for more flexibility on public sector borrowing for EE investments, multi-year contracting and retention of savings by public entities and SNGs
Budget Capture Mechanism
Grant for EE investment paid back to MoF. SNG or public entity pay back full or partial energy cost savings.
EERF with Two Windows
Windows for direct lending to public entities and direct investment through an energy service agreement. With a special decree, an EERF could be established in the next 2-3 years.

1 Introduction

The Republic of Belarus relies heavily on natural gas imports to meet domestic energy demand. Gas is imported at prices below those elsewhere in the region, but the nominal cost of gas has risen by about 14 times since 2006, from 100 BYR/m^3 to 1,400 BYR/m^3 in 2014 in part due to inflation and depreciation of the Belarussian ruble. In 2013, natural gas imports amounted to 4.5 percent of GDP or USD 3.29 billion. Of these gas imports, 70 percent is used to fire heat-only boilers (HOBs) or combined heat and power (CHP) plants. Significant efforts are made to reduce natural gas consumption; the share of domestic and renewable energy sources in fuel mix for electricity and heat generation is already 26.3 percent (2014). The building sector (including residential, public and commercial buildings) accounts for about 38 percent of the total final energy consumption in Belarus, compared with 23 and 22 percent for industry and transport, respectively. More specifically, the building sector consumes 67, 47 and 33 percent of the total final supply of heat, electricity and natural gas, respectively[11]. It is therefore a major focus of the government's energy efficiency efforts.

Much of the building stock in Belarus was built before 1996 when strengthened thermal insulation was not commonly required or practiced. These buildings consume almost twice as much energy per square meter for space heating than those built within the last four years, which comply with EU level thermal insulation standards. Specifically, 82 percent of the residential building stock, 95 percent of kindergartens and secondary schools, nearly all outpatient polyclinics, and 98 percent of administrative buildings were built before 1996. Moreover, most of these buildings are not equipped with thermostatic radiator valves (TRVs), limiting the ability to control room temperature and causing significant heat energy waste during the warmer months of the heating season.

The physical heat losses have fiscal consequences. Residential heating tariffs are currently 75 to 81 percent below the cost of service and are subsidized through direct fiscal transfers and cross-subsidies from electricity tariffs, and non-residential customers. The total fiscal and quasi-fiscal cost of heat subsidies amounted to roughly 1.5 percent of GDP in 2013, and another 1.4 percent of GDP is transferred through cross-subsidies from non-residential to residential customers, undermining industrial competitiveness.[12] Energy expenditures in schools account for about 45 percent of non-wage operating costs. In health sector buildings, energy expenditures are about 16 percent of non-wage operating costs.

Energy efficiency investments can significantly reduce budget outlays in the long-term while also improving the physical assets and quality of energy services. Investments in thermal retrofits of public and residential buildings can result in substantial economic benefits. The economic benefits come from increased tax revenues, lower operating costs, lower subsidy requirements, and employment resulting from the development of an EE service industry. Several European studies have found that USD 1 million invested in EE can result in USD 3.5 –

[11] Energy Statistics, International Energy Agency, http://www.iea.org/statistics/

[12] World Bank, "Heat Tariff Reform and Social Impact Mitigation: Recommendations for a Sustainable District Heating Sector in Belarus", 2014.

4.4 million in benefits. Building renovations, in particular, can be labor-intensive and create mostly non-exportable jobs, with 16–21 jobs created for every USD 1 million invested. Large scale investments in deep thermal retrofit, for example, at USD 1 billion per year, could sustain 16,000 jobs over a 17-year period.

Investment in EE can also enhance energy security. At 2015 import prices, deep thermal retrofit of pre-1996 residential and public buildings would result in at least USD 578 million of natural gas savings per year from reductions in heat consumption. If the price of natural gas imports were to increase to EU levels, import savings would amount to at least USD 799 million per year.

Recognizing the substantial energy savings potential in the buildings sector, the Government of the Republic of Belarus (GoB) has introduced policies and programs to promote the development of more energy efficient buildings, and the retrofitting of old buildings. The *Integrated Program for Design, Construction and Renovation of Energy-Efficient Housing in the Republic of Belarus for 2009-2010 and until 2020* sets a national target to reduce specific heat consumption in existing residential buildings by 60 kWh/m^2 through EE retrofits. The Program on Regulation, Standardization and Compliance Confirmation in Energy Saving for the period of 2011 – 2015 introduced energy passports, and EE building certificates. Technical regulation, which sets standards for the specific heat consumption of residential and public buildings has also been introduced. The National Housing Policy Concept (2013) further requires that all residential buildings built after 2013 should be designed according to energy-efficient standards, which limit energy consumption for heating and ventilation to a maximum level of 40 kWh/m^2 per annum. As of 2012, about 1.1 million m^2 of energy-efficient residential buildings were built in Belarus.

Significant progress has therefore been made, but barriers remain. Financing for EE retrofits of existing buildings is limited, and mostly supported by the state budget. In the past 15 years about 15 million m^2 of residential buildings (roughly 7.5 percent of the pre-1996 stock) was rehabilitated. However, the current legal and regulatory framework gives heat consumers few incentives to make such investments.

The objective of this study is to assess the investment needs and implementation constraints for scaling-up thermal retrofits and heating system upgrades in residential and public buildings, and to recommend suitable financing and delivery models for such investments.

The report is structured as follows:

- Section 2 assesses the progress GoB has made in creating an enabling environment for EE, and outlines areas where improvements could be made
- Section 3 describes the characteristics of the residential building stock, analyzes the potential for space heating EE improvements , identifies barriers to EE in residential buildings, and recommends financing options and a roadmap for scaling up investment in thermal retrofit of pre-1996 residential buildings
- Section 4 describes the characteristics of the public building stock, analyzes the potential for EE improvements in space heating, identifies barriers to EE in public

buildings, and recommends options for financing EE improvements in them, and sets out a roadmap for developing sustainable EE financing for public buildings.

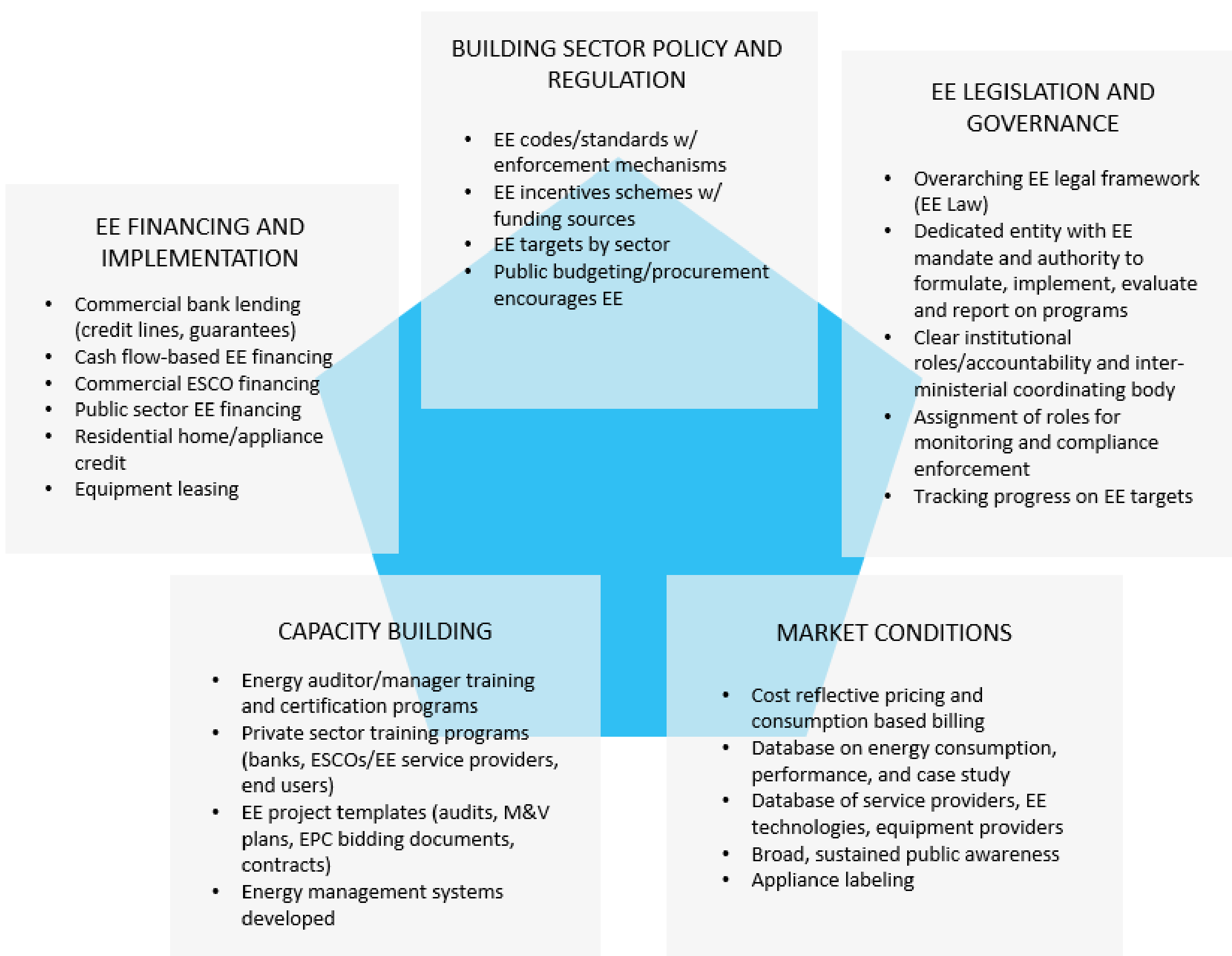
The appendices contain additional data and analysis referenced in the main body of the paper.

2 Enabling Environment for EE in Buildings

International experience has shown that a successful enabling environment for EE in buildings requires a robust foundation supported by five "building blocks": EE legislation and governance, buildings sector policy and regulation, market conditions, financing and implementation, and capacity building.

A number of indicators have been developed to assess a country's specific progress in each of these areas (Figure 2.1). Most indicators have binary outcomes, such as "yes" or "no", to reflect specific actions, such as the adoption of a sector strategy or EE targets by sectors. Others are numeric, for example, the percentage of buildings with building level metering. Some of the scoring is qualitative but it provides a rough assessment of a country's progress in adopting good practices on EE, and indicates gaps that can be areas for future activity.

Figure 2.1: EE Enabling Environment Framework



Source: Adapted from World Bank, "Western Balkans: Scaling Up Energy Efficiency in Buildings", 2014.

Belarus' progress against each indicator was scored qualitatively.[13] The percentage shown on Figure 2.2 represents progress made in that area so far, where the maximum score is 100 percent.

Based on the analysis above, areas pertaining to broad EE legislation and governance, and capacity building are relatively strong. Building sector regulation and market conditions are modest. Financing and implementation is the weakest for scaling up EE in buildings. The subsections below provide more detail on what Belarus has achieved in each area, and what work still needs to be done.

Building sector policy and regulation

The GoB has taken important steps to improve the legal and regulatory environment for EE in buildings:

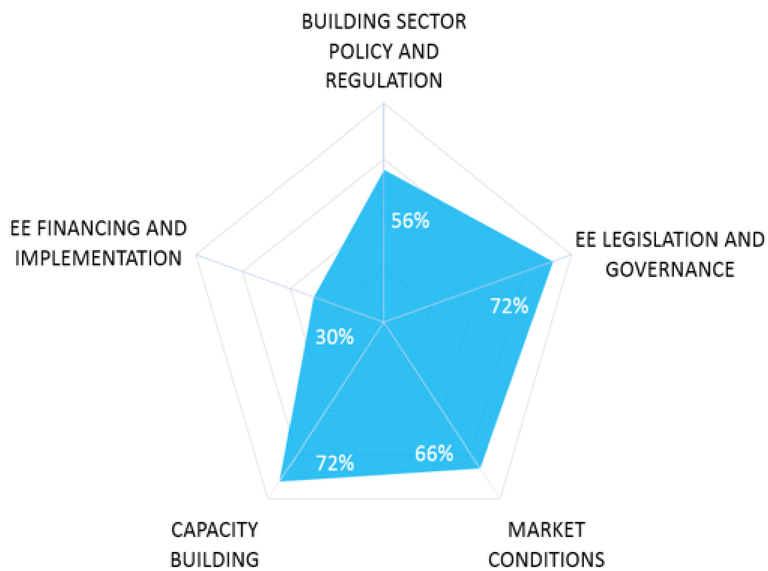
- The Council of Ministers issued Decree # 1820 'On Additional Measures for Efficient Use of Fuel and Energy Resources' in 2003, requiring all new and capitally renovated buildings to be equipped with individual heat substations; all public buildings, central heat substations and multi-apartment buildings (80 flats and more) to be equipped with heat and water meters and systems of heat energy regulation, and all billing to be based on the meters installed. This policy had good results. More than 95 percent of apartment buildings (with more than 20 apartments, connected to DH systems) are now equipped with heat and hot water meters.
- Decree # 45 'On measures to increase operational efficiency of housing stock, public and social sites and protection of consumer rights of utility services' in 2003 envisioned the start of capital renovations of apartment buildings constructed under the first standardized design series of large scale construction. It also required that technical standards be set for apartment level regulation and metering of heat consumption in all new, reconstructed and capitally renovated buildings. Over the last 15 years, around 15 million m^2 of floor space were capitally renovated[14].
- The Ministry of Architecture and Construction released a national building EE strategy in 2009, which set quantitative targets for building EE through 2020.[15] It is supported by the Program on Regulation, Standardization and Compliance Confirmation in Energy Saving for the Period 2011 – 2015 (2011); and the National Housing Policy Concept (2013).

[13] Each building block comprises of a set of indicators which was scored against a stoplight rating scale as green, yellow, or red. An indicator received a green rating if all of its sub-indicators were implemented, a yellow rating if at least one sub-indicator was implemented, and a red rating if none of its sub-indicators had been implemented. The indicators were then scored, where an indicator with a green, yellow or red rating obtained three, two, and one points respectively. Finally, the total score for each building block was calculated as a percentage of the maximum possible score for that category.

[14] Program on Housing and Utilities Sector Development by 2015.

[15] Resolution of the Council of Ministers № 706 01.06.2009, "On approval of a comprehensive program for the design, construction and reconstruction of energy efficient residential buildings in the Republic of Belarus for 2009-2010 and until 2020"

Figure 2.2: Summary of Assessment of the Enabling Environment for Belarus



STRENGTHS

Building sector policy and regulation
- Sector strategy
- Equipment standards

EE Legislation and Governance
- National EE law and secondary legislation

Market conditions
- Energy service providers (ESPs)
- Energy auditing

Capacity
- Energy information centers
- Capacity of energy auditors
- Capacity of energy entities

AREAS FOR IMPROVEMENT

Building sector policy and regulation
- Public procurement of EE services
- Building certificates/passports
- Data availability
- Regulations for utilities, energy performance contracting

Market conditions
- Residential heat tariffs
- Apartment level heat control and consumption-based billing
- Energy utility demand-side management
- Financial incentive programs

Capacity building
- Capacity of energy managers
- Knowledge of energy users

EE Financing and implementation
- Support for energy audit
- Financing for building EE
- Energy service companies

Source: Authors

- Upgrades to the building code were passed in 1993 and 2010, each representing large increases in thermal performance of buildings.[16] For example, a five-floor building built before 1996 has a specific heat consumption standard of 169 kWh/m^2, but a new five-floor building has a standard of just 48 kWh/m^2, a 72 percent reduction.[17]
- The GoB has also adopted standards for building insulation materials, and for the energy performance of windows and glass, lighting, air conditioning and refrigeration. These standards are in line with EU standards.
- The GoB recently released a plan to have residential heat tariffs reach full cost recovery by 2020, while mitigating poverty and social impact. This will dramatically reduce payback periods for EE investments and increase financial incentives in both the public and residential sectors.

The existence of EE policies and regulations, and initial positive results, is an excellent first step, but in Belarus—as in many countries in the region—monitoring and enforcement remain weak. More specifically:

- While inspections of new buildings are conducted, energy commissioning[18] is not.
- There are no specific requirements in the public procurement rules requesting the government to purchase or give the priority to products or services with increased level of energy efficiency compared to the existing standards and no policies or regulations supporting energy savings performance contracts (ESPCs).
- Access to data on energy performance of the existing building stock is limited. There is little information on the building types, market size, energy consumption, EE potential or EE investment needs in either the residential, commercial or public buildings market.
- Workmanship on wall insulation has deteriorated over time. Regulations on the design, installation and acceptance of thermal insulation projects are in place, but there is a lack of enforced compliance. Workmanship has consequently declined, as lower-quality insulation systems generally win tenders by keeping their bid prices low (Appendix I).

EE legislation and governance

The legal framework was established in 1998 with the adoption of the Law on Energy Saving, and currently takes into consideration new regional and world developments[19]. The

[16] Buildings from 2011 and later comply with current thermal protection standards passed in 2009. Buildings from 1996 to 2011 were built according to standards passed in 1994. These buildings could be upgraded to meet current thermal standards, but are not due for major repair for 25 years, so structural thermal upgrades are unlikely to occur soon.

[17] A United Nations Development Program (UNDP) project is currently underway in Belarus to incorporate EU Building Directives and EE Codes into Belarussian norms and standards.

[18] Energy commissioning refers to a systematic review of a building's energy performance to ensure that the building's energy performance performs according to the design intent and the building owner's operational needs.

development of the legal framework is being mainly shaped by the state agencies, with limited inputs from private and non-government sectors. More specifically:

- The legal framework seems to have been informed by limited market data and analyses.
- Participation of civil society and the private sector is limited in the formulation of and consultation on EE policies. Neither are represented on a national board of experts that was established to enhance the use of EE technologies.[20]

Market conditions

Market conditions are beginning to improve for EE investments in Belarus. For example, the Law on Energy Saving requires mandatory energy audits for legal entities with annual fuel and energy consumption of more than 1,500 tons of coal equivalent (tce). The Law also defines requirements for the outputs of energy audits. Incentives and financing for EE investments are available for industrial and commercial consumers, but are lacking for the residential sector:

- Industrial and commercial electricity prices are above cost-recovery levels but residential tariffs for electricity, gas and district heating (DH) are not. However, the tariffs for electricity are steadily increasing and are projected to reach 80 percent of cost recovery by the end of 2015. The situation with heat tariff increase is not as optimistic. The current level of cost recovery is around 15 percent. This level of heat cross-subsidization undermines incentives for EE by increasing the payback period for EE investments.
- EE obligations (EEOs) for different utilities are in place but have not been implemented.
- Commercial bank financing for EE investments is available to some extent in the commercial and industrial sectors, but only one bank offers EE loans to the residential sector. No commercial financing is available in public sector for building EE projects.
- Apartment-level heat control and consumption-based billing are absent in most residential buildings, reducing homeowners' incentives to conserve energy and invest in thermal retrofits.

Capacity building

Capacity building of energy auditors and energy service providers is quite strong in Belarus:

- Belarus has programs for training and certifying energy auditors. As of January 2015, 28 energy auditing firms had been certified to provide energy auditing services to organizations.[21]

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[19] In January 2015, the GoB passed a national EE law, the Law of the Republic of Belarus № 239-Z "on Energy Saving", to support implementation of the national building EE strategy.

[20] Experience in the region suggests that stakeholder consultation, while potentially time-consuming, can greatly improve the legal framework. This is true primarily because of the cross-sectoral nature of EE measures.

- There have been a number of donor-funded programs to build the capacity of energy service providers, and energy management systems (EMS) for large energy users have been introduced, and have training programs.

Capacity building is weak in other areas, however:

- There are not yet programs to build capacity of energy managers, or certify them.
- There are no regular measurements or evaluation of end-user practical awareness of EE or other types of feedback provision. EE information is provided to the population through special educational courses and advertisements, but it would help to sharpen the focus of the outreach and improve on the materials used.
- Data for the EE performance of retrofits in the public and residential sectors do not seem to be made publicly available. Handbooks or guides for EE have been developed, but there is no database of EE case studies in Belarus.
- There is a lack of confidence in, and awareness about the effectiveness of EE measures. For example, a thermal retrofit contractor interviewed for this study claimed that low awareness about technological and economic benefits of construction technologies among designers, developers and contractors leads to a lack of trust about the possibility of fully realizing the EE potential of thermal retrofits (Appendix I).

Financing and implementation

Existing options for long-term, affordable financing for EE investments in the building sector in Belarus are limited. There are no financial incentive programs or dedicated funds for EE investments or audits in buildings. Energy service companies (ESCOs) do not exist.

Other important barriers to financing and implementing EE improvements include:

- Homeowner associations (HOAs) are not well developed and are unable to take loans, leaving apartment owners to implement energy saving measures from their own collective funds. Moreover, consumer credit is limited, and with high interest rates. Lenders are generally unfamiliar with EE technologies and as a result have not provided substantial financing for thermal improvements. Moreover, EE measures are generally not considered as a way to improve the quality/value of the property and thus not duly reflected in the market prices;
- While there is an existing government program to provide low-interest loans to low-income consumers living in small cities to implement EE measures, including thermal retrofits, it has a long waiting list and limited resources.[22] In addition, starting in

[21] These trainings are given at the Belarusian State Institute of Advanced Training and Retraining in the Field of Standardization, Metrology and Quality Control. There have also been several donor-funded training programs for energy auditors, including programs funded by the EU and UNDP/GEF. Auditors (both individual auditors and energy audit organizations) are certified by RUE “BelGIM”. Recertification is required every three years.

[22] The program is based on the Presidential Decree #75 as of February 7, 2006. Loans are given for capital repairs and reconstruction of residential buildings, construction of engineering networks, etc. for low-income citizens - owners of residential premises, permanently residing and working in settlements with a population up to 20 thousand. The maximum

January 2015, the GoB reduced public financing for thermal retrofits; which will be included in the scope of capital reconstruction of apartment buildings, but to a very limited extent[23].

- Public entities are prohibited from borrowing, leaving them only their annual budget allocations. They cannot enter into multi-year contractual obligations (unless supported by an act of Government or the President). Line-item budgeting limits incentives to save energy.[24]
- Fragmentation of responsibilities in the public sector makes coordination of bundled procurement and investment in EE improvements more complex.[25]
- There is a lack of donor investment grant programs or credit lines in the public, residential or commercial building sectors
- International donor activity is mostly concentrated on supply side energy efficiency, covering the modernization of boiler houses and heat networks. Special large scale programs on demand-side EE are largely absent.[26]

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size of a soft loan - 90% of the costs, defined by design documentation. The loan amount should not exceed the threshold of 300 base values (around 3600 USD), period – up to 10 years, annual interest rate 3% (BYR).

[23] Decree of the Ministry of Housing Utilities of the Republic of Belarus as of January 27, 2015 #3

[24] Annual appropriations are set up as detailed line items, and budget cannot be reallocated from one line item to another. As such, public officials feel compelled to spend all that was budgeted under a particular line item to ensure that their budgets are not reduced in the next planning period.

[25] Different levels of government are responsible for different types of institutions. For example, expenditures of post graduate schools are financed by the republic budget while expenditures for lower level educational institutions such as pre-schools might be financed by oblast and base tier budgets.

[26] Over the last three years, there have been no donor investment grant programs or credit lines in the public, residential or commercial building sectors. In 2001 and 2006, the World Bank funded the Post-Chernobyl Recovery and Social Infrastructure Retrofitting demand side energy efficiency projects, respectively. These two projects included energy retrofits in social and public buildings, such as schools, hospitals and orphanages. The ongoing Energy Efficiency project, funded in 2009, is helping to reduce gas consumption and total efficiency in heat and power generation by converting six existing heat-only boiler plants to combined heat and power plants in different locations across Belarus.

3 Scale Up Thermal Retrofit of Residential Buildings

Roughly 82 percent (or 197.7 million m^2) of the residential building stock in Belarus was built before 1996, when buildings were constructed with little consideration for EE. Given the fact that buildings are generally due for major repair every 25-30 years after construction, there is a significant and increasing demand for structural thermal upgrades. Section 3.1 provides an overview of the pre-1996 residential building stock, including heating systems and energy performance of the buildings. Section 3.2 analyzes the technical, financial and economic potential of selected energy savings measures that could be implemented. Section 3.3 identifies barriers to thermal retrofit of residential buildings. Section 3.4 presents potential options for financing thermal retrofit. Section 3.5 concludes with a roadmap for scaling up thermal retrofit in residential buildings in Belarus.

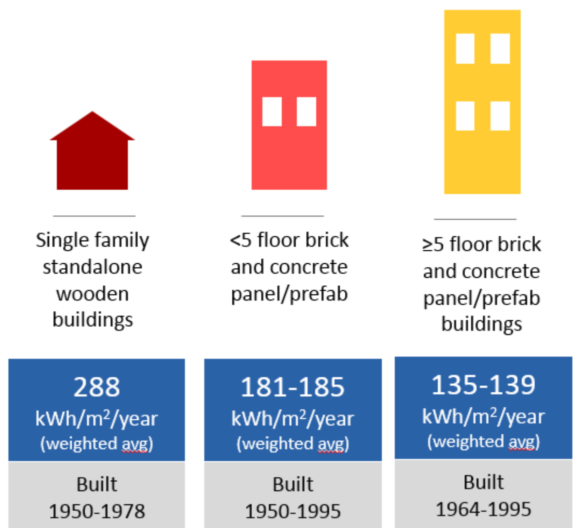
3.1 Characteristics of the Residential Building Stock

Total residential floor area in Belarus was 243.5 million m^2 in 2013, up from 197.7 million m^2 in 1995. Because most of the residential stock was rebuilt after the Second World War, there are only a few building types (where types are defined by the structural concepts and materials used). There are three main building types, and their heat consumption varies substantially (Figure 3.1).

In buildings built before 1996, roughly 17 percent of all dwellings are in stand-alone wood buildings (”Single Family” buildings). Another 31 percent of dwellings are in two-to-three-floor brick or panel buildings (”<5 Floor” buildings). The remaining 51 percent of dwellings are in brick or panel buildings of five floors or more (”>5 Floor” buildings) (Figure 3.2). Homeownership in Belarus is high. Roughly 90 percent of apartments and single-family homes are privately-owned.[27] Energy performance of the housing stock based on standard series of residential buildings is provided in Appendix L.

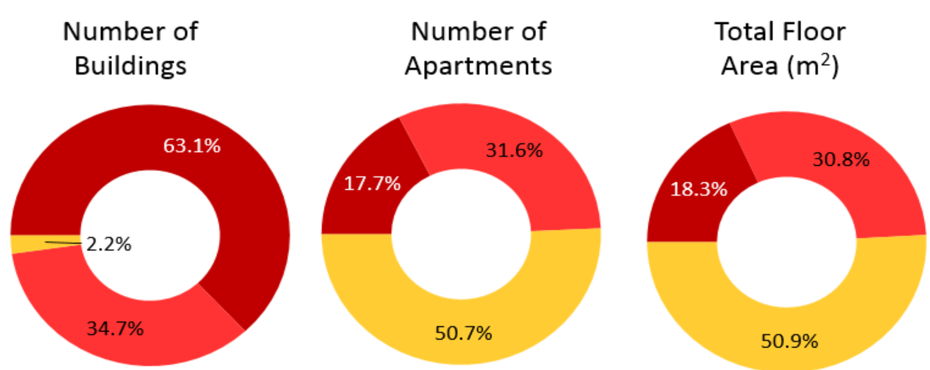
[27] The private residential stock includes buildings owned by individuals, by non-public organizations, and the mixed residential stock, which includes buildings owned by organizations with a mixed form of ownership, sometimes including foreign entities.

Figure 3.1: Typology of Buildings Constructed before 1996



Source: Authors, based on data from Pilot project on energy saving measures in building and residential sector of Belarus, EBEL-9502-1997

Figure 3.2: Overview of pre-1996 Residential Building Stock



	Single Family	<5 Floors	>5 Floors
Number of Buildings by Building Type (thou.)	676.3	371.8	24.1
Number of Apartments by Building Type (thou.)	707.6	1,267.2	2,032.5
Total Floor Area by Building Type (thou. m^2)	36,140	60,954	100,600

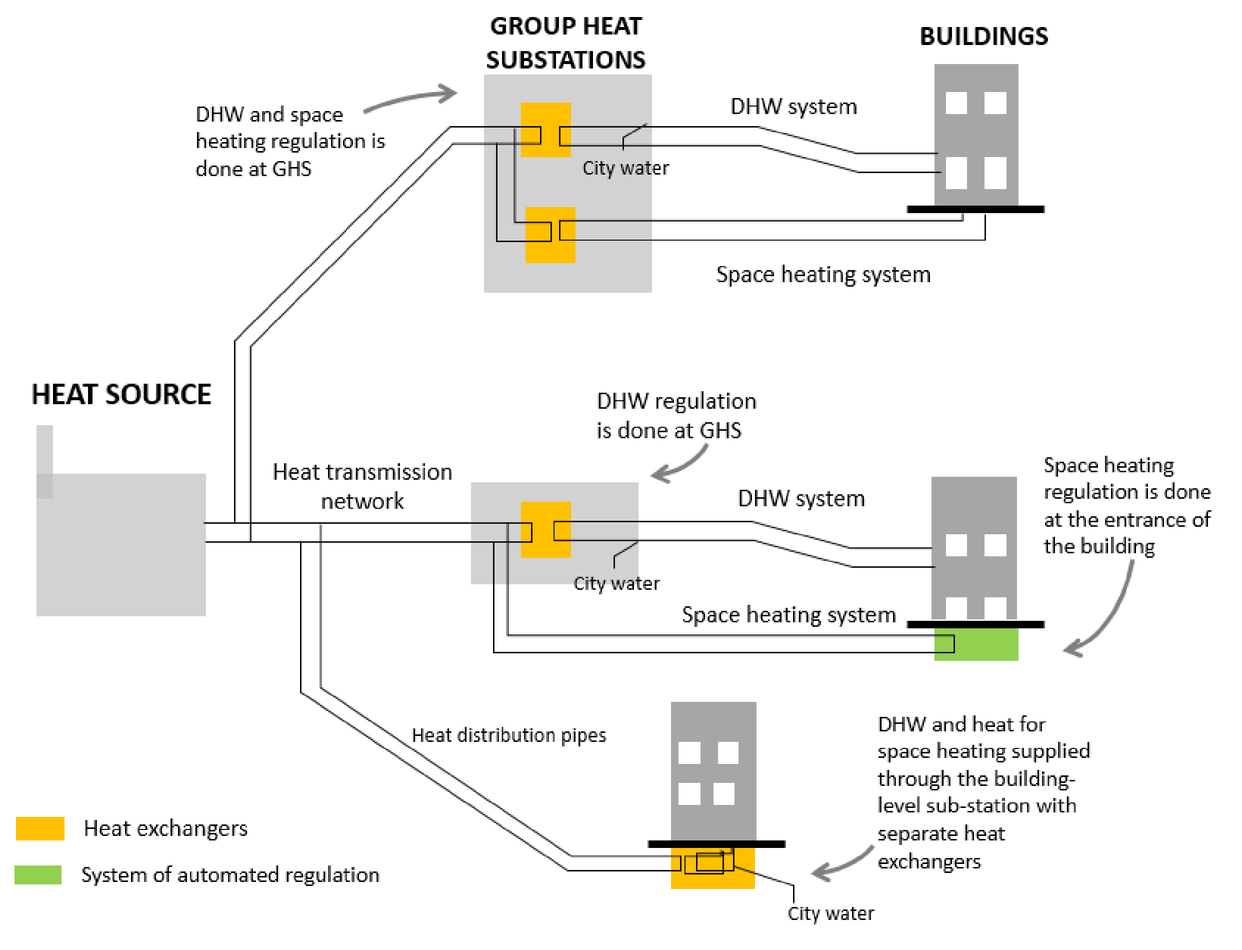
Source: Authors, based on data from Pilot project on energy saving measures in building and residential sector of Belarus, EBEL-9502-1997.

3.1.1 Heating Systems

There are three types of heat supply and provision in Belarus: district heating, individual natural gas boilers, and individual wood, coal boilers and stoves. Urban households are mostly served by district heating systems (around 80 percent of urban households), while rural households more typically use individual boilers and stoves (around 85 percent of rural households).

District heating (DH) supplies heat and domestic hot water (DHW) to a total of 61 percent of the households in Belarus. Almost all of pre-1996 <5 Floor and ≥5 Floor buildings are supplied with heat and DHW by group heat substations (GHSs), using a separate secondary network (two pipes for heat and two pipes for DHW). These buildings in general have building-level heat control responding to outdoor temperature instead of a building-level heat substation. All new multi-apartment buildings are equipped with the modern building level heat substations. Figure 3.3 depicts the two type of heat and DHW supply schemes.

Figure 3.3: Typical Schemes for Space Heating and Domestic Hot Water Supply in Belarus in Apartment Buildings

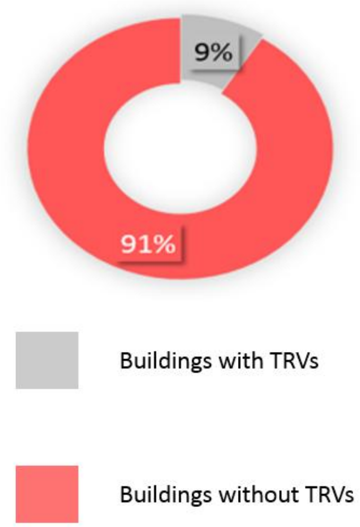


Source: Authors

Where possible, heat exchange at the building level substation for both space heating and DHW has greater EE than when conducted at group heat substations, which distribute heat and DHW to many buildings.

Only 9 percent of the multi-apartment buildings in Belarus have thermostatic radiator valves (TRVs) to control heating (room temperature) at the apartment level (Figure 3.4). TRV installations in pre-1996 buildings are virtually non-existent.

Figure 3.4: Percentage of Residential Buildings Nation-wide with Thermal Regulation



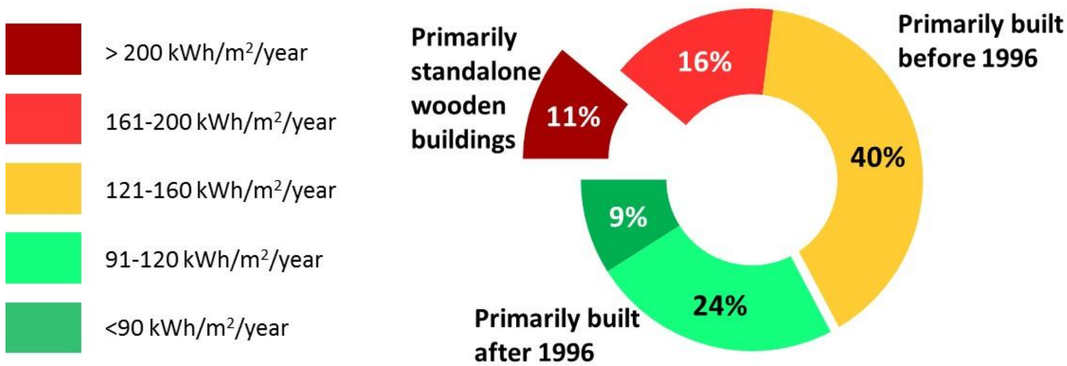
Source: Authors, based on legal and statistical data

Metering for heating and hot water is done at the building-level for more than 95 percent of the multi-apartment residential buildings in Belarus. Almost all apartments are equipped with hot water meters while only around 9 percent have space heating meters. Heating costs are thus typically distributed among households by a factor of the floor area of their apartments, rather than the heat they use.

3.1.2 Energy performance

Residential buildings in Belarus account for roughly 44 percent (23.4 million Gcal in 2013) of all heat consumption in the country. The proportion has remained approximately the same for the last 10 years. Metered consumption data shows that heat energy performance of residential buildings is much worse in standalone wooden buildings and buildings built before 1996 (Figure 3.5).

Figure 3.5: Energy Performance of the Residential Building Stock by Percentage of Floor Area

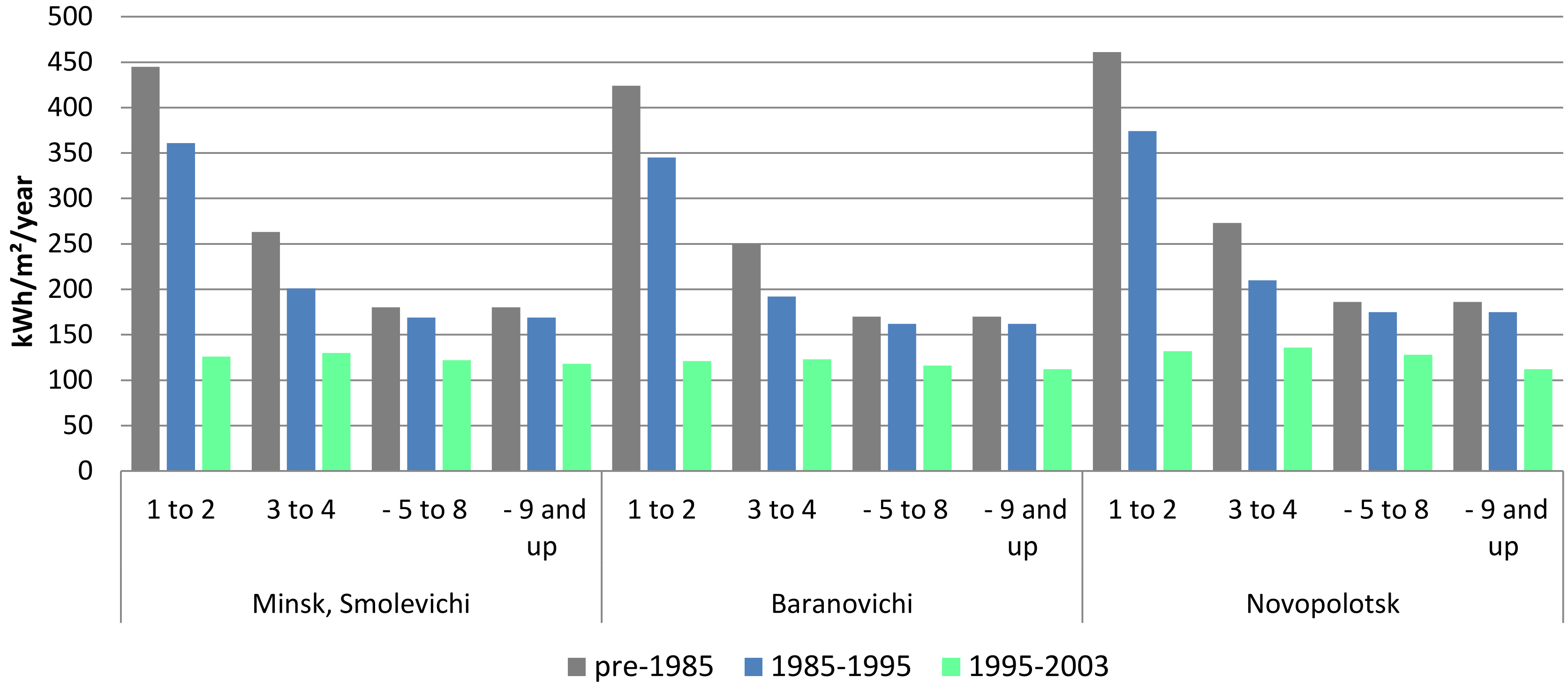


Source: Authors, estimated based on metered data.

Older buildings have substantially higher levels of heat consumption. For example, a one-to-two floor building in Minsk built before 1985 consumed 445 kWh/m^2 per year.[28] For the same type of buildings built between 1985 and 1995, consumption was 361 kWh/m^2. For the 1995 to 2003 construction period, consumption in one-to-two floor buildings was 126 kWh/m^2, about 72 percent lower than the consumption for pre-1985 buildings of the same height. Other types of residential buildings in Minsk see substantial energy reductions by construction period, as do buildings in Baranovichi and Novopolotsk (Figure 3.6).

[28] Standardized energy consumption for heating and ventilation in public and residential buildings is usually set for indoor air temperature at the level of 18^{o} C. Actual temperature level is typically 21-22^{o} C.

Figure 3.6: Annual Heat Consumption for Residential Buildings of Different Construction Periods, (kWh/m²)



Note: 1. The pre-1985 category excludes buildings that have received thermal upgrades as part of major renovations;

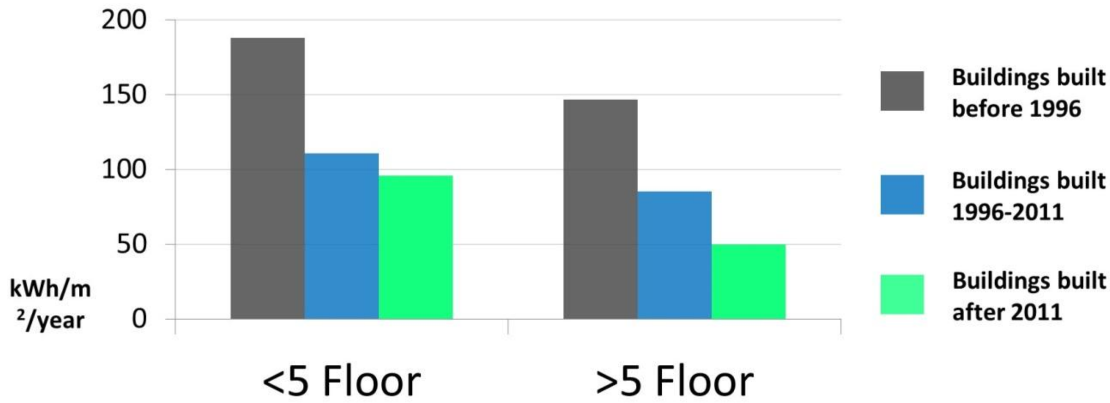
2. The 1985-1995 category excludes buildings that were built "with consideration of heating upgrades";

3. For the 1995-2003 category, only compound panel buildings are included for buildings of at least 3 floors.

Source: Authors, based on metered data and standards in SNB 4.02.01-03 "Heating, Ventilation and Conditioning" and TCP 45-2.04-196-2010 "Heat Protection of Buildings. Heating Properties. The Method of Determination".

Heat consumption in <5 Floor and >5 Floor residential buildings differs over three periods of construction: before 1996, from 1996 to 2011, and after 2011. Heat consumption is much higher in buildings built before 1996 than in buildings of the later construction periods. (Figure 3.7).

Figure 3.7: Changes to Specific Heat Consumption over Different Construction Periods



Source: Authors, based on metered data and standards in SNB 4.02.01-03 "Heating, Ventilation and Conditioning" and TCP 45-2.04-196-2010 "Heat Protection of Buildings. Heating Properties. Methods of Determination".

3.2 Costs and Benefits of Thermal Retrofit

The potential heat energy savings in the residential building sector is substantial. Most of the savings potential lies in buildings constructed before 1996, and could be achieved by implementing energy saving measures (ESMs). To allow for an aggregate national estimate of energy-savings potential and cost-effectiveness, the most suitable ESMs for these buildings have been grouped into three packages: end-user heat control, simple thermal retrofit, and deep thermal retrofit (Figure 3.8).

- **End-user Heat Control and consumption-based billing** involves installing TRVs and HCAs on all radiators in each apartment. TRVs allow households to adjust the room temperature. HCAs are devices for allocating a building's heat consumption among different apartments proportional to actual consumption. HCA data are collected electronically through a central unit at building level. This package is an important first step in any renovation project, as it gives households control over the amount of heat they consume and enable them to benefit from reduced heat bills. Experience in other European countries indicate that such a package usually result in 10 – 15 percent heat energy savings per buildings if under-heating is not a widespread problem (Appendix G).
- **Simple thermal retrofit** adds window replacement to the end-user heat control package. Old windows are inefficient and have poor insulation properties, leading to high heat losses. Newer energy efficient double-glazed windows could reduce these losses by an additional 6 to 8 percent per building, depending on the building type. Total energy savings per building from the simple retrofit package can reach about

20 percent. Investments in window replacement are already taking place in households (reflected in further calculations), but this is still a small portion of the pre-1996 building stock.

- **Deep thermal renovation** adds exterior wall and roof insulation to the simple renovation package. This is similar to what is referred to as "capital renovation" in Belarus. Better insulation of the building envelope can reduce heat losses by an additional 24 to 27 percent, depending on the building type. Total energy savings from the deep renovation package can reach 40 percent or more.

While these packages allow for a manageable analysis of savings potential at national level, they are not intended for being used as model packages for thermal retrofit. Actual thermal retrofit projects require detailed energy audits to determine specific ESMs to implement to achieve a given level of post-retrofit thermal performance while meeting the cost-effectiveness criteria.

Figure 3.8: Packages of Energy Saving Measures for analyzing pre-1996 Residential Buildings

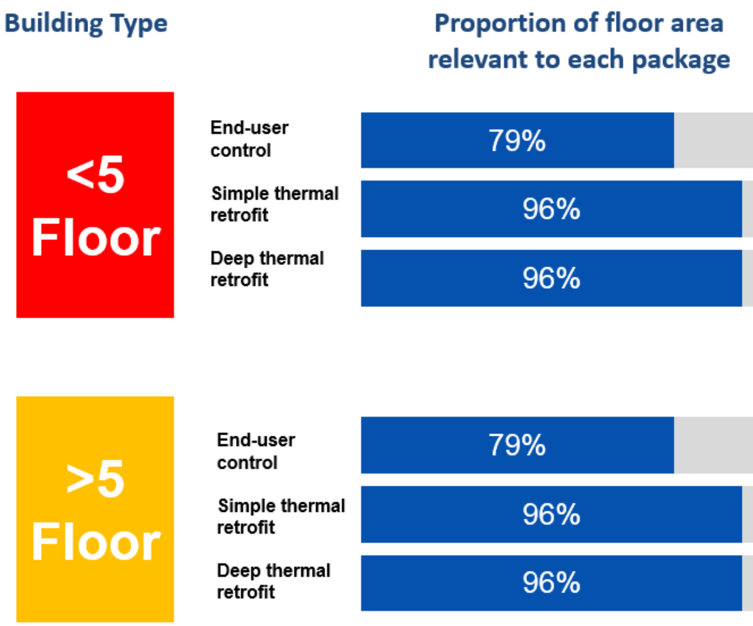
Package	End-user Heat Control	Simple Thermal Retrofit	Deep Thermal Retrofit
	TRVs and HCAs on all radiators in each apartment*.	End-user Heat Control Package, plus window replacement	Simple Thermal Retrofit Package, plus thermal insulation of exterior walls and roofs
	TRVs allow households to adjust the room temperature. HCAs are devices for allocating a building's heat consumption among different apartments proportional to their actual consumptions. This package gives households control over the amount of heat they consume and benefit from reduced heat bills. It can result in 10-15 percent energy savings.	Old windows are inefficient and air permeable, leading to high heat losses. Newer EE double glazed windows could reduce these losses by an additional 6 to 8 percent, depending on the building type. Total energy savings from the simple thermal retrofit Package can reach about 20 percent.	Better insulation of the building envelope can reduce heat losses by an additional 24 to 27 percent, depending on the building type. Total energy savings from the deep thermal retrofit package can reach 40 percent or more

Note: * International experience has shown that this can be applied to vertical piping effectively.

Source: Authors, based on data from "Heat Consumption in Residential Sector (Minsk)", Mr. Krushanov Ruslan, Director of Belzhilproekt Institute.

The baseline heat consumption of building types was estimated and verified using actual energy consumption data from residential buildings in Minsk. These baseline consumption values were then multiplied by the total floor space of each building type to determine its total energy consumption for heating. Relative savings from each ESM were estimated to determine how much energy could be saved by implementing each package in each building type. The total energy savings were also adjusted to take into account buildings that have already received these upgrades[29], or, in the case of the End-User Heat Control Package, buildings that cannot receive TRVs and allocators because the radiators are located within walls and renovations would be so costly and disruptive as to be financially unviable under any circumstances. End-user Heat Control is therefore only applicable in 79 percent of buildings. Simple and Deep Retrofits are applicable for 96 percent of buildings (Figure 3.9).[30]

Figure 3.9: Relevance of Each Package to the pre-1996 Building Types



Note: For Simple and Deep Retrofit, 96 percent of the floor area would receive the additional measures (new windows and wall/roof insulation, respectively), but the area receiving TRVs and allocators would still be 79 percent. Therefore, some buildings would receive Simple or Deep Retrofit without receiving TRVs and allocators (where radiators are inside the walls).

In addition, a survey of households Appendix H) conducted for this study showed that many respondents have already replaced their own windows (in Minsk this ratio could be as high as 40 percent). If true of the wider population, this would reduce the investment cost necessary for Simple and Deep Retrofit. For case studies of buildings that have already received thermal retrofits, see Appendix C.

Source: Authors

The savings from each package of ESMs is substantial. The End-user Heat Control package saves more than 3,000 GWh of heat energy per year. Simple retrofit can save about 5,500 GWh heat energy per year, and Deep retrofit saves more than 12,000 GWh heat energy per year. At

[29] During the recent fifteen years about 15 million m^2 of residential buildings have undergone capital renovation all over the country. Minsk has been a market leader in residential thermal retrofit. From 2007 to 2014 the city supported capital renovation of 4.6 million m^2 residential buildings. As a part of the effort to increase energy efficiency of Minsk City, Minsk City Housing Company introduced the system for remote regulation of building level heat consumption and data reading from heat meters (97.5% of building heat meters and 71.1% of building heat regulation systems in the Minsk have been connected to the system of remote reading and regulation).

[30] See Appendix F for a more complete description of the methodology used to estimate savings.

current tariffs, however, few of these investments have reasonable payback periods. Simple and deep retrofits both have payback periods well over 100 years. Payback periods could be reduced dramatically by increasing tariffs to cost-recovery level. Table 3.1 shows the potential annual energy savings (in GWh) of each package, the capital expenditure (CAPEX, in USD) required to implement each package and payback periods at the current tariff (about USD 7.50 per Gcal, or USD 0.00645 per kWh) and at cost-recovery level (about USD 90 per Gcal, or USD 0.07739 per kWh, which is the cost of service estimated for small natural gas fired DH systems). It also includes the present value of the energy savings as a percentage of Belarus' GDP (as of 2013).

Table 3.1: Summary of Savings Potential and Investment Costs, by Package and Building Type

Package	Group of buildings	Floor area (m^2) receiving the measure	Annual energy savings, GWh	CAPEX (million USD)	Payback period at current tariff	Payback period at cost-recovery	PV of savings as % GDP (2013)
End-User Heat Control	<5 Floor	47,821,217	1,412	$ 143.16	16 years	1 year	0.23%
	>5 Floor	78,926,193	1,740	$ 234.72	21 years	2 years	0.28%
Simple Retrofit	<5 Floor	58,393,635	2,315	$ 1,733.27	116 years	10 years	0.39%
	>5 Floor	96,375,365	3,199	$ 2,948.39	143 years	12 years	0.55%
Deep Retrofit	<5 Floor	58,393,635	5,466	$ 6,176.39	175 years	15 years	1.01%
	>5 Floor	96,375,365	6,591	$ 8,047.84	189 years	16 years	1.21%

Note: For Simple and Deep Retrofits, the total investment includes the cost of installing TRVs and allocators twice, as they need to be replaced every 10 years. The floor area receiving the TRVs and allocators remains the same as shown for End-User Heat Control. This means that some buildings will receive Simple or Deep Retrofit without receiving TRVs and allocators. Energy audit and design costs for deep retrofit vary depending on the size of the project. A rule of thumb estimate would be about 10 percent of CAPEX. A 10 percent increase in CAPEX would increase the payback periods of the deep retrofit by about a year.

Source: Authors.

Supply curves offer a convenient visual way of analyzing the relationship between investment cost and savings. The levelized cost of energy saved is the cost of reducing a unit of energy demand (USD per kWh), discounted over the life of the implemented measure. This cost can then be compared to the current tariff as well as the full cost tariff, in order to determine which of the energy savings measures are financially viable, given current energy costs. Table 3.2 summarizes the assumptions used to create the supply curves.

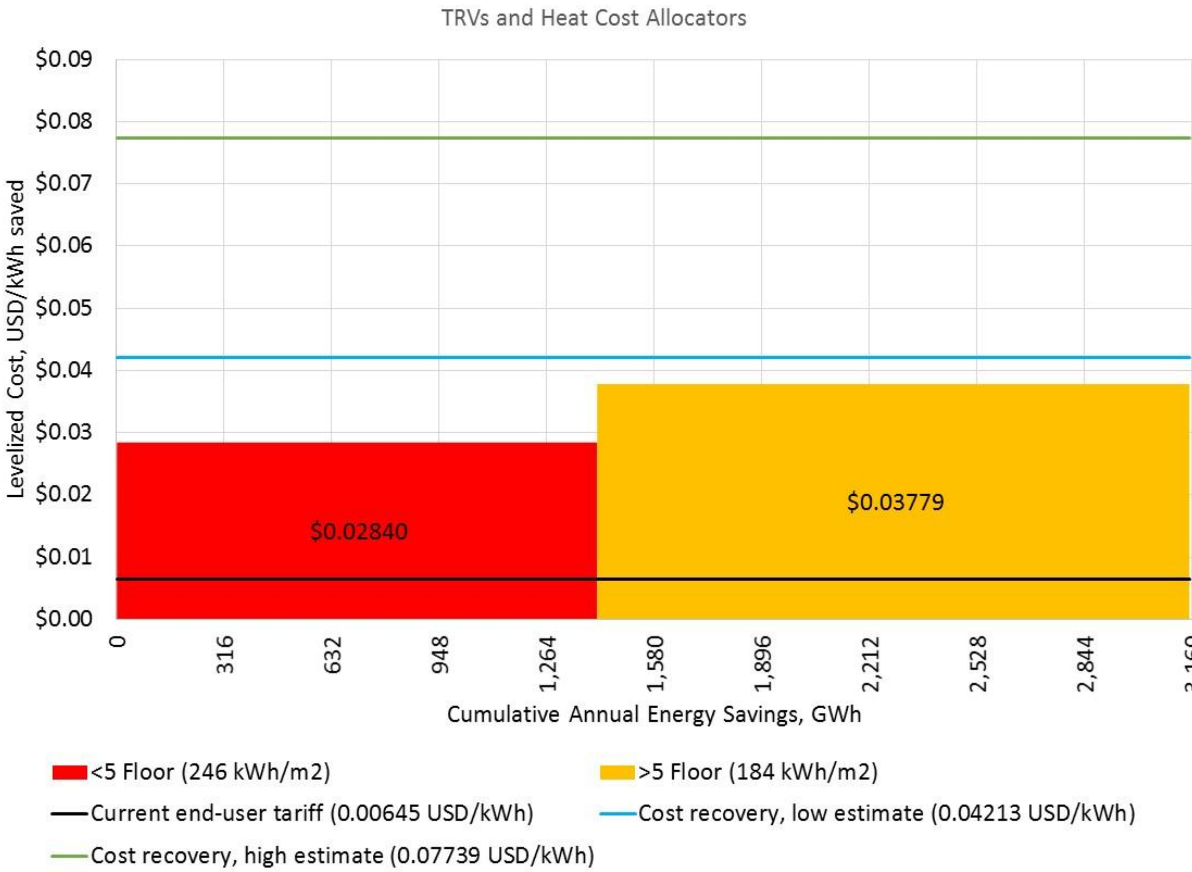
Table 3.2: Key Assumptions for Supply Curve Analysis

Parameter	Assumption
Discount rate	25% (commercial borrowing rate)
Asset life	20 years for insulation and windows 10 years for TRVs and HCAs
Construction period	1 year
Tariff needed to recover cost of supply by the big DH systems under Ministry of Energy (CHP plants)	0.04213 USD/kWh (49 USD/Gcal)
Tariff needed to recover cost of supply by the small DH systems under Ministry of Housing and Utilities (natural gas heat-only boilers – HOBs)	0.07739 USD/kWh (90 USD/Gcal)

Source: Authors.

The EE supply curve for End-User Heat Control plots (on the x-axis) the cumulative energy savings potential of the package by building type and (on the y-axis) the levelized cost of the package for each building type (Figure 3.10). The horizontal lines show the current residential tariff and two estimates of the full cost of heating (depending on DH system type).

Figure 3.10: Levelized Energy Cost of End-User Heat Control Package



Note: The energy consumption baselines shown here differ from those shown in Section 3.1. These baselines have been adjusted to assume an internal temperature of 24° C[31], to allow a more accurate estimate of the potential energy savings of the ESM packages.

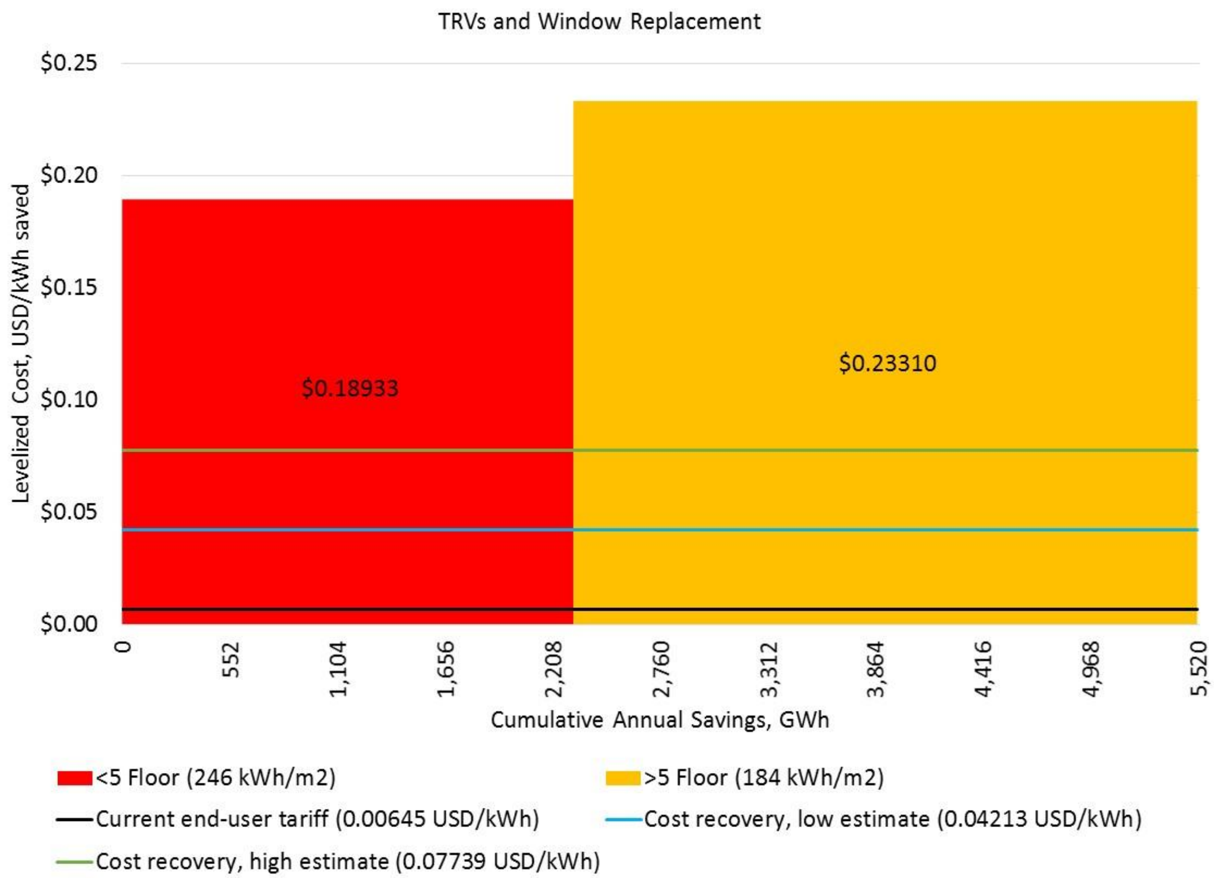
Source: Authors.

The levelized cost of TRVs and HCAs is higher than the current tariff. To be financially viable for end-users, the levelized cost of the package must fall below the level of the current tariff (the black line). Under the current end-user tariff, there would be no incentive for users to pay investments to install TRVs and HCAs because the levelized costs exceed the tariff. However, End-User Heat Control would be financially viable for both building types at both cost-recovery for heat supply by either the Ministry of Energy (CHP plants) or the Ministry of Housing and Utilities (HOB) because their levelized costs are below the blue and green lines that represent cost-recovery levels.

[31] Based on limited surveys thermal comfort level in Belarus is found to be high, on average the indoor temperature is 21-22° C, many of apartments have up to 24° C

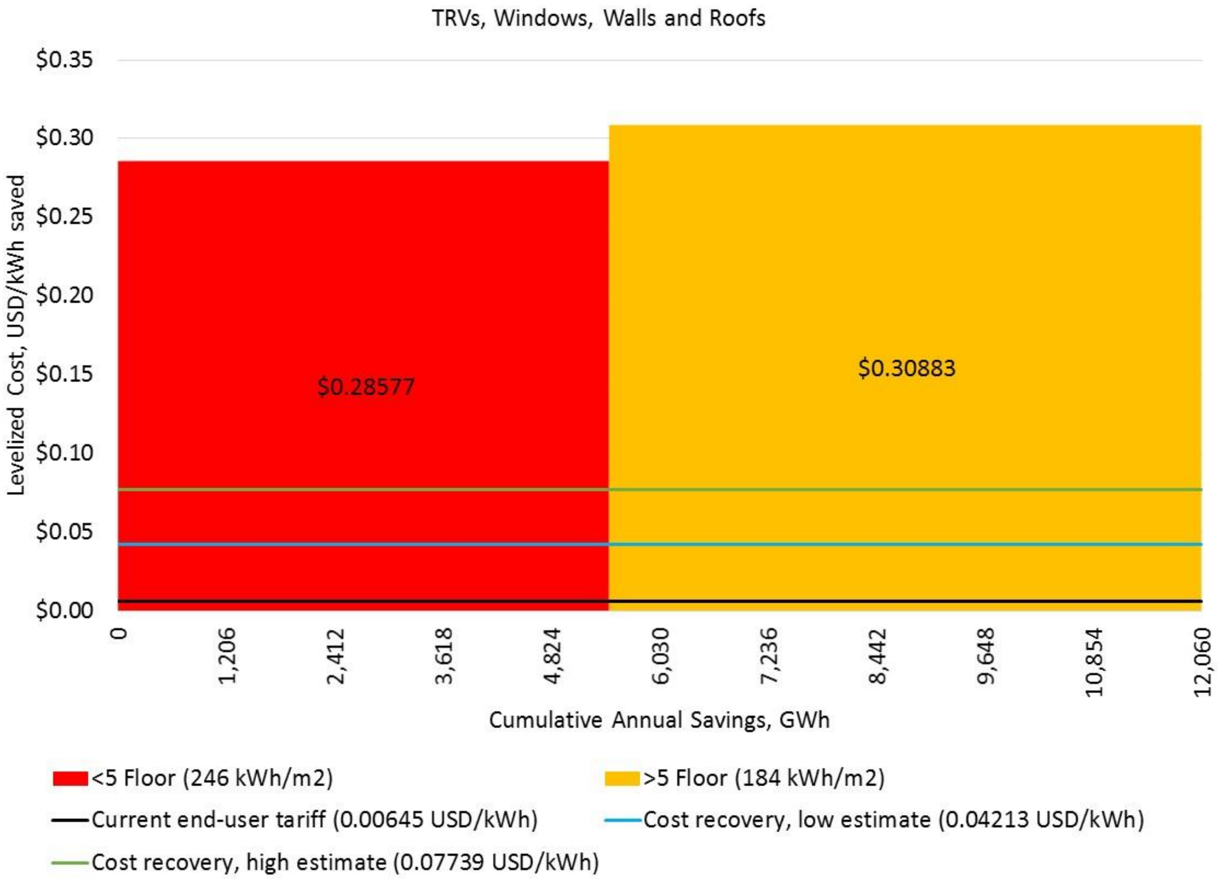
Neither Simple Retrofit nor Deep Retrofit is financially viable at commercial interest rates, as the levelized cost for both building types exceeds even the highest cost-recovery level for both packages (Figure 3.11 and Figure 3.12).

Figure 3.11: Levelized Energy Cost of Simple Thermal Retrofit



Source: Authors.

Figure 3.12: Levelized Energy Cost of Deep Thermal Retrofit

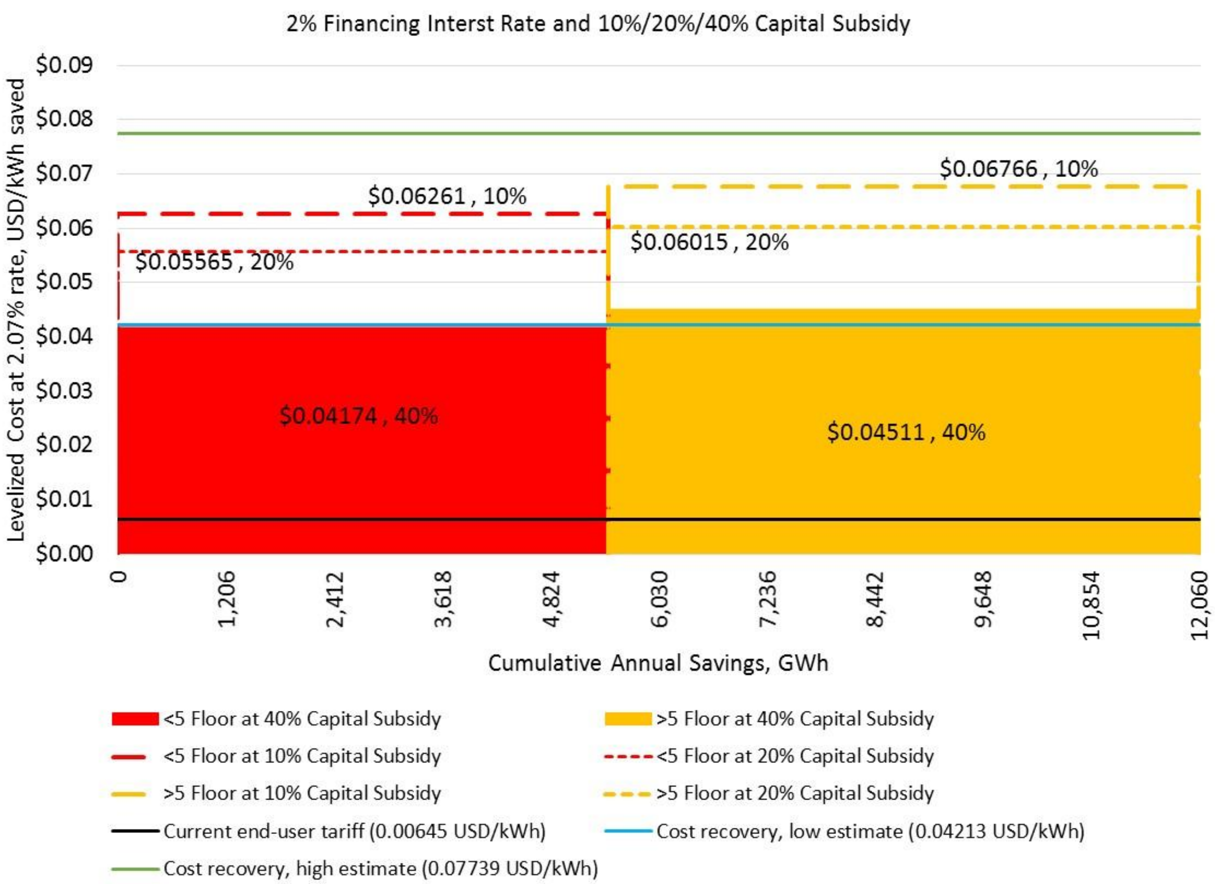


Source: Authors.

Deep Retrofit could, however, become financially viable with low-cost financing from International Financial Institutions (IFIs), along with a capital subsidy (Figure 3.13). The assumptions for the supply curve below are the same as in Table 3.2, but using 2.07 percent financing interest rate in place of the 25 percent discount rate, and with the addition of a 10, 20 or 40 percent capital subsidy.

This simple analytical exercise clearly indicates the easy gains achievable by introducing TRVs and HCAs, as well as the huge financial challenge to scaling up deep renovation. The heat tariff reform planned by GoB would give households clear incentives and benefits from investing in TRVs and HCAs. However, even with full cost recovery tariffs, the energy cost-saving benefit alone would still be too small for households to justify investments in deep retrofit. Thus, the government has a critical role in helping secure long-term capital at attractive interest rate and in providing additional incentives to leverage private investments.

Figure 3.13: Levelized Energy Cost of Deep Thermal Retrofit, with Low-Cost Financing and Capital Subsidy



Source: Authors.

3.3 Barriers to Scaling Up Thermal Retrofit

Barriers to residential thermal retrofit in Belarus fall into the following categories: incentive-related barriers, financial barriers, and implementation barriers. The subsections below describe each of them in more detail.

Incentive-related barriers

- **Heat and electricity tariff subsidies.** Residential heat customers receive generous cross-subsidy from commercial and industrial heat customers. Residential heat tariffs are around 85 percent below cost-recovery levels. This significantly undermines incentives for implementing EE measures by increasing payback periods.
- **Absence of heat metering and controls at the apartment level.** As described in Section 3.1, only nine percent of residential buildings are equipped with apartment level heat meters and TRVs. Heat is generally metered at the building level, but the household heating bill is generally based on the floor area of its apartment. Most

customers' bills therefore have no direct relation to how much they consume, and the absence of TRVs means that—even if customers were billed on the basis of consumption—they would have no ability to change their consumption in response to price changes.

- **Long payback periods of some EE investments.** At current tariff levels, both simple and deep retrofits have extraordinarily long payback periods, ranging from 116 to 189 years. In other words, these packages are not economically or financially viable based on energy cost savings justification. If tariffs are increased to cost-recovery levels[32] however, the longest simple payback period amongst all the packages decreases significantly, to 16 years.
- **EE is undervalued by the market.** Specific heat consumption for space heating and hot water supply is not considered to be an important market valuation criterion for residential flats or apartments because of the current low tariffs.

Financing barriers

- **Inability of homeowners associations to take loans.** The inability of homeowners associations to take loans and conduct building-wide thermal retrofits leaves homeowners to carry out individual small-scale retrofits, decreasing the cost effectiveness and thermal efficiency of improvements. According to the survey that was conducted as part of this study, about 70 percent of respondents in buildings that had not received thermal retrofits spent their own money to replace windows or entry doors.
- **Consumer credit is limited; interest rates are high and loan terms short.** Private investments in deep retrofit are more likely if low cost financing with long loan terms are available. This is particularly true if a long payback period is needed to achieve energy cost-savings from investments.
- **Limited of government financial resources to support thermal retrofits.** The existing government program, which provides low-interest loans to individual households to conduct different EE measures (including thermal retrofits), has a long waiting list, limited resources and is available only for low income households in small cities. Beginning in 2015, the GoB reduced public financing for thermal retrofits. Previously, when multi-apartment buildings were selected for capital improvements, costs for thermal retrofit were included in the scopes of work and the costs shared by the households and public sector (20 percent by the households, 80 percent by the public sector). As of 2015, the cost of thermal retrofit will still be included in capital modernizations, but to a more limited extent. Public funds will be available to subsidize the capital renovation, but expensive thermal retrofits will be included in the renovation only if a technical review finds that defects in the building envelope have an impact on the building's structural integrity.

[32] The existing cost recovery level was taken into consideration for this study. In reality the cost recovery level may change due to efficiency improvement or new investment. The study did not make tariff projections.

Implementation barriers

- **Lack of proven sustainable and scalable commercial model.** The largely government-financed capital renovation program has implemented deep thermal retrofit in a significant number of buildings. With an 80 percent capital subsidy, it is not a sustainable financing model. These projects are exclusively implemented through the existing state unitary enterprises of housing repair and maintenance (ZhREO) with limited engagements of the private sector energy service providers, and without the involvement of commercial banks. Reforms in the housing and utility sector have been planned, and when implemented, will likely have significant implications on the feasibility of the delivery model used in the capital renovation program so far.
- **Lack of awareness.** Belarus is working with the population to promote awareness of EE for end-users, however there is no regular measurements or evaluation of end-user practical awareness of EE or other types of feedback provision. Awareness of the technological and economic benefits of construction technologies is quite low among designers, developers and contractors.

3.4 Options for Financing and Delivery

Regional experience with residential retrofits indicates that there are a number of options for overcoming the barriers described in Section 3.3, and facilitating the scale up of EE investment in residential buildings. These options are summarized in Table 3.3 and described in greater detail in Appendix D. As the commercial market for EE financing is not yet established in Belarus, the option considered most suitable for Belarus is the EE fund option, with two potential variations. One involves the Ministry of Finance (MoF) on-lending to the municipal housing agencies or another municipal-level implementation entity and one involves the establishment of a national housing renovation fund (Table 3.3). These options are presented in the following sub-sections.

Table 3.3: Summary of Possible EE Financing Mechanisms in the Residential Sector

Option	Pros	Cons
EE Funds Independent entity providing financing for EE (e.g., loans and guarantees)	• Can be sustainable; mandated to promote EE • Can develop specialized products; centralized experience and lessons	• May distort market • Could create monopoly • May not operate efficiently • Can be captured by political interests
Commercial Bank Financing	• Sustainable • Allows for competition of financing and builds off existing credit system	• Only serves creditworthy customers • May involve high interest rates • Banks may lack incentive to market aggressively
Partial Credit Guarantees Offering coverage of potential losses from EE loan defaults	• Encourages commercial banks to finance EE • Helps overcome risk perception of banks • Can lead to sustainable commercial financing	• Requires mature banking sector interested in EE financing • May need substantial capacity building of banks • May serve only creditworthy customers
Utility EE programs in the form of DSM or an EEO scheme	• Can be done sustainably • Builds on utility relationships and services • Allows for simple collections (on-bill repayment)	• Utilities lack incentives to reduce energy sales • Regulations may limit new utility services, billing • Can create a monopoly

Source: Western Balkans: Scaling Up Energy Efficiency in Buildings." 2013. The World Bank Group.

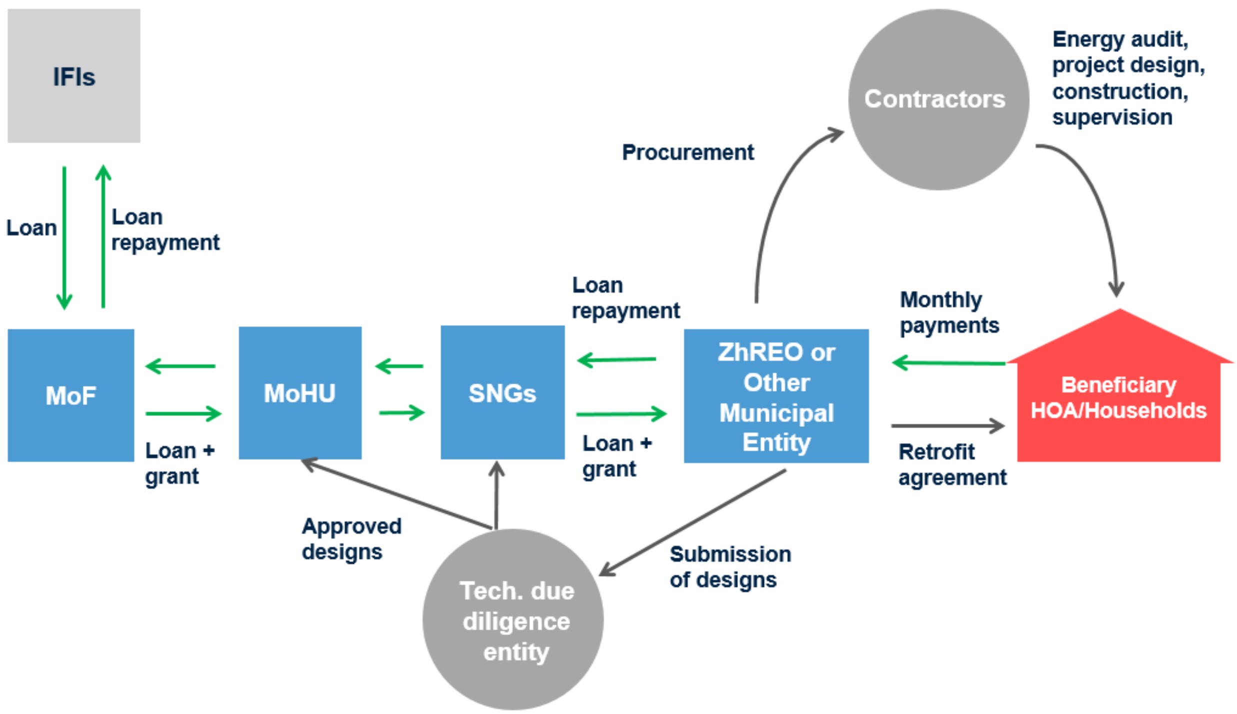
Ministry of Finance On-Lending to Subnational Governments

This potential national scheme builds on the existing implementation system of the capital renovation program (Box 3.1), but dedicated specifically with residential thermal retrofits, using debt financing arranged by the national government. The primary objective of such a program is to demonstrate a scalable delivery mechanism for deep thermal retrofit using debt financing, thus paving the way for commercial financing in the long-term. It differs from the existing capital renovation program in two main areas: (1) the share of capital grant will be substantially lower. For example, instead of 80 percent, a 40 percent capital grant may be considered (the actual level will need to be further analyzed based on in-depth market studies); and (2) the role of HOAs will be much more important since substantially higher monthly fee contribution from households will be needed in order to pay for the loaned amount of the investment. As a result, households are likely to have a much stronger interest in participating in the decision making process and in the quality of retrofit work.

Under this arrangement, the Ministry of Finance uses budget resources or low cost capital from international finance institutions (IFIs). The funds would be on-lent to subnational governments (SNGs) through a central agency (e.g., Ministry of Housing and Utilities). The SNGs will be responsible for the selection and approval of the buildings for thermal retrofit. ZhREO or other municipal implementation entity will be responsible for implementing the thermal retrofit projects (Figure 3.14). Grants for reducing the capital cost incurred by households (encouraging them to participate in the program) can be disbursed through the same system, and MoF may require SNG contributions to the grant funds. HOAs may elect to pay upfront, thus reducing the ongoing monthly fees. An indicative financing package could be, for example, 50 percent debt

(MoF on-lending), 40 percent capital grant (include SNG contributions), and 10 percent down-payment by HOAs.

Figure 3.14: Ministry of Finance On-Lending to Subnational Governments



Source: Authors.

The ZhREO would serve as the implementing agency, carrying out its existing mandate. It would manage the process of planning, procuring, disbursing funds for retrofits based on agreed terms and conditions, and collecting repayments from households. Designs and drawings would be approved by a separate, technical due diligence entity, which provides independent technical review of proposed thermal retrofits from ZhREO. The State Construction Expertise (GosStroiEkspertiza) could possibly fulfill this role.

Box 3.1: Existing Approval and Financing Processes for Thermal Retrofits in Residential Buildings in Belarus

The process of initiating and getting approval and financing of thermal retrofits for a residential building is fairly complex in Belarus. State Unitary Enterprises of Housing Repair and Maintenance (ZhREOs) are unitary enterprises responsible for maintaining the building stock. They are accountable to sub-national governments (SNGs), but operate as commercial entities. They collect fees from residents for building maintenance and capital repairs, but because these fees are low, ZhREOs receive subsidies from local governments. There are also ZhREOs that are responsible for preparing, and submitting project design documents to introduce thermal retrofit of buildings to the respective authorities for appraisal, review, and approval. At the subnational level, project design documents are submitted to the various unitary enterprises known as "GosStroiEkspertiza" for appraisal. The appraisal process takes up to one month, during which project feasibility is evaluated. Once the project design documents are approved, a list of projects is submitted to Departments of Construction which are part of local executive committees. ZhREO procures services for construction using an official online platform called icetrade.by. The contractor may be a private or public enterprise such as the Directorates of Capital Construction. Residents pay for their share of retrofit cost through monthly payments for housing maintenance and communal services rendered by the ZhREO.

Customers would repay the loan portion of the investment through an addition to the monthly service fees they currently pay the ZhREO. The ZhREO would use those funds to repay the loans to SNGs which in turn will forward the payments to MoF. Taking into consideration the ongoing reform of the housing and utility sector, the existing ZhREOs might be transformed to some other form of utility or might fulfill some additional functions. In such case, the financial delivery mechanism remains generally unchanged, only ZhREO will be replaced with a new entity established within the reform process.[33]

Housing retrofit fund

To move to a more stable and dedicated long-term financing platform for residential thermal retrofit, the GoB could consider the creation of a housing retrofit fund (HRF). The HRF can be initially capitalized by government budget and/or IFI loan, and set-up and operated as a capital grant fund or a loan fund. The capital grant fund would aim at directly leveraging commercial bank financing for residential thermal retrofit by subsidizing the capital cost of retrofit thus reducing the principle amount which a HOA needs to borrow. The commercial banks would lend to HOAs at market rates. Such a grant fund is similar to the Thermal Modernization Fund of Poland (Box 3.2). But this approach requires maturity and capacity of HOAs and strong commercial bank involvement, two aspects which still need further development in Belarus.

[33] The reform of the system of housing and utility services started in March 1, 2015 with a pilot project in Partizansky and Pervomaisky Districts of Minsk. The key element of the reform is the separation of the administrator and contractor functions of the existing ZhREOs. In Pervomaisky District the existing ZhREO was supplemented by the Housing and Utility Enterprise of Pervomaisky District. Under the new structure, the ZhREO will only perform contractor activities, such as maintaining buildings and facilities, while the Housing and Utility Enterprise of Pervomaisky District will be the administrator who tenders bids and arranges for housing management, major repairs, grounds cleaning, emergency and lift services, solid waste management, fee-based services, and processing of individual requests of the households.

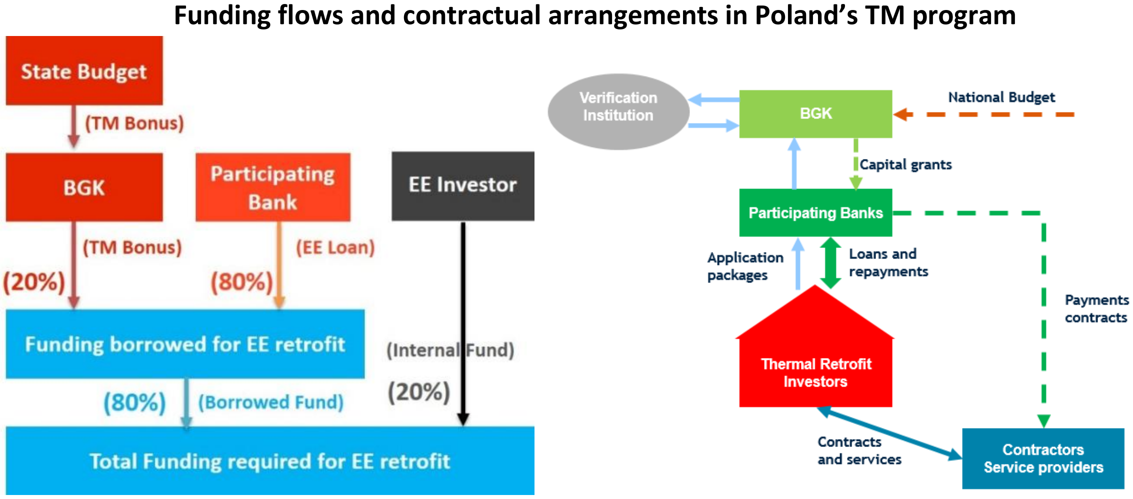
Box 3.2: Poland Thermo-Modernization Program

Poland introduced a Thermo-Modernization (TM) program in 1998 to finance EE investments in existing non-commercial buildings. The TM program leverages domestic commercial financing by providing a significant subsidy upon completion of eligible projects. Five years after rollout, uptake remained low, so the government streamlined the application process and made grants available earlier, and response to the program improved. The state-owned Bank Gospodarstwa Krajowego (BGK) administers the program and disburses the TM subsidy. Sixteen banks participate by providing loans on commercial terms.

The program supports EE investments in residential, non-commercial and public buildings, and district energy networks and providers. Eligible entities are HOAs, cooperatives, individuals, companies, and city and local authorities. Typical measures include insulation, window replacement, installation of thermostatic valves and weather-driven controllers, and water heater upgrades.

Once investors identify an EE retrofit project, an energy auditor examines designs appropriate measures. Project proponents then submit the audit report with a combined application for a commercial loan (of up to 80 percent of project costs; see figure) and TM subsidy (up to 20 percent of the loan value) to one of the 16 participating banks, which appraises the loan application, verifies creditworthiness, and confirms eligibility for the subsidy. BGK then reviews the application package and commissions an independent verification of the energy audit. On approval, the borrower executes the EE project, usually through a contractor. Upon project completion, BGK disburses the TM funds to the bank, which applies it to the outstanding loan principal. Banks may also pay contractors directly, although this shifts the burden of procurement oversight to banks, and requires upfront expenditures by contractors, demanding that they have strong financial positions.

Funding flows and contractual arrangements in Poland's TM program

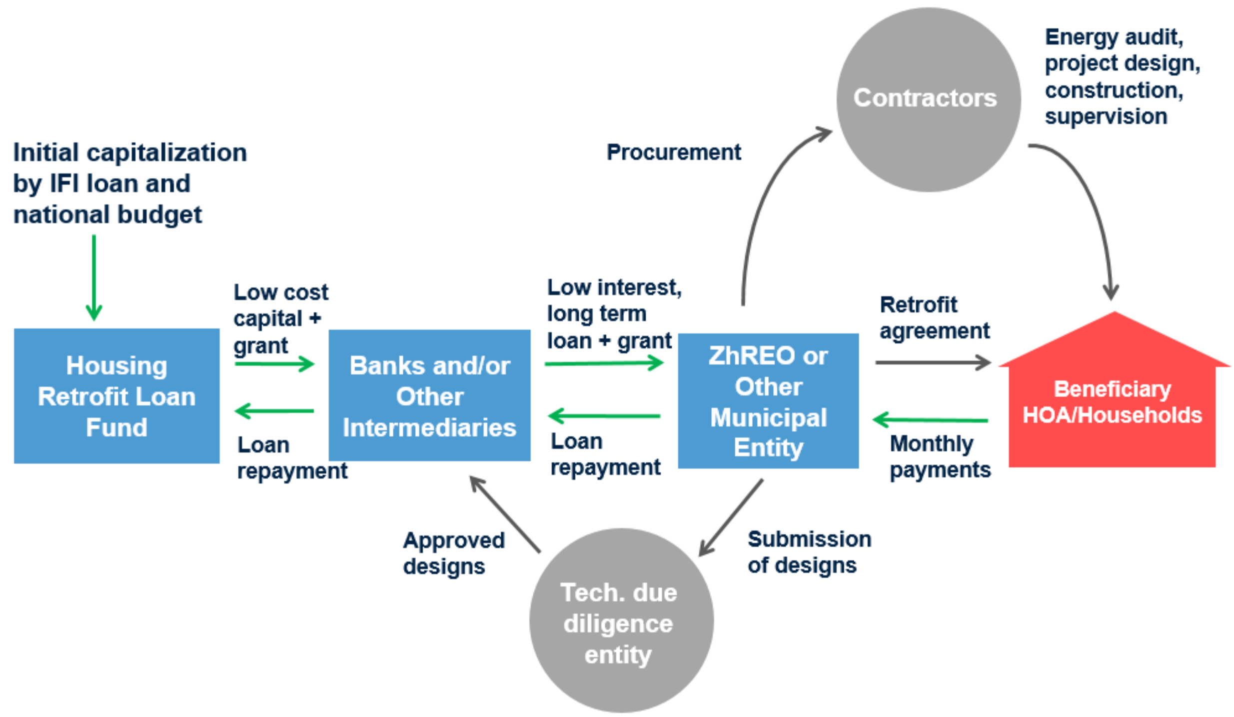


Subsidy applications grew from just 144 in 1999, peaked at over 4,200 in 2012, then declined to about 1,500 per year. Of the 32,417 applications received as of March 2014, 30,153 were approved, with total subsidy value around US$533 million, representing 88 percent disbursement and leveraged US$2.56 billion in commercial project financing. Most subsidy applications came from HOAs (54 percent) and housing co-operatives (35 percent). The remainder were from municipalities (5 percent), individuals (4 percent) and social housing associations (2 percent). Most applications (93 percent) were for projects in apartment buildings, and a small number for public utility buildings (4 percent), detached houses (2 percent) and other buildings (1 percent).

Source: Based on presentation of Marian Rekiel, Thermo-modernization and Refurbishment Program in Poland, 2014

The loan fund, while being able to still provide capital grants, would mainly aim at shoring up low interest, long-term loans for HOAs. While commercial banks can be part of the scheme (but lending at agreed interest and term), government agencies can be intermediaries as well. Such a loan fund is similar to the housing renovation fund in Lithuania (Box 3.3). This approach could rely more on municipal entities for implementation and can tolerate HOAs without adequate capacity or borrowing legitimacy, thus is considered a more suitable option, at least in the near term, for Belarus. A possible arrangement is depicted in Figure 3.15.

Figure 3.15: Potential Arrangements for a Housing Retrofit Loan Fund



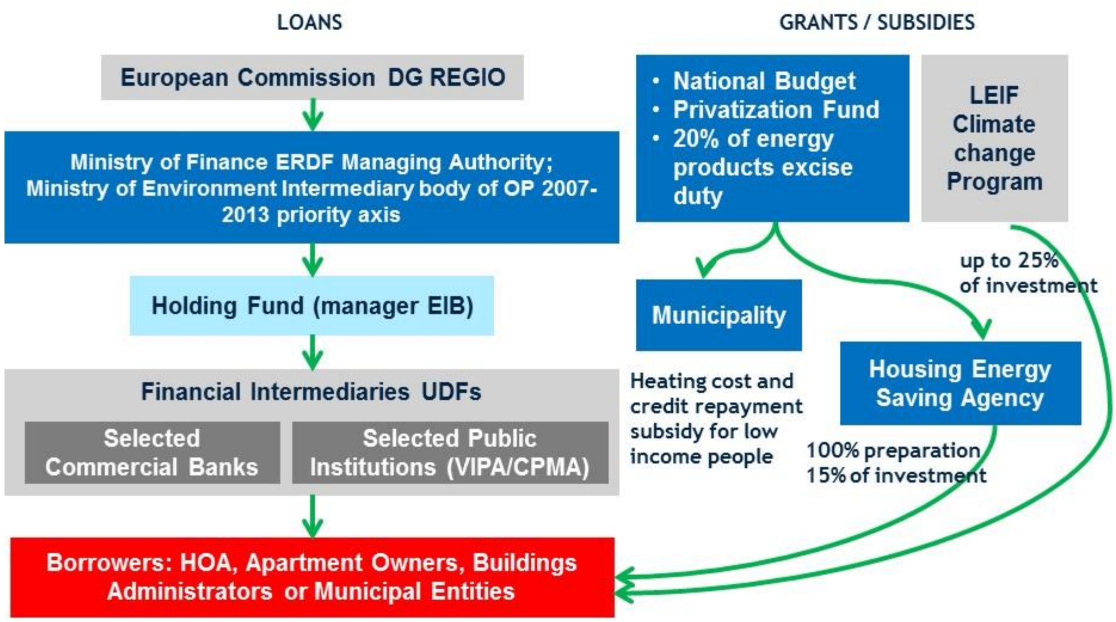
Source: Authors.

Compared with the MoF on-lending scheme, the housing retrofit loan fund is not only a permanent and professionally managed platform for channeling government support for residential thermal retrofit, but also a platform for leveraging the skill and resources of commercial banks and other financial intermediaries. The lower stream of the initial setup of the housing retrofit loan fund looks similar to the MoF on-lending scheme. In the longer-term, HOAs which are able to borrow and implement retrofit projects on their own may choose to directly borrow from participating banks or other financial intermediaries. It is likely that the establishment of the housing retrofit loan fund would require a presidential edict to allow public entities to take on loans. The housing renovation fund in Lithuania is a successful example which combines a financing window and grant component, and subsidies for low income households to increase the uptake of thermal retrofits in residential buildings (Box 3.3).[34]

[34] The housing renovation fund in Lithuania includes a subsidy component for low income households. Low income households are wholly subsidized and do not need to pay for retrofit costs. However, if low income households refuse the retrofit, they also receive a penalty in the form of reduced heat subsidies.

Box 3.3: Housing Renovation Fund in Lithuania

The housing renovation fund is a dedicated fund that provides capital for long-term and low interest loans to finance EE investments in apartment buildings. It is complimented by additional grant financing for project preparation and capital subsidies for households. Established in 2009, the fund received an initial injection of EUR 100 million from the national budget and EUR 127 million from European Regional Development Fund (ERDF) as part of the Joint European Support for Sustainable Investment in City Areas (JESSICA) initiative.[35] These funds are allocated to the Housing Energy Saving Agency (HESA) and Ministry of Environment which serve as the managing authorities of the funds. A holding fund managed by the European Investment Bank (EIB) is responsible for disbursement and administration of credits to renovation project owners (HOAs, apartment owners, buildings administrators, or municipal entities) further directs funds to Urban Development Funds (UDF), or financial intermediaries which are selected commercial banks or public institutions. In parallel, state grants and subsidies are available to borrowers for EE projects that meet specific energy performance standards. Low income households are wholly subsidized, and do not have to pay for preparation and renovation costs. Conversely, low-income households that oppose the renovations face the reduction of heat subsidy as a penalty. The loans have an interest rate of 3 percent, and term of 10 – 20 years. They are repaid through building administrators out of the savings residents make on heating payments, which are collected by the mechanism of the monthly building administration and communal services fee. If apartment owner is borrower, owner makes repayment to the UDF. If an implementation agency is borrower, apartment owners make an upgrading payment to the agency, who then makes repayment to the UDF. To account for the lender's lack of capacity, technical assistance with the preparation of technical documentation is provided.



Source: ESMAP, Case Study on the Residential EE Program in Lithuania, prepared by Viktoras Sirvydis, 2014.

[35] The JESSCIA initiative is a financing mechanism which was developed by the European Union Commission and European

3.5 A Roadmap for Scaling Up Thermal Retrofit of Residential Buildings

The two financing and delivery options identified in Section 3.4 could provide a feasible framework for scaling up thermal retrofits in Belarus through debt financing given existing administrative arrangements. Both would help increase the transparency of government assistance, accountability of key stakeholders, and the capacity of service providers. This would hasten the transition to a residential thermal retrofit regime that is primarily driven by private investments through commercial financing.

Such a transition requires a number of legal and regulatory changes, critical among them a transition to cost-recovery heat tariffs, giving households the ability to control their heat consumption, and consumption based-billing at the apartment level. Another priority is giving homeowners the ability to borrow collectively through HOAs for thermal retrofits.. Pilots will need to be carried out to test and put in place an effective financing and delivery system, including an appropriate subsidy mechanism, proper procurement and contractual arrangements for a large scale retrofit program, and quality and performance assurance. The most important barriers, and possible solutions, are summarized in Table 3.4. The principal activities to be undertaken in the next five years are illustrated in a stylized roadmap in Figure 3.16.

Investment Bank to promote sustainable urban development in EU countries, for example EE investments or other investments in urban infrastructure. It is funded through the ERDF, which provides loans at low interest rates to some EU members. See: http://ec.europa.eu/regional_policy/en/funding/special-support-instruments/jessica/

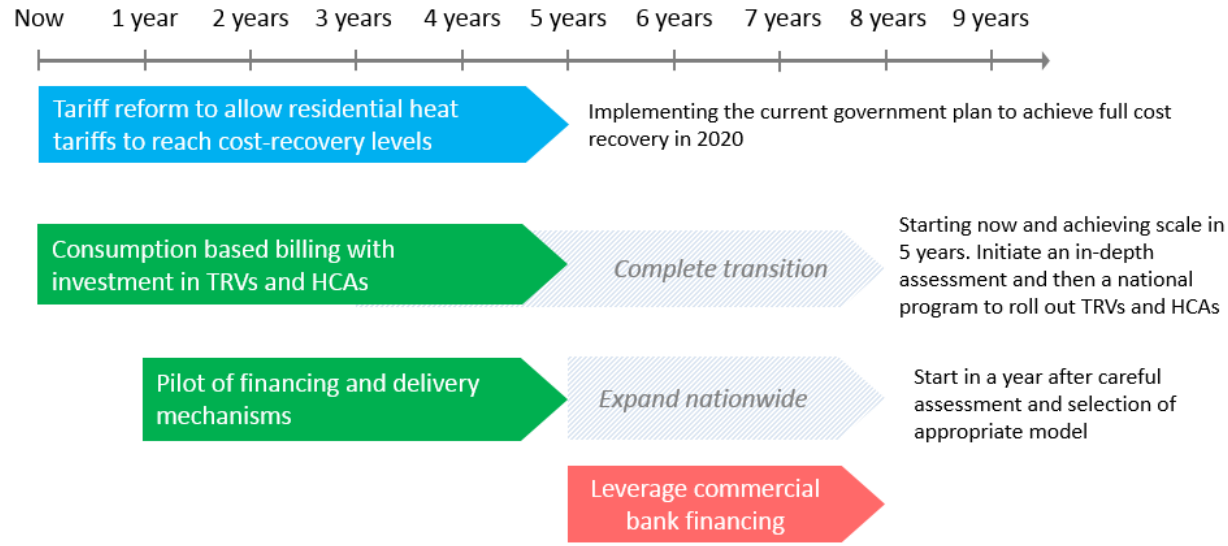
Table 3.4: Solutions to the Main Barriers to Residential Thermal Retrofit

Category of Barrier	Solutions
Incentive-related	▪ Tariff increases to cost recovery levels as planned already by the government ▪ Installation of TRVs to enable households to control heat consumption ▪ Installation of HCAs to enable apartment-level consumption-based billing ▪ Introduce system of consumption based billing alongside installation of TRVs and heat allocators ▪ Improvement of modern automated building level heat control systems (potential options include building-level heat substations, which also improves efficiency and service quality of domestic hot water supply) ▪ Launch extensive informational campaign, explaining consumption based billing system and benefits of energy efficiency.
Financing	▪ Government facilitation of debt financing supported by long-term, low cost capital [36] ▪ Capital grant subsidies to incentivize households and HOAs to invest in deep thermal retrofit ▪ Create conditions for commercial banks to enter the thermal retrofit market
Implementation	▪ Government can demonstrate the growth potential of EE retrofit market by supporting pilot projects and publishing energy savings data ▪ Government support can demonstrate viable delivery models ▪ Develop standard documents and guides (audit and tender templates, loan applications, energy calculators, HOA registration) to simplify implementation ▪ Support development of HOAs and their capacity

Source: Authors.

[36] Many ESMs have long payback periods, upwards of 10 years. Commercial financing typically only offer loans with much shorter pay-back periods. Mechanisms to extend loan tenors can be as important as grants to reduce investment costs.

Figure 3.16: Roadmap for Scaling up Deep Thermal Retrofit of Residential Buildings



Source: Authors.

Efforts for scaling up deep thermal retrofit of pre-1996 residential buildings begin with the implementation of the government's tariff reform plan which aims at achieving full cost recovery in 2020. Consumption-based billing at the apartment-level should be introduced parallel to increases in tariff levels, improvements to social assistance programs, and implementation of informational campaigns.

Investments in TRVs and HCAs should be made through a national program. The cost-effectiveness of such investments have been widely proven in countries where cost recovery heat tariffs are in place, but an in-depth assessment should be carried out to help develop a clear strategy and approach. The national program could begin with a pilot phase and could be expanded nationwide after three years. Investments in building-level substations may also be appropriate for some buildings (e.g., those with radiators embedded inside the walls). These investment measures will allow consumers to see how individual consumption habits impact heating bills, and to adjust their behavior accordingly.

Expenditures in residential energy subsidies could be shifted to investments in energy efficiency and more effective social assistance to help households cope with tariff increases (Box 3.4).[37] When apartment-level consumption-based billing is in place, a policy of cost recovery tariffs will be easier to implement as customers are able to scale back consumption based on their ability and willingness to pay for heat at a higher tariff rate.

International experience indicates that fast-paced tariff reform coupled with the broad introduction of consumption-based billing and investment in TRVs and HCAs is feasible and can bring visible evidence of reform benefits (Box 3.5). This requires extensive informational

[37] Caterina Ruggeri Laderchi, Anne Olivier, and Chris Trimble, "Balancing Act: Cutting Energy Subsidies While Protecting Affordability", Washington, DC: World Bank, 2013.

campaigns for consumers on both a national and DH utility level, explaining the benefits of consumption based billing, energy efficiency, and tariff reform to homeowners.[38] To help households cope with tariff increases, reform should be supported by an expansion of the GoB's Targeted Social Assistance Program and possible reintroduction and refinement of the Housing and Utility subsidies program.[39]

With consumption-based billing in place, and tariffs at cost-recovery levels, consumers will have stronger financial incentive to undertake thermal retrofits. These retrofits will also have a dramatic effect on improving level of comfort, and reducing moisture build-up on walls during the winter months. Concessional lending and grant funding will still be necessary and could be implemented through either of the options previously discussed. Concessional financing will, in particular, be important to incentivize investments where payback periods are longer than the typical terms of commercial loans.[40] However, the need for concessional financing could be reduced over time (i) as commercial lenders begin to enter the market; (ii) as tariffs are increased, reducing payback periods; and (iii) as income growth drives households demand and affordability for investment in improved housing and thermal comfort conditions.

[38] A recent focus group discussion and stakeholder analysis conducted as part of the World Bank's *Belarus Heat Tariff and Reform and Social Impact Mitigation* Study found that insufficient interaction between DH service providers and consumers contributed to a lack of trust and understanding.

[39] World Bank, "Heat Tariff Reform and Social Impact Mitigation: Recommendations for a Sustainable District Heating Sector in Belarus", 2014.

[40] Eligibility criteria for grant and concessional financing can be determined during the piloting phase. These criteria will likely be based on a demonstrated minimum energy efficiency threshold or specific heat consumption achieved after retrofits.

Box 3.4: An Integrated Strategy for Improving Fiscal Sustainability While Ensuring Affordability

An integrated strategy is required to ensure the affordability of energy for the vulnerable groups while increasing tariffs to cost-recovery levels. This involves introducing or revising measures and programs that support low-income customers while offering incentives for all households to better manage their energy consumption. According to World Bank estimates, countries in the Europe and Central Asia (ECA) region stand to save 0.5 to 1 percent of GDP by putting in place a comprehensive strategy.

Common measures to mitigate the impact of tariff increases on low-income households in the ECA region have included lifeline tariffs and transfer programs, which can either be earmarked for energy consumption or non-earmarked. Since the beginning of the global economic crisis in 2008, a number of countries have introduced important reforms in social assistance systems to increase their effectiveness including strengthening the targeting of the programs and moving away from some of the categorical benefits. For example, in Romania, recent changes in the eligibility criteria for district heating subsidies were introduced to ensure that the subsidy program could better cushion the impact of the removal of central subsidies for district heating producers. Efforts have been put in place to create more transparent and accountable systems. These efforts also cut down on the bureaucratic requirements that can make it difficult for low-income households to apply for the benefits. Such efforts should help create a unified registry of beneficiaries and consolidate the many small programs that are part of the overall social assistance system.

In Belarus, the GoB could expand the Public Targeted Social Assistance Program (GASP) and reintroduce the housing and utilities (H&U) program. To expand the GASP program, GoB could consider extending the payment period from six months to a year, raise the income eligibility threshold and increase government funds dedicated to this program. If the GoB re-introduces the H&U program, it could incorporate a refined income test to determine eligibility and to differentiate benefit payments based on income levels. For example, the expenditure thresholds above which households are eligible to receive subsidies should be higher for higher-income households and lower for poorer households. The study *Heat Tariff Reform and Social Impact Mitigation: Recommendations for a Sustainable District Heating Sector in Belarus* estimates the fiscal cost and improved targeting efficiency of expanding GASP and reintroducing the H&U program (Appendix K).

The second pillar of the integrated strategy involves efforts to reduce residential energy demand, including: (i) developing energy efficiency strategies and implementing energy efficiency programs; (ii) disseminating information to assist users; (iii) comprehensive planning to address all issues; (iv) offering grants and funds; (v) developing and updating building standards; and (vi) helping owners and renters implement energy efficiency measures in buildings. Moreover, while changes in laws and regulations can be undertaken quickly, changes in behavior are slow. Specific measures, such as introducing smart metering and certificate programs, can help because they allow households to make informed decisions.

Finally, because putting in place effective measures to help households adapt and cope with higher energy tariffs is going to require time, countries should assess the temporary or transitional measures that might be needed to avoid sharp shocks that would make it difficult for households to cope.

Source: Caterina Ruggeri Laderchi, Anne Olivier, and Chris Trimble, “Balancing Act: Cutting Energy Subsidies While Protecting Affordability”, Washington, DC: World Bank, 2013. World Bank, “Heat Tariff Reform and Social Impact Mitigation: Recommendations for a Sustainable District Heating Sector in Belarus”, 2014.

Box 3.5: Heat Metering and Billing Reforms Unlock Adoption of EE in Buildings: Poland's Experience

With partial support from a World Bank loan, four Polish cities of Warsaw, Krakow, Gdansk, and Gdynia renovated their heat supply systems. From 1991 to 1999, building-level heat meters were installed in existing buildings and heat tariff reform was introduced. The existing heat tariff charged at the building level was changed to a square-meter basis. During this time, the Government of Poland introduced additional measures to increase households' responsibility to pay for delivered heat, thereby stimulating more-efficient use of heat. Households (or companies acting as their agents) invested in radiator valves (TRVs), heat allocation meters, better windows, and insulation. While building piping systems generally remained unchanged—single-pipe vertical systems are still in place— radiator bypass pipes were added where needed. Overall, the per m^2 cost of heating fell by 55 percent owing to consumers' efficiency measures, and to technical, operational and management improvements by heat supply companies, mitigating the impact of subsidy removal.

Results in Four Cities	1991-1992	1999	Change
Household heat bill subsidy (%)	67	<5 (1994)	-93%
Heat bill charged to households (1999 US$/$m^2$)	13.7	6.2	-55%
Heated floor area (million m^2)	63.8	68.6	+7%
Heat energy sold (Gcal/m^2)	0.27	0.22	-18%
Energy savings			22%

Nationwide, household heat subsidies provided by municipal governments were eliminated by the end of 1997 from 78 percent of the cost of service in 1991. Installation of building-level heat meters has been mandatory since 1999. A total of 5.5 million heat allocation meters—to assign heating costs among units—were installed as of 1997, covering about 30 percent of dwellings nationwide (apartment-level heat meters are significantly more expensive). Projects often required water quality improvements to ensure that meter installations were effective. More than ten companies have competed for billing services, including allocation meter installation, meter reading, billing and maintenance. Energy savings stemming from the reform and reflected in customer heat bills typically range from 20 to 40 percent.

Poland's end-use demand for heat energy fell, but similar measures may not have that same impact in other countries as heating levels in Polish apartments were generally adequate before the reforms, such that post-reform service levels were approximately the same. Elsewhere, such as in Lithuania, apartments tend to be under-heated, so energy efficiency gains may be harvested more in terms of improved comfort level instead of energy savings (decrease in overall demand). It is possible that residential sector heat demand could stay at roughly the same level while meeting substantial latent demand for energy services—achieving a significant development impact with no net increase in primary energy consumption.

Source: World Bank, Implementation Completion Report for a Heat Supply Restructuring Project, Report No.20394, June 2000

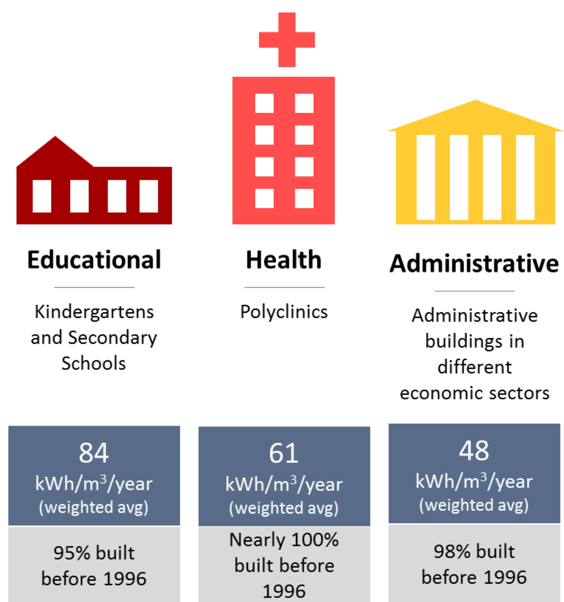
4 Financing and Delivery of EE in Public Buildings

The public building stock, like the residential building stock, consists of mostly pre-1996 buildings with poor energy performance. Recently constructed public buildings have substantially better energy performance than those built before 1996. Section 4.1 describes the characteristics and performance of the public building stock, with a focus on educational, health and administrative buildings. Section 4.2 analyzes the technical, financial and economic potential of selected energy savings measures that could be implemented. Section 4.3 identifies barriers to EE in the public sector. Section 4.4 presents potential options for financing EE improvements. Section 4.5 concludes with a roadmap for scaling up EE in public buildings in Belarus.

4.1 Characteristics of the Public Building Stock

More than 90 percent of public buildings in Belarus were built before 1996, including 95 percent of kindergartens and secondary schools, nearly 100 percent of polyclinics, and 98 percent of administrative buildings (Figure 4.1). Thermal retrofits in these buildings could result in substantial energy savings.

Figure 4.1: Typology of Public Buildings Built Before 1996



Note: In Belarus, energy performance of public buildings is measured in terms of volume (kWh/m^3) instead of area (kWh/m^2) as in residential buildings.

Source: Authors based on data from SNB 4.02.01-03.

The GoB began work to improve the EE of the public building stock many years ago (e.g. Council of Ministers' Decree # 1820 'On Additional Measures for Efficient Use of Fuel and Energy Resources' in 2003, to equip all public buildings with heat and water meters and systems of heat energy regulation). The work has included close collaboration with the IFIs. Box 4.1

includes information about two such World Bank projects implemented jointly with the Energy Efficiency Department, Ministry of Energy and Oblast Executive Committees.

Box 4.1: World Bank Investment Projects aiming at Increasing EE in Public Buildings

Post-Chernobyl Recovery Project (2006-2013), USD80 million investment

The project provided the population residing in the Chernobyl-affected area with energy-efficient and reliable heat and hot water services. Implemented in the three most affected oblasts: Brest, Gomel, and Mogiliev, the project addressed such immediate problems as (i) replacement of inefficient old boilers and heat distribution systems, (ii) installation of new windows, (iii) improvement of lighting and insulation in social institutions such as schools, hospitals, and orphanages, and (iv) restoration of essential heat and hot water services to social institutions that were receiving less than adequate services. Investments in residential gas connections provided clean and improved space heating to households that were burning wood inside homes with negative environmental and health consequences. The project improved energy service for 246,000 students, teachers, patients, and medical staff; 4,600 individual houses previously burning wood for heating were converted to reliable gas heating; 376 buildings were rehabilitated with improved lighting and/or upgraded windows; and 32 boilers were renovated. The measures resulted in annual savings of about 180,000 MWhs of heat energy and 15,800 MWhs of electricity. The economic internal rates of return evaluated at the completion of the project ranged from 18 to 31 percent, indicating substantial value for money.

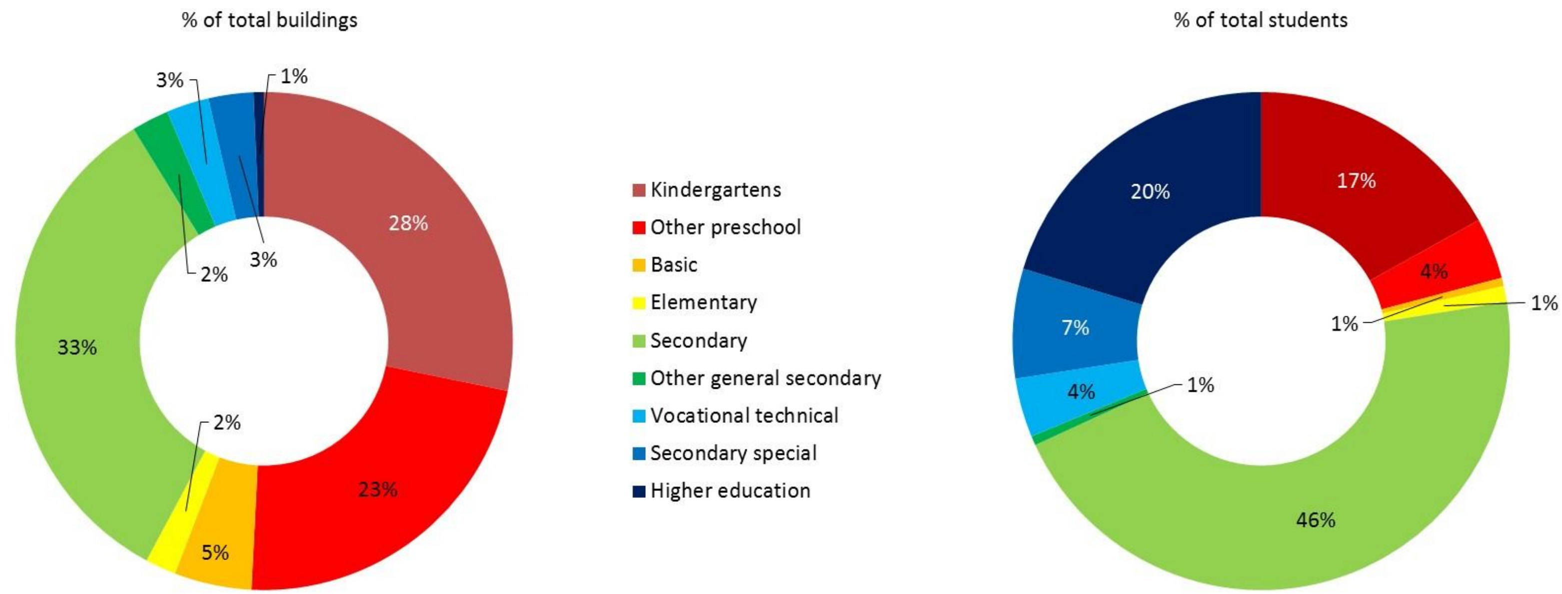
Social Infrastructure Retrofitting Project (2001-2010), USD37.6 million investment

The project aimed at improving the social sector facilities, with particular emphasis on reducing energy consumption, encouraging a more effective use of resources, and reducing operation and maintenance costs in schools, medical and other selected social facilities such as orphanages and community homes for the elderly and disabled. A total of 207,100 students, teachers, patients and medical staff benefitted from better facilities, including better thermal comfort and lighting conditions. Some 745 social sector buildings were retrofitted with energy efficiency improvements, 300 educational facilities received lighting improvements, 42 boiler houses and 541 heat substations were renovated. Energy consumption in the improved facilities was significantly reduced. Total annual saving of fuel and energy resources amounts to 243,300 MWh per year.

4.1.1 Educational Buildings

In 2013, Belarus has 7,926 educational institutions, including preschool, general secondary, vocational technical, special secondary and higher education establishments, attended by 1,946,000 students. Assuming that the educational institution is located in at least one building, the above number can be interpreted as the number of buildings of educational institutions in the first approximation. These can be further broken down by type of school. Kindergartens make up 28 percent of all educational buildings, while secondary schools make up another 33 percent. Since the other building types either have few buildings, few students, or both, they are not further considered in this analysis. Roughly 55 percent of secondary schools are in rural areas, and 45 percent are in urban areas. (Figure 4.2).

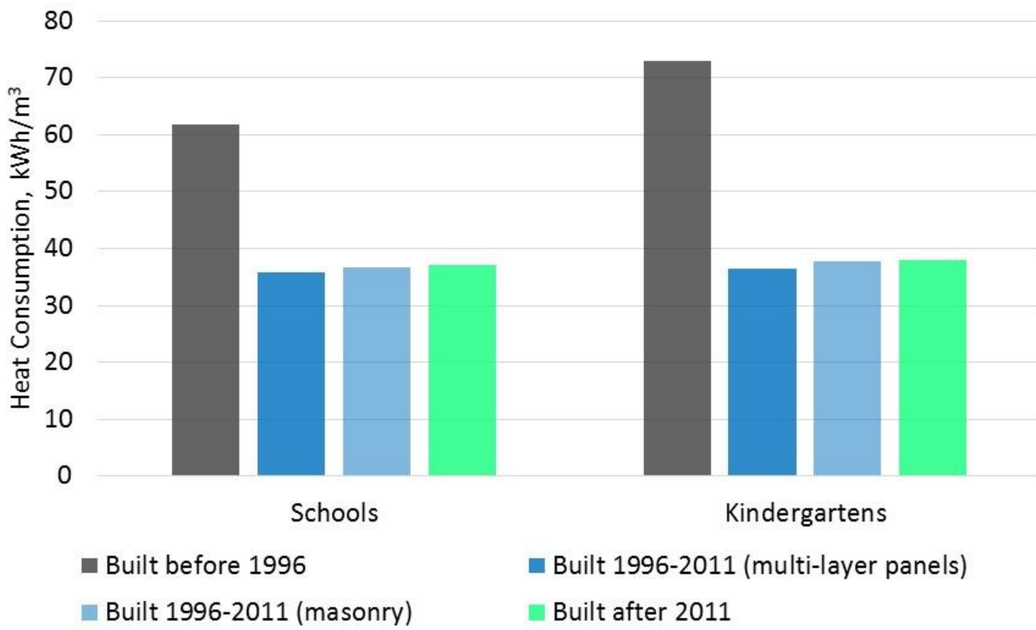
Figure 4.2: Overview of Educational Building Stock



Source: Authors' estimates.

Annual energy consumption for heating in secondary schools and kindergartens differs by construction period. The total annual consumption for heating differs across construction periods and construction materials used (Figure 4.3). Schools and kindergartens built before 1996 have substantially higher consumption than those built in later periods, and therefore have considerable energy savings potential.

Figure 4.3: Annual Heat Consumption in Schools by Period of Construction (kWh/m^3)



Note: The small deviation in specific heat consumption in buildings built after 2011 is due to changes in the approach to standardization of rated values.

Source: Authors based on SNB 4.02.01-03 and TCP 45-2.04-196-2010.

Because of a lack of available data, the breakdown on the number of secondary schools and kindergartens built in different periods must be estimated based on new student numbers and known new school construction. As of 2013, there were 2,645 secondary schools and 2,236 kindergartens in Belarus. Since 2000, new construction of kindergartens has provided room for an additional 991 kindergarten students each year, on average. Over the same period, new secondary schools provided room for an additional 6,408 students per year, on average. Taking into account the average number of students per school allows a calculation of how many new schools must have been built since 2000 (Table 4.1).

Table 4.1: Estimates of Secondary Schools and Kindergartens Built before 1996

School type	Number in 2013	Estimated number schools built, 2000-2013	Estimated number schools, pre-1996	% of total built before 1996
Urban secondary schools	1,200	75	1,125	94%
Rural secondary schools	1,445	92	1,353	94%
Kindergartens	2,236	95	2,141	96%
Total	**4,881**	**262**	**4,619**	**95%**

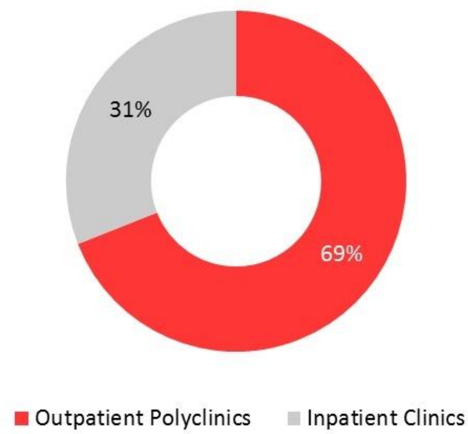
Source: Authors.

There have been an estimated 167 new secondary schools and 95 new kindergartens built since 1996. That leaves 2,479 (about 94 percent) secondary schools built before 1996. Pre-1996 secondary schools can be further divided into 1,125 urban and 1,353 rural schools. For kindergartens, 2,236 (about 96 percent) were built before 1996.

4.1.2 Health Buildings

There is no publicly available statistical data on healthcare buildings in Belarus. Energy saving potential was thus estimated using the number of healthcare organizations and healthcare building design standards. The two relevant energy typologies of health care organizations are inpatient clinics, where patients can stay overnight, and outpatient polyclinics, where patients come only for visits. As of 2000, there were 830 inpatient clinics in Belarus and 1,843 outpatient polyclinics (Figure 4.4). The Ministry of Health has designated about 10 percent of healthcare buildings for top priority renovation.

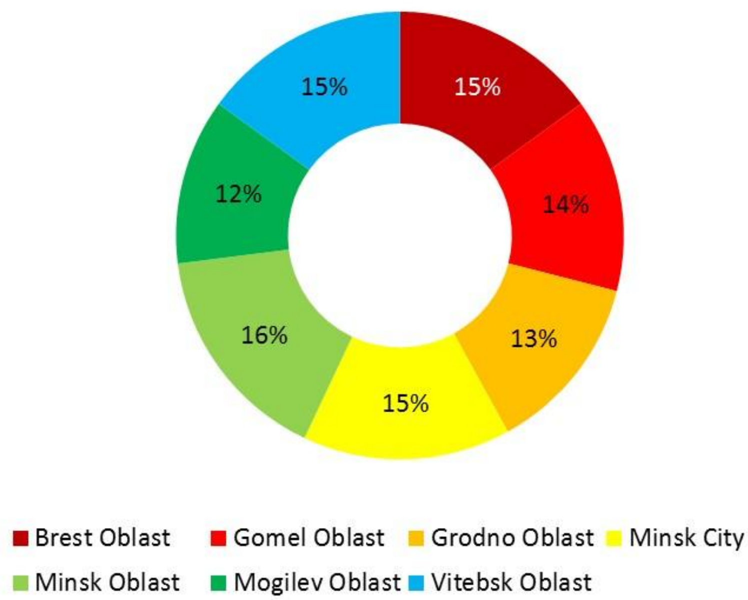
Figure 4.4: Proportion of Healthcare Organizations in Belarus, 2000



Source: Authors, based on data from Republic of Belarus Statistical Yearbook, Minsk 2014.

It can be assumed that the number of outpatient polyclinics organizations equals the number of polyclinic buildings. However, inpatient clinic organizations often occupy several buildings, and it is not possible to accurately estimate the total number of buildings they occupy. Therefore, only outpatient polyclinics are considered for further analysis. In addition to making up the majority of healthcare organizations, outpatient polyclinics are also evenly distributed among the regions of Belarus, with every region containing between 12 and 16 percent of the nation's outpatient polyclinic organizations (Figure 4.5). The number of outpatient polyclinic buildings analyzed for savings potential is 1,718, after removing those outpatient polyclinics with very small capacity (fewer than 460 outpatient visits per shift). This leaves a total heated area for outpatient polyclinics of 6,633,000 m^2 (or a total heated volume of 21,623,000 m^3) in need of thermal renovation.

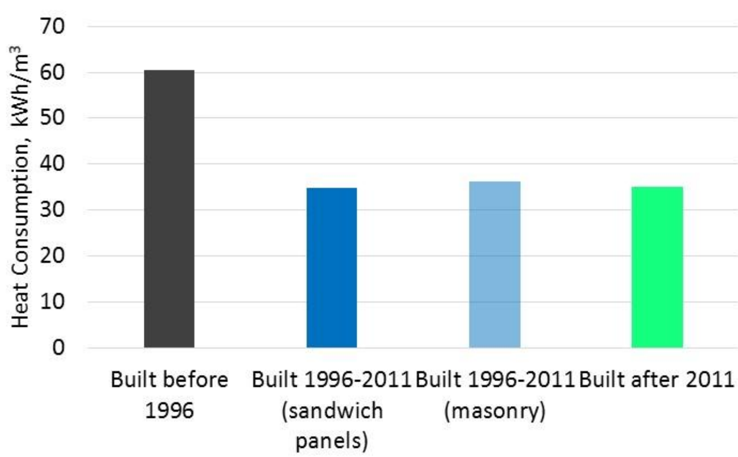
Figure 4.5: Regional Distribution of Outpatient Polyclinic Organizations



Source: Authors, based on Republic of Belarus Statistical Yearbook, Minsk, 2014.

Heat consumption in outpatient polyclinic buildings differs across construction periods and building materials. Outpatient polyclinics built before 1996 have substantially higher heat consumption than those built in later periods, and therefore have considerable energy savings potential (Figure 4.6)

Figure 4.6: Heat Consumption Standards in Outpatient Polyclinics by Construction Period



Source: Authors, based on data SNB 4.02.01-03 and TCP 45-2.04-196-2010.

Because the estimate for the number of outpatient polyclinic buildings is based on data from 2000, it can be assumed that the vast majority of outpatient polyclinic buildings would have been built before 1996.

4.1.3 Administrative Buildings

There are no publicly available statistical data on administrative buildings in Belarus. The total area of administrative buildings can be estimated based on the number of administrative workers in various economic sectors as well as design standards for selected administrative buildings. Analysis of building design documentation suggests an area of 8.15 m^2 per worker. It can be estimated that this “worker area” per building is about 65 percent of the total heated area for each building. These estimates result in a total heated area for administrative buildings of 9,619,000 m^2 (Table 4.2).

Table 4.2: Estimated Heated Area of Administrative Buildings

Economic Sector	Number of administrative workers (thou.)	Total "worker area" (thou. m^2)	Total heated area (thou. m^2)
Industry	103.7	850.3	1308
Construction	0.54	4.4	7
Trade	48.8	400.2	616
Public Catering	79.6	652.7	1004
Public Agencies	68	558	859
Small Organizations	462	3786	5825
Total	762.64	6,251.57	9,619

Source: Authors based on data from Republic of Belarus Statistical Yearbook, Minsk, 2014.

It is estimated that about 98 percent of all administrative heated area was constructed before 1996. This leaves a total of 9,485,000 m^2 of heated area (or 31,490,000 m^3 of heated volume) in need of thermal retrofit, corresponding to 1,841 administrative buildings.

4.2 Costs and Benefits of EE Improvements

The energy savings potential for pre-1996 educational, health and administrative buildings is substantial. The packages of ESMs that are most suitable for public buildings are the same as those for residential buildings described in Section 3.2, with the exception that HCAs are not necessary in public buildings. The relative savings potential for each package is different, however:

- **End-user Heat Control:** For public buildings this includes only TRVs. This package could result in about 5 to 9 percent energy savings, depending on the building type and sector.

- **Simple thermal retrofit:** Window replacement could result in additional 11 to 13 percent energy savings, depending on the building type. The Simple Renovation package could result in a total of about 17 to 20 percent energy savings.
- **Deep thermal retrofit:** Insulation of walls and roofs could result in additional 36 to 38 percent energy savings, depending on the building type. The Deep Renovation package could result in a total of about 52 percent energy savings.

The method for determining the potential energy savings is the same as for residential buildings. Baseline energy consumption values (in kWh/m^3) were estimated for each building type, and multiplied by the building types' total heated volume to calculate total annual consumption. Relative savings from each ESM package were estimated for each building type.

This methodology allows for the calculation of the potential annual energy savings (in GWh) of each package, the capital expenditure (CAPEX, in USD) required to implement each package, and payback periods at current tariffs. For customers connected to the DH system of Ministry of Energy tariffs are about USD 49 per Gcal, or USD 0.04213 per kWh. Customers served by the Ministry of Housing and Utilities pay about USD 90 per Gcal, or USD 0.07739 per kWh. Educational buildings have the greatest potential annual savings (2,030 GWh for Deep Thermal Retrofit), but also require the greatest investment (about USD 1.5 billion for Deep Thermal Retrofit). Payback periods using cost-recovery levels are reasonable, and are better for Deep Thermal Retrofit than for Simple Thermal Retrofit. Table 4.3 shows the results of the analysis and shows the present value of the energy savings as a percentage of Belarus' GDP in 2013.

Table 4.3: Summary of Savings Potential and Investment Costs, by Package and Public Building Type

Package	Building Type	Annual energy savings, GWh	Total investment (million USD)	Payback period, at current tariff (DH system of Ministry of Energy)	Payback period, at current tariff (DH system of the Ministry of Housing and Utilities)	PV of savings, as % GDP (2013)
–End-User Heat Control	Educational	363	$ 28.72	2 years	1 year	0.15%
	Health	122	$ 13.81	3 years	1 year	0.05%
	Administrative	75	$ 19.73	6 years	3 years	0.06%
–Simple Thermal Retrofit	Educational	771	$ 625.28	20 years	10 years	0.25%
	Health	262	$ 225.94	21 years	11 years	0.08%
	Administrative	260	$ 323.06	30 years	16 years	0.08%
–Deep Thermal Retrofit	Educational	2,030	$ 1,471.40	18 years	9 years	0.64%
	Health	686	$ 523.83	19 years	10 years	0.22%
	Administrative	801	$ 733.37	22 years	12 years	0.25%

Note: Simple and Deep Renovation both include twice the cost of TRVs, as they must be replaced after 10 years. See Appendix C for case studies of buildings that have already received thermal retrofits. Energy audit and design costs are not included in the investments. A rule-of-thumb estimate of such costs is about 10 percent of CAPEX. Including these costs would increase the simple payback period by about 1 year.

Source: Authors.

Supply curves were made for the public building stock in the same manner as for the residential stock. In the supply curves that follow, the black horizontal line represents the current tariff of DH systems of the Ministry of Energy (MoE), and the green horizontal line – tariffs of smaller DH systems of the Ministry of Housing and Utilities (MHU). Most of the assumptions for the supply curves below are the same as for residential buildings, with the exception of the discount rate used (see Table 4.4).

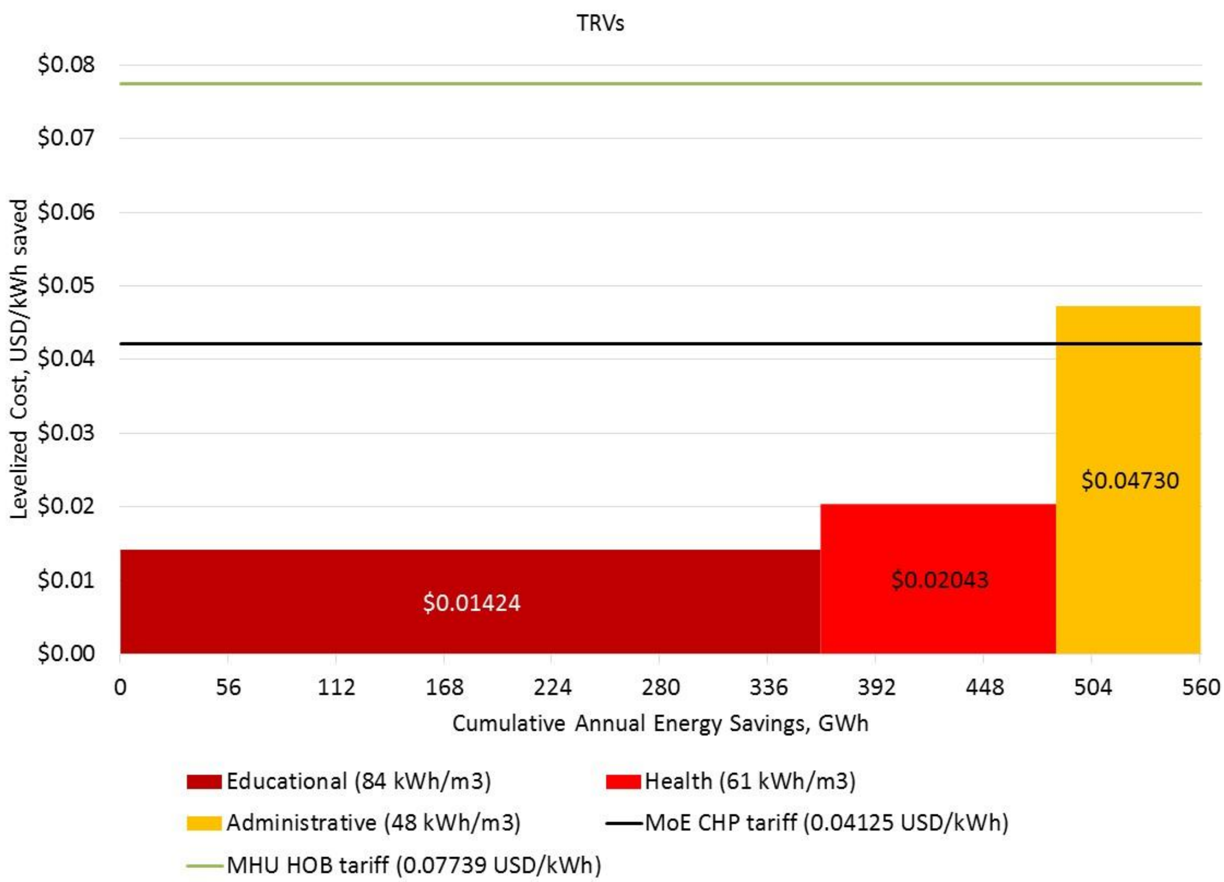
Table 4.4: Key Assumptions for Supply Curve Analysis in Public Buildings

Parameter	**Assumption**
Discount rate	12.45% (based on Government of Belarus 1-year bond yield as of June 2015)
Asset life	20 years for insulation and windows 10 years for TRVs
Construction period	1 year
Tariff of DH systems of the Ministry of Energy	0.04213 USD/kWh (49 USD/Gcal)
Preliminary tariff of DH systems of the Ministry of Housing and Utilities (natural gas)	0.07739 USD/kWh (90 USD/Gcal)

Source: Authors.

At MoE tariffs, End-User Heat Control is financially viable for educational and health buildings (their levelized energy costs are below the black line representing the MoE tariff), but not for administrative buildings. At the MHU tariff, the package is viable for all building types, as each building type's levelized energy cost is below the green line representing the MHU tariff (Figure 4.7).

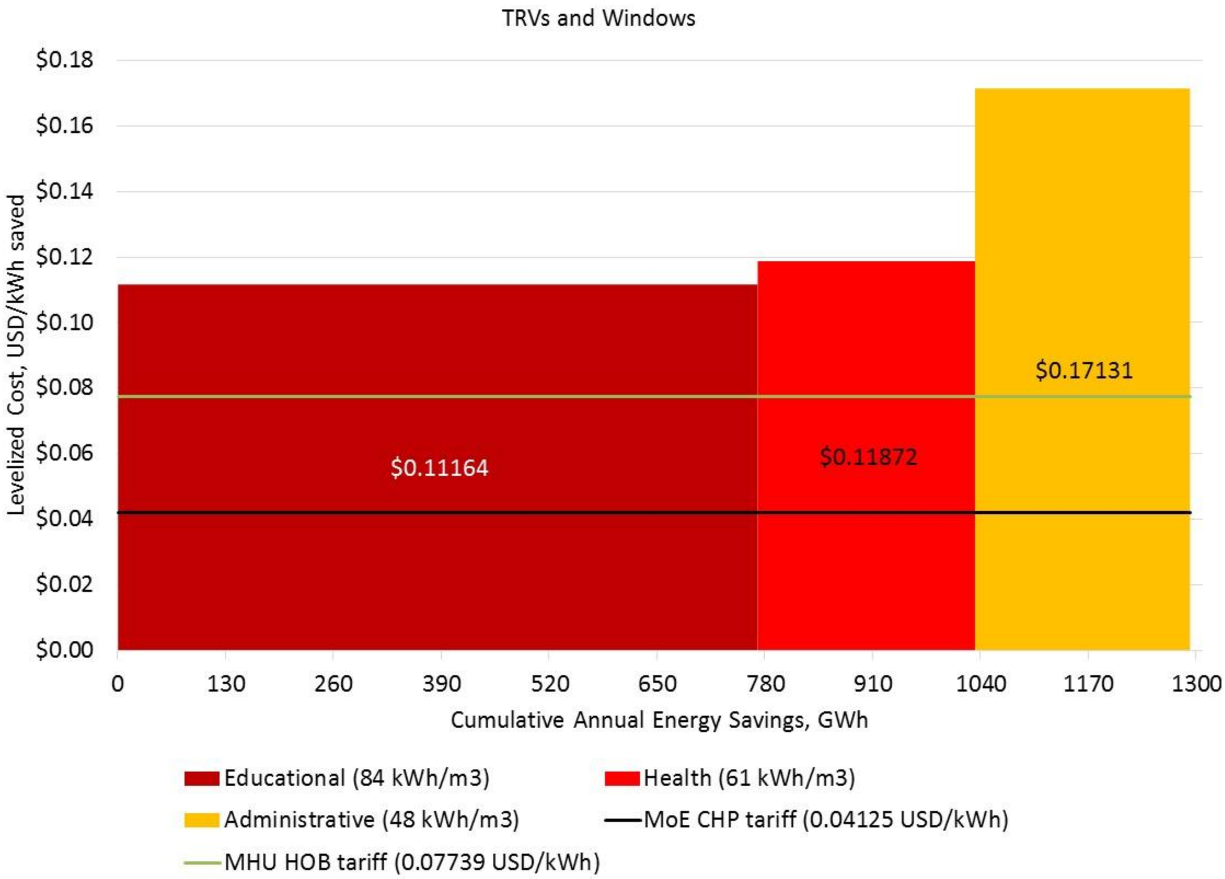
Figure 4.7: Levelized Energy Cost of End-User Heat Control, Public Buildings



Source: Authors.

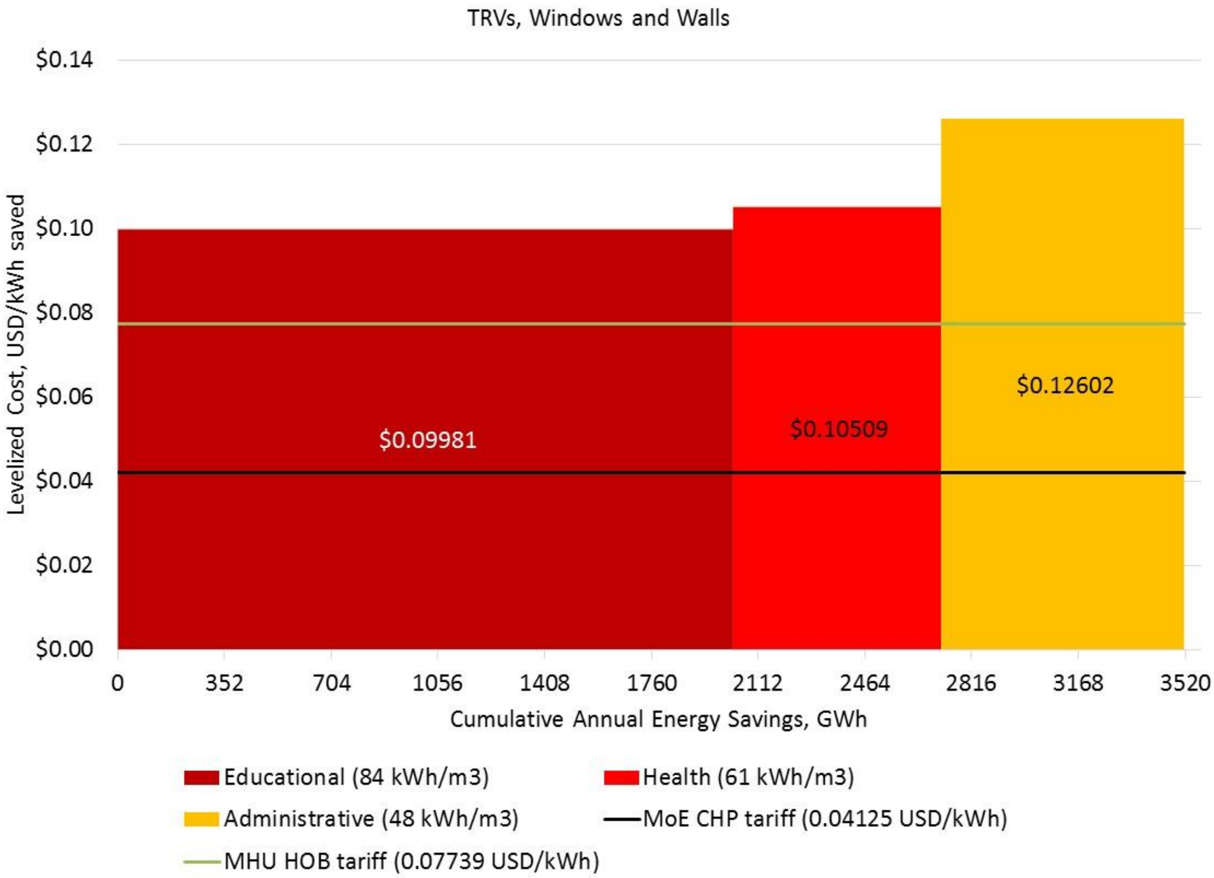
Neither Simple Thermal Retrofit nor Deep Thermal Retrofit is financially viable, as the levelized cost for each type of building exceeds even the higher tariff of small DH systems of the Ministry of Housing and Utilities (Figure 4.8 and Figure 4.9).

Figure 4.8: Levelized Energy Cost of Simple Renovation, Public Buildings



Source: Authors.

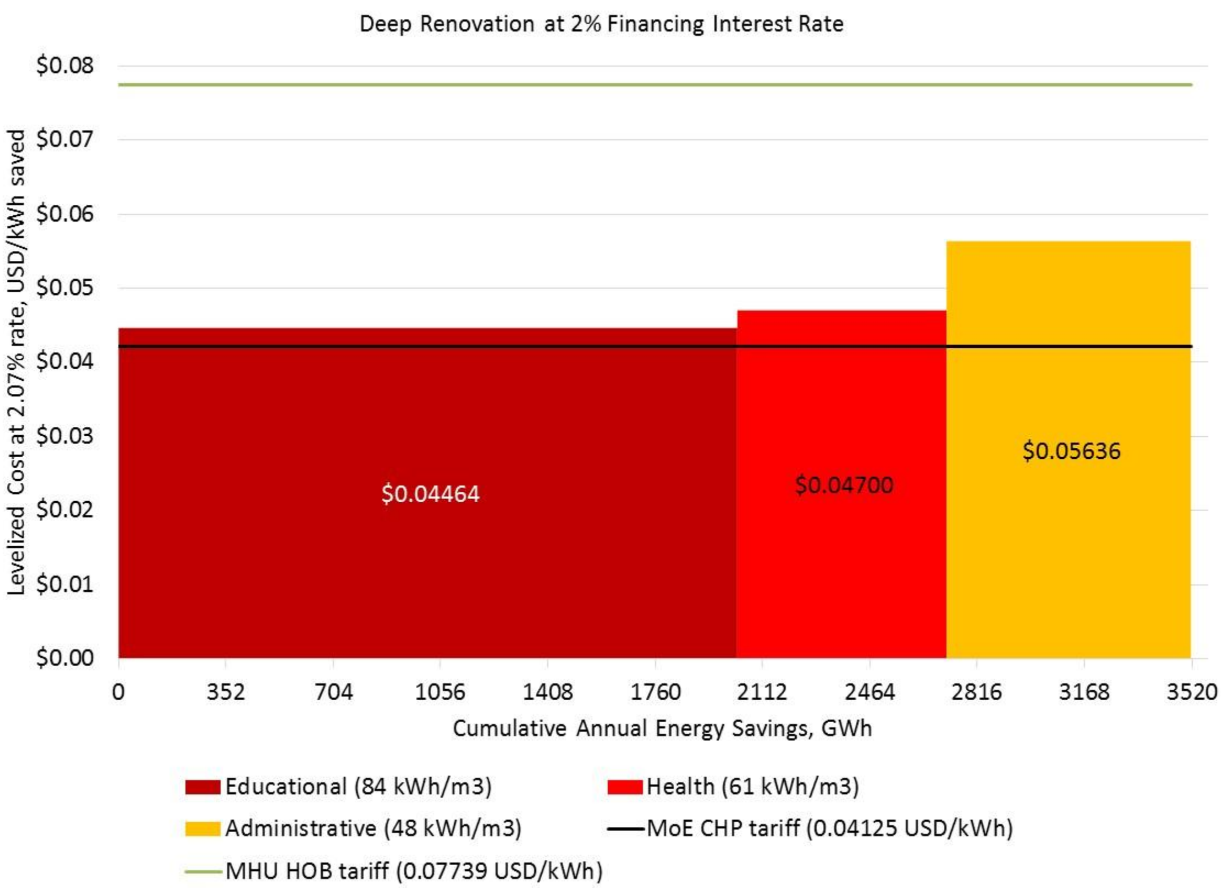
Figure 4.9: Levelized Energy Cost of Deep Renovation, Public Buildings



Source: Authors.

However, with low-cost financing (about a two percent interest rate) obtainable from government and donors, Deep Renovation could become financially viable. No additional capital subsidy would be necessary (Figure 4.10).

Figure 4.10: Levelized Energy Cost of Deep Renovation with Low-Cost Financing, Public Buildings



Source: Authors.

4.3 Barriers to EE in Public Buildings

Barriers to EE in public buildings in Belarus fall into the following categories: legal, regulatory and institutional, incentive-related, and financing. The barriers are described in more detail below.

Legal Regulatory, and Institutional

- **Inability to reallocate expenditure between line items.** Annual budget appropriations are broken down on a quarterly basis into very detailed line-items. These limits are entered into the Treasury system and become hard cash controls. This means that the amount set aside in a budgetary organization's budget to pay energy bills (measured, for example, in cost per liter, cubic meter, ton or kWh of purchased energy) cannot be used for other purposes (for example, a reserve fund to pay for investments in EE). Under the current budget rules, any savings from operating expenses cannot be shifted to capital expenses, and vice versa. Several public sector stakeholders interviewed as part of this study indicated that they would like to be able to use energy savings to pay for thermal retrofits (Appendix I).

- **Restrictions on multi-year obligations.** Article 138 of the Budget Code prohibits any commitments beyond the approved annual appropriations. The restriction on multi-year obligations stifle the evolution of organizations like ESCOs, or companies providing ESCO-like functions, which could help public organizations save on energy consumption. To get around this restriction, administrators of budget funds typically try to ensure that their medium- to long-term projects are supported by an act of the Council of Ministers or the Presidential Decree.
- **Highly fragmented responsibilities for certain sectors.** This fragmentation makes coordination of bundled procurement and investment in EE improvements in the public sector more complex. In the education and health sectors, there are many levels of government responsible for financing expenditures of schools and hospitals. Different levels of government are responsible for different types of institutions. For example, expenditures of post graduate schools are financed by the Republic budget while expenditures for lower level educational institutions such as pre-schools might be financed by oblast and base tier budgets.

Incentive-related

- **Inability to retain savings on energy.** Budgetary organizations in Belarus use incremental, line-item budgeting that tend to limit budgetary organizations' incentives to save energy. This traditional type of public sector budgeting, while widely used throughout the world, also leads to a "use it or lose it" mentality in which public officials feel compelled to spend all that was budgeted under a particular line item to ensure that their budgets are not reduced in the next planning period.
- **"Mutual settlement" and other inter-governmental transfers.** The system of transfers between levels of government creates little incentive for SNGs to reduce operating expenditures and generate permanent fiscal savings. Approximately 35 percent of the budget for subnational governments is sourced by transfers from the central government, three-fourths of which being general purpose grants. These transfers fill the gap between tax revenues of SNGs and their expenditures, removing an incentive for SNGs to reduce their operational expenditure (OPEX). Additionally, "mutual settlement" transfers are allocated in the course of the fiscal year by oblast governments to cities and raions for emergency expenditures. The size of these largely discretionary grants suggests that they are used to finance regular rather than exceptional expenditures, further reducing the incentive for cities and raions to reduce expenditures.

Financing barriers

Article 79 of the Budget Code forbids public entities from borrowing in any form. However, SNGs may issue securities on the domestic market or may take intergovernmental loans to finance in-year cash shortfalls or implement investment projects. Public enterprises may borrow from commercial banks, using their assets as collateral, but such permissions are granted by the Government (owner of public enterprise) only on a limited basis.

4.4 Options for Financing and Delivery

International and regional experience financing of EE improvements in public buildings indicates several options for facilitating scale up of EE investment. These are summarized in Table 4.5 and described in detail in Appendix E. The arrangements most suitable for Belarus described below—budget capture, Super Energy Service Company (ESCO), and Energy Efficiency Revolving Fund (EERF)—reflect a progression in market development. Budget capture, at one end of the spectrum is a relatively simple mechanism, implementable with limited legal, regulatory and institutional changes. EERFs, at the other end of the spectrum, have features of budget capture and Super ESCOs. EERFs requires more preparation and change than a simple budget capture mechanism, but are more scalable and can leverage commercial financing in the longer-term.

Table 4.5: Summary of Possible Investment Mechanisms in the Public Sector[41]

Option	Pros	Cons
Grants Public budget, IFI/ donor funds provided to public entities to cover 100% of EE project costs	Builds market capacity, easy to implement, can directly finance municipalities	Not sustainable/scalable, relies on limited grant resources
Budgets/ Grants w/ co-financing Partial budget support/grants with some co-financing (loans, equity) from public entities	Builds market capacity, easy to implement, can directly finance municipalities that may not be able to borrow, co-financing increases ownership	Not sustainable or scalable, relies on limited grant funds
MOF financing w/ budget capture Budget financing to public agencies/municipalities, with repayment through reduced future budgetary outlays	Builds market capacity, relatively easy to implement, can directly finance municipalities that are not able to borrow, could allow funds to revolve (if MOF reinvests reflows), no repayment risks	Requires MOF to allocate substantial budget for financing, sustainability relies on MOF PIU, scale relies on PIU and borrower capacities, reducing future budget provisions can be complex
Utility (on-bill) financing Utility borrows and finances EE investments in public clients; recovers investments through customers' utility bills	Streamlined repayments, lower repayment risk if risk of utility disconnection, builds off of utility relationships and services, can be done on a sustainable and scalable basis	Requires changes in utility regulations and billing systems, creates potential for monopolistic behaviors, financing competes with local banks, may be easier for power utilities than heating ones
EE revolving funds Independent, publicly-owned entity provides financing for EE to public clients, repayments based on estimated energy cost savings	Builds market capacity, can directly finance municipalities that are not able to borrow, can better leverage funds by pooling, greater potential for bundling of projects and development of simple ESCOs, centralized implementation and procurement can lower costs, can recover operating costs through fees	Recovering operating costs in early years is difficult, using private fund manager to oversee public funds may not be politically desirable, heavy reliance on good fund manager, need mechanisms to help ensure public client repayment, fund can act monopolistic

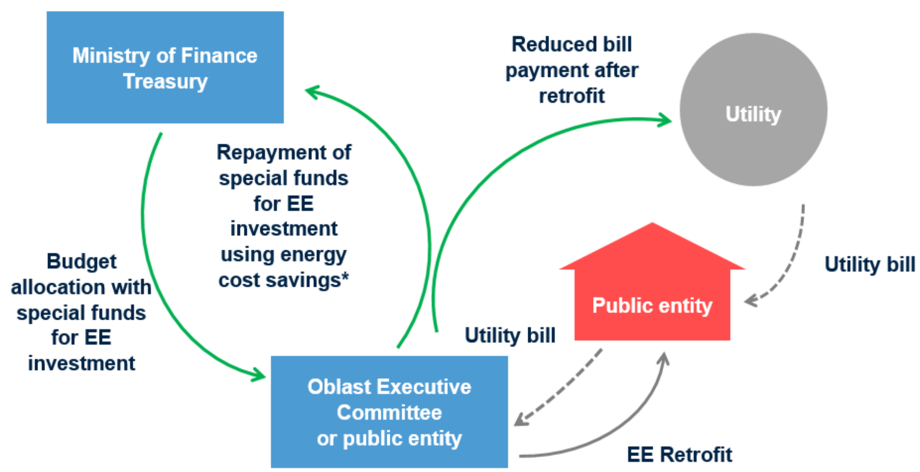
[41] This table is a shortened version of the options presented in Appendix E. "Western Balkans: Scaling Up Energy Efficiency in Buildings." 2013. The World Bank Group.

Option	Pros	Cons
Super ESCO Publicly owned company that provides financing for EE projects with public entities with repayments based on energy cost savings	Builds ESCO market capacity through subcontracting, helps address public procurement and financing issues, centralized implementation and procurement can lower costs, greater potential for bundling of projects and development of simple ESCOs models	Super ESCO can be monopolistic and may be subject to public sector bureaucracies (procurement, staffing, budgeting), appropriate exit strategy may be needed if private ESCO/ESPs enter the market, super ESCO requires access to long-term financing
Credit line with municipal (development) bank Dedicated municipal bank lending to public agencies for EE, using government or IFI funds	Builds commercial lending market by demonstrating public agencies can repay, allows public agencies to undertake own procurement/implementation which can allow for greater scale, allows for lower interest rates, funds can revolve (if bank relends reflows for EE) making it more sustainable	Relies on strong banking partner with incentive and ability to proactively develop pipeline and offer good financial products, serves only creditworthy municipalities, some municipal banks do not do proper risk assessments and appraisals or take risks
Credit line with commercial bank(s) Selected commercial bank(s) lending to public agencies for EE, using government or IFI funds, or purchase of account receivables from private ESCOs (i.e., factoring)	Builds capacity of commercial banks to market and appraise EE projects, mobilizes commercial financing which can deliver scale and be sustainable, allows public agencies to undertake own procurement/implementation	Relies on strong banking partner with incentive and ability to proactively develop pipeline and offer good financial products, serves only creditworthy municipalities able to borrow, requires complementary TA to work well, EE investments have to compete with other investment for limited capital, some credit lines distort the market
Partial credit guarantee Risk-sharing facility that can offer partial coverage to commercial lenders from EE loan defaults	Allows banks to expand their potential customer base, mobilizes commercial financing which can deliver scale and be sustainable, can allow more banks to participate thereby increasing competition, can help address overcollateralization/short tenor issues, allows public agencies to undertake own procurement/ implementation	Relies on network of strong banking partners with ability to proactively develop pipeline and assume some risks, partial risk coverage may only allow lending to a few additional municipalities, can create moral hazard depending on risk coverage

Budget Capture Mechanism

A "budget capture" mechanism allows a public entity to retain energy cost savings, and to use those savings to service debt on investments in retrofits. Under this scheme, financing is provided by a government agency, such as MoF, using a combination of government budget allocations and IFI or donor funds. This funding covers the investment costs of the EE projects in public buildings and facilities of municipal governments. The recipient "repays" the funds using the savings generated by the investment project in the form of reduced energy bills in future years. The size of the reduced outlay is usually based on the amount of energy cost savings. The flow of funds to pay for EE improvements follows the same flow as the normal appropriations from the MOF. The repayment to MOF could be complete (all cost savings) or partial (a portion of cost savings). The partial approach encourages public agencies to participate in the program because they retain a share of the savings achieved.

Figure 4.11: Budget Capture Principle – After Retrofit



*Could also include payback of amounts saved on energy as a result of the retrofit. Either approach may require some changes to the budget code.

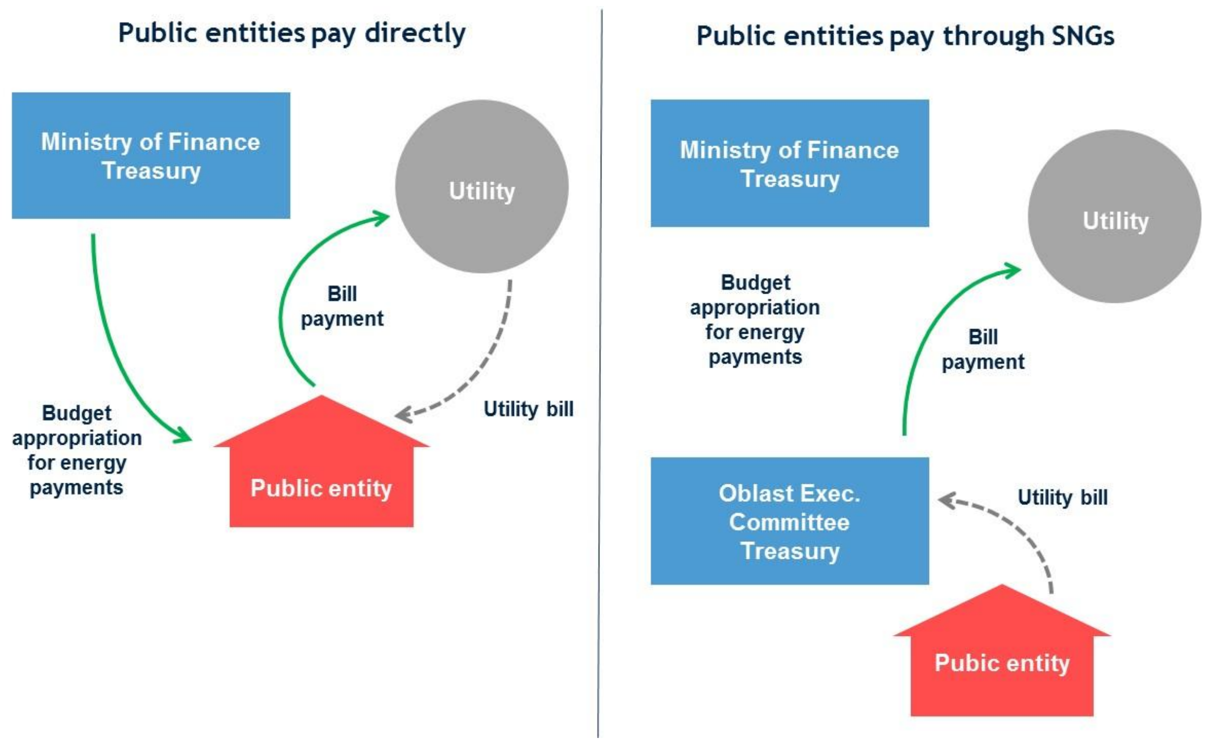
Source: Authors.

In the case of Belarus, the MoF would provide special funds to the Oblast Executive Committee or a public entity, which then pays for the EE retrofit (Figure 4.11). The retrofit may be done by ZhREO or private contractors. Implementing budget capture in Belarus would require changes to the Budget Law. Funds available to SNGs and public entities for energy payments are approved during the annual budget process, based on the past year's energy consumption, current energy prices and expected inflation (Box 4.2). As noted in Section 4.3, the budget allocation is strictly earmarked for energy; it cannot be reallocated to other budget line items.

Box 4.2: How Public Entities in Belarus Pay Energy Bills

Public entities and SNGs in Belarus currently i) pay for energy directly or ii) pay through the SNG's Executive Committee. Public entities with their own accounting units will pay for energy directly and will typically agree on a new contract with the utility each year (left most panel of the figure below). Public entities that do not have their own accounting units will have contracts with the utility through, and have their bills paid by, the subnational government department to which the public entity reports (rightmost panel of the figure below). Depending on the payment arrangement, the utility may invoice for actual consumption or request an advance payment, which is followed by a settlement at the end of the month based on the public entities' actual consumption. The public entity forwards payment instructions to the treasury which dispenses the funds to the utility.[42]

Budget Capture Principle – Existing Arrangement



Source: Authors.

A budget capture mechanism was used in Macedonia as part of the World Bank's Municipal Services Improvement Project (MSIP) (Box 4.3).

[42] The treasury system in Belarus has various units at the republican, oblast and local government levels that execute operations such as accounting and processing payments in accordance with republican, oblast and local budgets. For example, the treasury unit at the local level will process an invoice from a heat utility to a local level public entity.

Box 4.3: Budget Capture Mechanism for Municipal Services Improvements in Macedonia

Begun in August 2009, the MSIP aims to improve transparency, financial sustainability and delivery of targeted municipal services in Macedonia. The project is financed by a World Bank loan to the government, which the Ministry of Finance (MoF) then lends to eligible municipalities and public sector entities based on municipal investment proposals.

Investments are focused on municipal services projects that generate revenue and/or reduce costs, including EE in public buildings and street lighting. Municipalities repay the loans through from revenues or cost savings generated by the investments. Repayments can either be made separately or by reconciling future budgetary outlays, thereby allowing MOF to "capture" the repayments through the budget system. This essentially eliminates all repayment risk.

In addition, the project supports local capacity building through a Project Implementation Unit (PIU) in the MOF. The PIU funds technical assistance, training and consultancy services for municipalities that lack the capacity for project design and implementation.

The total loan value of projects completed or approved to date is €19.9 million. Eleven projects have been completed, including a few EE projects. Twenty projects are currently under implementation. About one third of municipalities have started to increase their revenue earnings and/or cost savings from the completed projects. An additional 21 municipalities are preparing investment projects with PIU support.

Sources: World Bank, 2009. Project Appraisal Document for a Municipal Services Improvement Project in Macedonia. World Bank: Report No. 462 16-MK. Washington, D.C., March 2009; World Bank, 2012a. Project Paper on a Proposed Additional Loan and Restructuring for the Municipal Services Improvement Project in Macedonia. World Bank: Report No. 67713-MK. Washington, D.C., April 2012; World Bank, 2013b. Implementation Status and Results Report. MSIP: Sq.no 11. Washington D.C., June 2013.

National Super ESCO, Energy Service Agreement (ESA) Model

A super ESCO is a government-owned corporation established primarily to undertake EE projects in the public sector. As a public enterprise, it can:

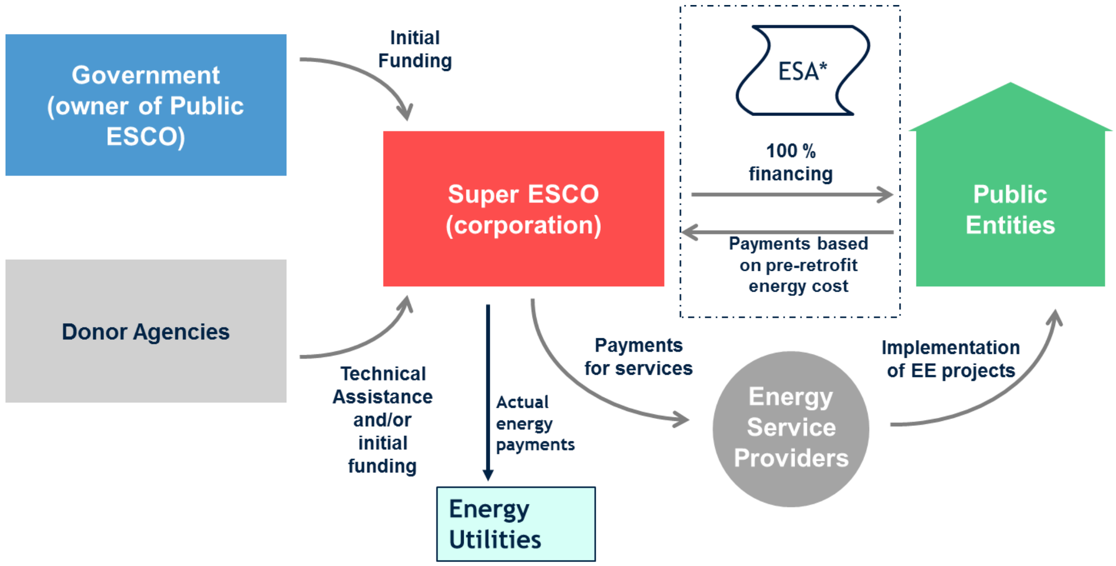
- Sign contracts with other public agencies without going through a competitive process.
- Access public, donor, and other funds and, thus, can offer 100 percent project financing to public entities.

A possible operational model for the Super ESCO would be the use of energy service agreements (ESAs). Under such an approach the Super ESCO would provide 100 percent financing for the thermal retrofit of a public entity, creating an ESA. Under the ESA, public entities continue to pay the same baseline energy expenditures to the Super ESCO after a retrofit is completed, despite the reduction of their energy expenditures (Box 4.4).[43] The Super ESCO then pays the utility actual bills and uses the surplus savings as repayment of the retrofit

[43] One public sector stakeholder interviewed for this study expressed concern over the monitoring of the contract, and the responsibility for losses caused by inflation (Appendix I). Sometimes, an additional verification process is conducted to ensure that energy expenditures have in fact been reduced. Baseline payments from public entities are also adjusted via a predetermined formula for expected changes including: tariff levels, heating load, number of occupants, and inflation.

costs. After the ESA contractual period (usually 8 or so years), the public entity resumes paying the utility directly and reaps the full financial benefits of the retrofit (Figure 4.12).

Figure 4.12: Potential Super ESCO Arrangement in Belarus



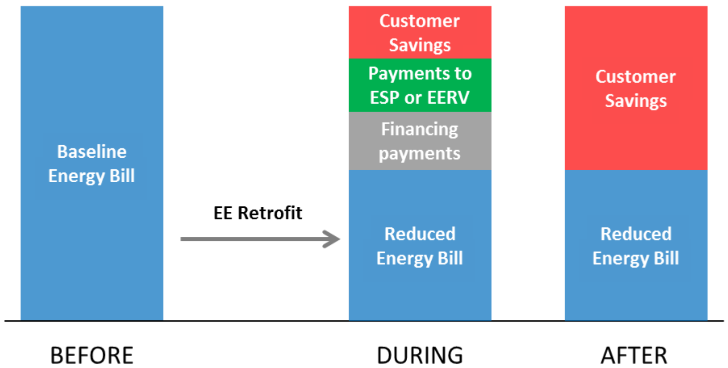
*ESA=Energy Service Agreement (usually for 5-8 years depending on the time needed to recover EE investment) in which a certain level of energy service and cost savings are guaranteed in return for monthly payments based on pre-retrofit energy cost.

Source: Authors.

The Super ESCO typically subcontracts the implementation of EE retrofits to private or commercial contractors, thereby fostering the growth of the energy service industry. Super ESCOs can thus serve as an incubator for private ESCOs, while allowing the concept of energy performance contracting to become accepted, and providing the private ESCOs with experience and a track record for their future marketing.

Box 4.4: The Energy Service Agreement (ESA)

An energy service agreement (ESA) is a contracting mechanism to implement EE projects on turn-key basis – i.e., design, equipment procurement, construction/installation, and savings verification. Typically, compensation is tied to actual energy savings from the client or 'host facility.' The ESA allows host facilities with limited capital to pay for EE upgrades from future energy savings, while mobilizing private capital and sharing of project performance risks. ESAs are generally carried out by energy service companies (ESCOs), or energy service providers.



Source: Authors.

As there are currently no private ESCOs in Belarus, and not likely to emerge in the near term, Super ESCOs can be used to accelerate investments in the public sector, which private ESCOs may be unable to serve in the near term, and to provide economies-of-scale. They can also be used to catalyze ESCO business models. One example of a Super ESCO is renewable resources and energy efficiency (R2E2) Fund in Armenia (Box 4.5) which also serves another function as an EE Revolving Fund.

Box 4.5: Super ESCO and EERF in Armenia – R2E2 Fund

The R2E2 Fund was established in 2005 initially as a PIU for a World Bank-supported EE/renewable energy (RE) project. The Fund operates on a fully commercial basis and is governed by a board of trustees made up of representatives from the government, private sector, NGOs, and academia. Day-to-day activities are managed by a government-appointed executive director, supported by technical and financial staff. The Fund is currently implementing a World Bank/GEF-supported project that provides EE services in public sector facilities—including EE investments in schools, hospitals, and administration buildings as well as street lighting—using a revolving fund scheme.

For entities that have their own revenue streams outside of government budget, the R2E2 fund provides loans to these entities directly.

For schools and other public entities that are not legally or budget independent, ESAs are used. Under the ESA, a public entity pays the R2E2 Fund its baseline energy costs (with adjustments for energy prices, usage, and other factors) over the contract period. The Fund designs the project, hires subcontractors, oversees construction and commissioning, and monitors the project. In this case, the client incurs no debt; the Fund directly pays the energy bills to the utility on the client's behalf, and retains the balance to cover its investment cost and service fee.

R2E2 Fund uses simplified performance contracts to shift some performance risks to private construction firms/contractors and to support the build-up of an ESCO industry in Armenia. Under these contracts, firm selection is based on the net present value of the projects proposed, and a portion of their final payment (around 30 percent) is based on a commissioning test.

The investment criteria for the R2E2 Fund are that projects have a minimum 20 percent energy savings and simple payback period of less than 10 years.

While R2E2 has an active EERF function, it also acts as a super ESCO, subcontracting out to private construction firms/contractors with simplified performance contracts. In this way R2E2 Fund shifts some performance risk to the private contractors and supports the build-up of an ESCO industry in Armenia. Under these contracts, firm selection is also based on the net present value of the projects proposed, and a portion of their final payment (around 30 percent) is based on a commissioning test.

Source: World Bank, 2012b. *Project Appraisal Document for an EE Project in Armenia.* World Bank: Report No. 67035-AM. Washington, D.C., March 2012.

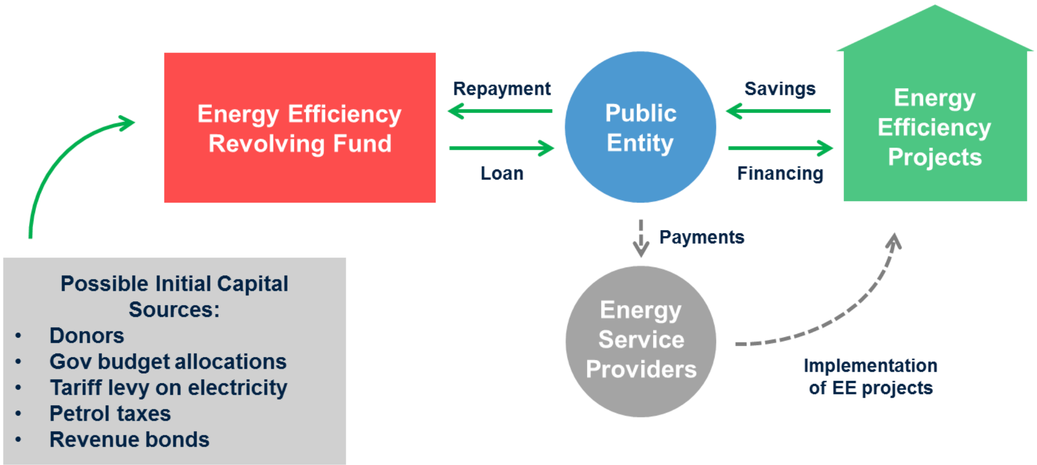
EE Revolving Fund (EERF)

An EERF is a fund which makes loans to EE projects in the public sector. Savings from these projects are then used to pay back the loans so new loans can be made.

Because many EE projects have positive financial rates of return, capturing these cost savings and reusing them for new investments creates a more efficient use of public funds than typical budget- or grant-funded approaches. Public sector investment in EE can help demonstrate the commercial viability of EE investments and provide credit histories for public agencies, paving the way for future commercial financing.

EERFs may offer many services, through a range of financing "windows."[44] Two common windows are a debt financing window and energy service window. An EERF with a debt financing window in Belarus would make loans directly to public entities, which then use these funds to pay for thermal retrofit of their properties. The retrofits may be conducted by the ZhREO or private contractors. The savings that result from the retrofit can then be used by the public entities to pay back the loan from the EERF (Figure 4.13). The EERF could pool government, IFI, donor and even some commercial financing into one program, thereby creating a sustainable and scaled-up structure.

Figure 4.13: Potential EERF for Belarus with Debt Financing

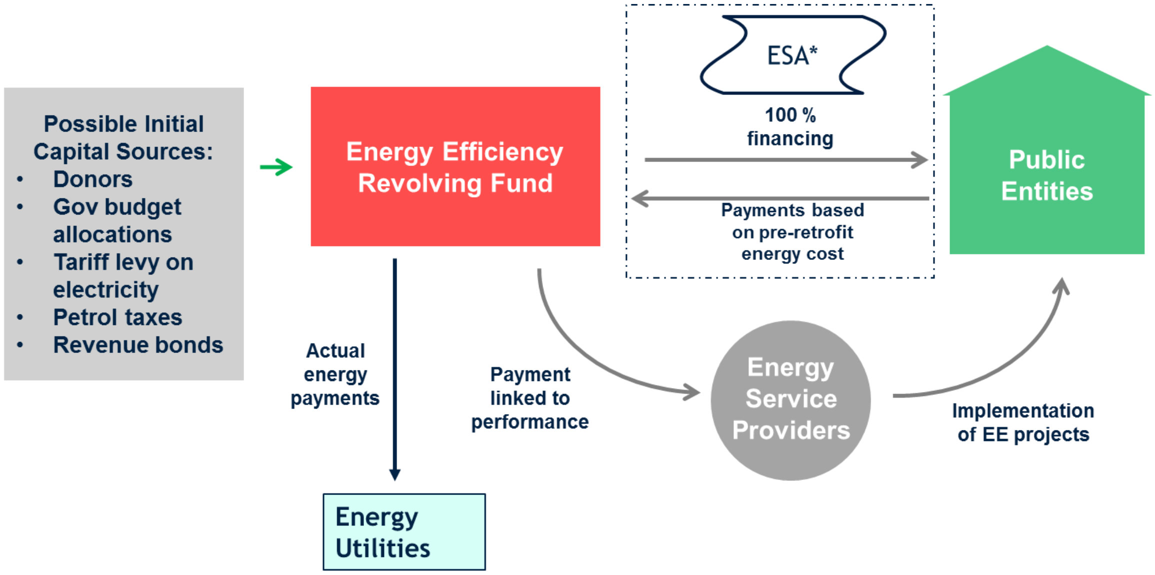


Source: Authors.

Where public entities lack the capacity to implement EE projects or are unable to borrow (as is the case currently in Belarus), the EERF can also provide an energy service agreement window. The ESA window offers a full package of services to identify, finance, implement, and monitor EE projects. These can be administered through the EERF, much like under the Super ESCO arrangement (Figure 4.14).

[44] Possible windows for EERFs include debt financing windows, energy services windows, risk guarantee windows, grants window, budget capture, and forfeiting. A description of these is provided in Appendix A

Figure 4.14: Potential EERF for Belarus with ESA Window, Acting as a Super ESCO



Source: Authors.

Initial capital for the EERF could come from a combination of donor funds, budget allocations from the GoB, tariff levies, and revenue bonds. The fund could be managed by a newly created organization; an existing non-independent public agency; a national development bank; a utility; or another public enterprise.[45] In addition to providing loans and ESAs for energy retrofits, the EERF may also provide technical assistance to public agencies and energy service providers, with procurement and implementation services that can transfer some of the implementation risk to energy service providers and facilitate the development of an energy services market. The fund can also develop standard procedures and bidding documents for procuring EE services. Similarly, it could conduct audits and ensure adequate capacity for measurement and verification (M&V), which is essential for monetizing savings.[46]

Other functions of the EERF could include bundling public procurement of EE projects and conducting marketing and awareness raising campaigns. As mentioned above, a good example of an EERF is the R2E2 Fund in Armenia, which also acts as a Super ESCO (Box 4.5 above).

4.5 A Roadmap for Developing Sustainable Financing for Public Buildings

The financing and delivery options identified in Section 4.4 will require changes in budget regulation and public procurement rules, and will depend on the availability of the initial capital to generate an energy cost-saving cash stream (Table 4.6). Moreover, pilot programs of the delivery option are important and should be conducted as soon as possible. The key activities to

[45] More guidance on the management of EERFs can be found in Appendix A

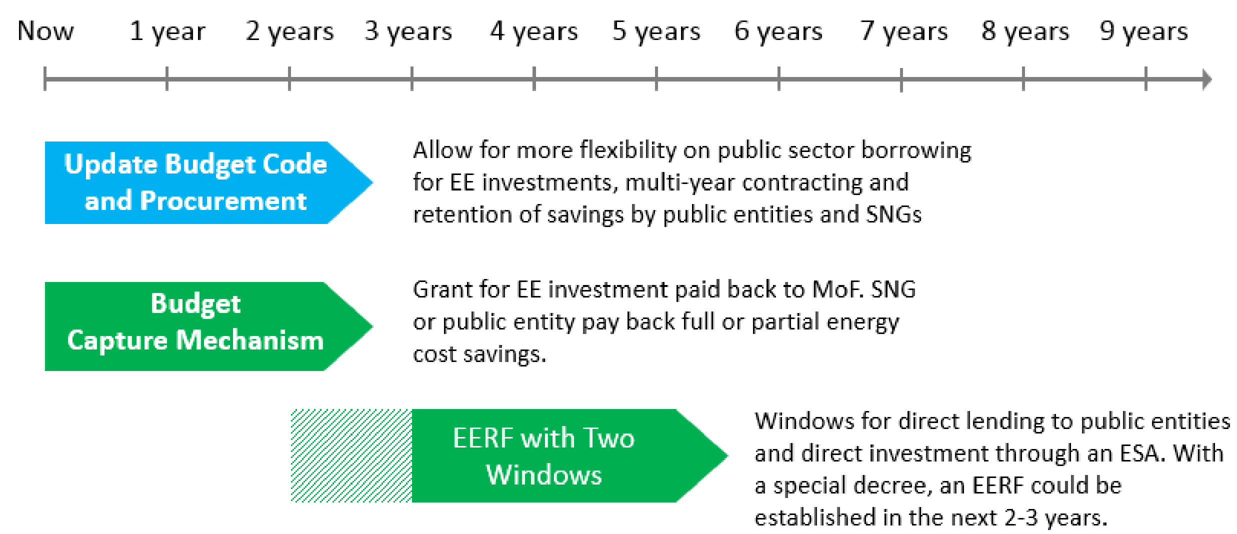
[46] M&V entails: (i) Development of baseline characteristics and typical operating conditions; (ii) Clear methodology for measuring energy savings that is acceptable to all parties; and (iii) Development of estimates of the actual energy savings, cost savings, and other performance characteristics of a project.

be undertaken by the GoB to encourage market development and introduce more sustainable financing arrangements within the next five years are illustrated below (Figure 4.15).

Table 4.6: Potential Solutions to EE Barriers in Public Buildings

Category of Barrier	Potential Solutions
Incentive-related **Financing and delivery**	Solutions are cross-cutting and can be phased: ▪ In the short-term, "Budget Capture" or retention of savings by Ministry of Finance and changes to procurement to allow life-cycle cost considerations. ▪ In longer-term, changes to Budget Code and other legislation to allow public entities and SNGs to: i) retain savings in annual budgets, ii) reallocate budget between line items, iii) enter into multi-year obligations, and iv) borrow from commercial lenders ▪ Creation of EE Revolving Fund (EERF) or "Super ESCO"

Figure 4.15: Roadmap for Scaling up EE in the Public Sector



Source: Authors.

Efforts can begin with a phased program to introduce the "revolving" funding mechanism, first through the "budget capture" approach and then moving to either "EERF" or "Super ESCO" approach.

The legal and regulatory changes described in this section would facilitate the creation of more scalable and sustainable arrangements for financing EE in the public sector. The creation of a dedicated EERF for public buildings would help focus resources, both capital and human, on resolving the main financing and implementation capacity constraints faced by most local public entities. A series of pilot projects with public entities can then be conducted through the

EERF, showcasing the energy efficiency improvements and energy cost savings associated with retrofits. The EERF can then eventually begin to offer products which would attract commercial financing into public sector EE investments.

5 Conclusion

Belarus could see substantial economic benefits and improved energy security from investments in thermal retrofits of residential and public buildings. Table 5.1 below summarizes the energy savings potential and investment cost of each ESM package in each type of building described in this study.

Table 5.1: Summary of Energy Savings Potential and Investment Costs, by ESM Package and Building Type

			Annual Energy Savings, GWh	CAPEX (million USD)	Payback Period, at current tariff (residential) and current MOE tariff (public)	Payback Period, at cost-recovery tariff (residential) and current MHU tariff (public)	PV of Savings, as % GDP (2013)
End-User Heat Control	*Residential*	<5 Floor	1,412	$ 143.16	16 years	1 year	0.23%
		>5 Floor	1,740	$ 234.72	21 years	2 years	0.28%
	Public	Educational	363	$ 28.72	2 years	1 year	0.15%
		Health	122	$ 13.81	3 years	1 year	0.05%
		Administrative	75	$ 19.73	6 years	3 years	0.06%
	Total		**3,712**	**$ 440.14**	--	--	**0.77%**
Simple Thermal Retrofit	*Residential*	<5 Floor	2,315	$ 1,733.27	116 years	10 years	0.39%
		>5 Floor	3,199	$ 2,948.39	143 years	12 years	0.55%
	Public	Educational	771	$ 625.28	20 years	10 years	0.25%
		Health	262	$ 225.94	21 years	11 years	0.08%
		Administrative	260	$ 323.06	30 years	16 years	0.08%
	Total		**6,807**	**$ 5,855.94**	--	--	**1.35%**
Deep Thermal Retrofit	*Residential*	<5 Floor	5,466	$ 6,176.39	175 years	15 years	1.01%
		>5 Floor	6,591	$ 8,047.84	189 years	16 years	1.21%
	Public	Educational	2,030	$ 1,471.40	18 years	9 years	0.64%
		Health	686	$ 523.83	19 years	10 years	0.22%
		Administrative	801	$ 733.37	22 years	12 years	0.25%
	Total		**15,574**	**$ 16,952.83**	--	--	**3.33%**

Source: Authors.

Deep thermal retrofits in pre-1996 multi-family, educational, health, and administrative buildings can alone result in a reduction of more than 15,500 GWh of heat energy per year, or about 6.7 percent of final energy consumption in Belarus in 2013. About USD 17 billion would be needed to make the necessary investments in deep renovation for all building types. At cost-recovery tariffs, payback periods range from 9 – 16 years, excluding public buildings supplied by CHP plants (which sell heat at lower tariffs than the HOB plants).

The fiscal savings that could be achieved by deep renovation is substantial. The present value of the energy saved annually by completing deep renovations is about 3.33 percent of Belarus' GDP (2013), or about USD 2.39 billion. The reductions in heat consumption would save Belarus about USD 578 million per year (at 2015 prices) just on imports of natural gas.

There are also important ancillary benefits, in terms of job creation and energy security, to investing in deep retrofits. The reduction in transfers from non-residential to residential customers is likely to increase Belarus' industrial competitiveness. Non-residential customers, including industrial enterprises, currently pay a 50 percent premium over the actual production cost on their electricity consumption to support underpriced residential heat.[47] If non-residential electricity prices are reduced back to cost-recovery levels, the average unit energy cost of manufacturing could decrease by about 24 percent.[48] Gains can also be expected in the job market. Since building renovations can be labor-intensive and rely on non-exportable workers, it is expected that a program which invests USD 1 billion a year in deep renovations could sustain 16,000 jobs over a 17-year period. Thermal retrofits in residential and public buildings will improve comfort levels and indoor air quality as well. Finally, reduced energy consumption means Belarus will be less reliant on importing natural gas, enhancing its energy security.

Much can be achieved in 5 – 8 years. To realize these benefits, the GoB needs to take several actions to enable rational economic decisions, introduce sustainable financing and delivery models and address key implementation barriers (see sections 3.3 and 4.3 above).

In the residential sector, consumption-based billing for heating at the apartment level should be introduced in parallel with higher heating tariffs, on a path to full cost-recovery. At the same time, the rollout of extensive public information campaigns about consumption-based billing and the benefits of energy efficiency, more effective social assistance programs, and cost reductions on the supply side will be crucially important. Installations of TRVs and HCAs to allow for apartment level heat control and billing can then be piloted and scaled up nationally to remove key incentive barriers for investments in thermal retrofit and will provide a foundation for the proposed financing mechanisms (see 3.4 above).[49]

[47] World Bank, "Heat Tariff Reform and Social Impact Mitigation: Recommendations for a Sustainable District Heating Sector in Belarus", 2014.

[48] The industries that will be most impacted are: wood, textile, food and paper. World Bank, "Heat Tariff Reform and Social Impact Mitigation: Recommendations for a Sustainable District Heating Sector in Belarus", 2014.

[49] The possibility to regulate the heat consumption on apartment level and arrangement of pilot schemes were identified as critical elements of tariff reform in consultations with the Ministry of Housing and Utilities.

In the public sector, the GoB should consider introducing regulatory changes to allow greater flexibility in public sector budgeting and financing, specifically for energy efficiency improvements. The regulatory changes include allowing for multi-year contracting of energy efficiency services, and retention of energy cost savings by subnational governments and other public entities. Adjustments in public procurement would be needed also to allow for consideration of investments' life-cycle costs. This will facilitate energy performance contracting (see section 4.3 above).

The regulatory changes would facilitate the revolving of energy cost savings and the creation of more scalable and sustainable arrangements for financing EE in the public sector. Such arrangements could include a dedicated EE revolving fund and the use of energy savings performance contracting (see 4.4 above). After choosing a delivery option, pilot programs should be conducted as soon as possible and a national program should be rolled out, building upon lessons learned in the demonstration projects.

In both residential and public building sectors, the GoB will need to evaluate and choose from various financing and delivery options. It is important that future financing and delivery mechanisms harness the effective elements of the existing institutional and financial framework. The introduction of new financing and delivery mechanisms, preceded by pilots, would facilitate the learning process and allow sufficient time to make required changes in the existing legislation for both public and residential buildings. Technical assistance from IFIs can support the GoB in assessing delivery options, designing institutional set-ups and staffing requirements for the selected options, and developing investment plans.

Appendix A: Possible Windows of EERFs

An EERF should be designed to serve the needs of all public agencies. Some of these agencies may not be creditworthy, or have no borrowing history; others may not have available borrowing capacity; and others may not have the internal capacity to identify, design, and manage the implementation of EE projects. To address some of these issues, the EERF may offer several financing products and "windows," which may include:

- **Debt financing window –** can offer 100 percent debt financing. Options for payment security include: public entity pays baseline bills to escrow while EERF pays energy bills from escrow, guarantee from MOF.
- **Energy services window -** for municipalities that lack the capacity to borrow funds or to effectively implement EE projects, an energy services agreement (ESA) can offer a full package of services to identify, finance, implement, and monitor EE projects.
- **Risk guarantee window –** leverage commercial financing through risk guarantee
- **Budget capture -** may be used when the public agency receives dedicated funds from the MOF or another government agency to pay its energy bills. In such cases, after the EERF invests in EE projects implemented by the public agency, the government (i) reduces its budgetary outlays to that public agency by an amount equivalent to the amount of energy cost savings (thereby "capturing" the savings) and (ii) redirects these funds to the EERF. This would require that the government agrees to provide the same amount to the public agency for energy bill payments in subsequent years.
- **Grants window –** When sustainable financing sources is available (such as service improvement fee), fund can give grants to improve economics of projects
- **Forfeiting –** Buying future savings from projects conducted by another ESCO, giving the ESCO more capital to do extra projects (not applicable in Belarus)

Appendix B: Management of EERFs

EERFs may be managed by newly created organization; an existing non-independent public agency; a national development bank; a utility; or another public enterprise. International best practice has shown that the fund functions best when established as an independent organization—either a corporation or an NGO. EERFs are also usually governed by a government-appointed board of governors or board of trustees made up of both public sector and private sector members.

The governing board and the management team need to provide a balance between public interest (since the fund will be targeting public agencies) and private sector perspectives regarding financial structuring of projects, risk assessment, and market development.

The fund management team must have: knowledge and understanding of EE technologies and options; skills in market assessment and pipeline development; capabilities in credit analysis, financial analysis, and project appraisal; and understanding of EE and energy services markets.

Appendix C: Case Studies of Completed Thermal Retrofit Projects

This appendix presents information on selected residential and public buildings in Belarus that have already received thermal retrofits. The tables below provide information (where available) on the types of retrofits implemented, their cost and the resulting energy savings.

Twelve residential buildings were identified and reviewed for this study. For buildings where energy savings information is available, savings were between 19 and 46 percent (Appendix Table C.1).

Appendix Table C.1: Selected Residential Buildings Receiving Thermal Retrofits

City (Year)	Floor area (m^2)	Primary heating source	Measures taken	Cost	Heat consumption for heating purposes before renovation	Heat consumption for heating purposes after renovation	Savings
Baranovichi (2013)	5,652	DH	▪ Light plaster system for insulation of exterior walling structures ▪ Wooden windows replaced with plastic insulated glazed units ▪ Thermal insulation of roof ▪ Interior work ▪ Improvement of the heating regulation system	BYR 4,334.5 million	531.161 Gcal	354.696 Gcal	33%
Novopolotsk (2014)	3,525	DH	▪ Light plaster system for insulation of exterior walling structures ▪ Window replacement ▪ Thermal insulation of roof ▪ Interior work ▪ Installation of heat regulators	65-70% national budget, 30-35% residents' contributions	0.198 Gcal/hour	485 Gcal	No information available

City (Year)	Floor area (m^2)	Primary heating source	Measures taken	Cost	Heat consumption for heating purposes before renovation	Heat consumption for heating purposes after renovation	Savings
Ozeritskaya Sloboda agrotown (2012)	380	DH	▪ Exterior wall insulation with Styrofoam boards ▪ Plastering and painting	BYR 81,548,996	52.71 Gcal	No information available	No information available
Minsk (2014)	4,255	DH	▪ Insulation of longitudinal exterior walls with a light plaster system ▪ Insulation material: Styrofoam boards PPT-15N-A ▪ Roof insulation with Styrofoam boards PPT-25N-A ▪ Insulation material used for the basement exterior walls: mineral wool boards PL75 ▪ Windows: wooden insulated glazed units with a tilt and turn mechanism ▪ Interior work: replacement of main pipelines and replacement of heat regulators	No information available	0.207 Gcal/hour	No information available	No information available
Minsk (2008)	4,259	DH	▪ Insulation of longitudinal exterior walls with a light plaster system, insulation material: Styrofoam boards 15N-A ▪ Roof insulation with Styrofoam boards PPT-35-A ▪ Windows: wooden insulated glazed units with a tilt and turn mechanism ▪ Interior work: replacement of main pipelines; replacement of heat regulators	No information available	0.207 Gcal/hour	No information available	No information available

City (Year)	Floor area (m^2)	Primary heating source	Measures taken	Cost	Heat consumption for heating purposes before renovation	Heat consumption for heating purposes after renovation	Savings
Soligorsk (2003)	3,420	DH	▪ Exterior wall insulation (including jointing) with PAROC thermal insulation polystyrene boards ▪ Windows: split (insulated glazed units on the inside and a glass pane on the outside) ▪ Roofing: RANNILLA metal tiles ▪ Rafter system: boards and beams ▪ Heating system: two-pipe, with bottom manifold distribution connected to heating networks through a regulated hydraulic elevator. The heating system risers are exposed. ▪ Heating appliances: MC1040 radiators with thermal output through double-control valves. An RT-98 regulator is provided to control carrier supply. Heat is metered by TEM-05M-1.	BYR 1,388,433 (in benchmark prices of 1991)	No information available	No information available	No information available
Minsk (2011)	3,050	DH	No information available	No information available	135 kWh/m^2	97 kWh/m^2	28.1 %
Minsk (2011)	5,500	DH	No information available	No information available	135 kWh/m^2	72 kWh/m^2	46.7 %
Minsk (2011)	3,999	DH	No information available	No information available	135 kWh/m^2	110 kWh/m^2	18.5 %
Minsk (2011)	3,190	DH	No information available	No information available	135 kWh/m^2	84 kWh/m^2	37.8 %
Minsk (2011)	3,515	DH	No information available	No information available	135 kWh/m^2	81 kWh/m^2	40.0 %

City (Year)	Floor area (m^2)	Primary heating source	Measures taken	Cost	Heat consumption for heating purposes before renovation	Heat consumption for heating purposes after renovation	Savings
Zhodino (2006)	1,080	DH	▪ Façade insulation with 80 mm Styrofoam boards PPT-15N in the Termoshuba style (a multilayer light structure with a thin layer of plaster), including repair of cracks in the facade joints. ▪ Insulation of window jambs with 20 mm rigid mineral wool boards ▪ Window sets replaced for insulated glazed units. ▪ Balcony unit replacement and single-pane glazing of recessed balconies. ▪ Balcony wall capping with metal profile. ▪ Insulation of the crawl space ceiling with 100 mm FASROCK mineral wool boards. ▪ Thermal insulation of roof. ▪ Repair of basement entrances and interior finishing of stairwells.	BYR 690,517 (in prices of 1991), including BYR 483,175 for thermal renovation	No information available	No information available	No information available

Source: Authors.

Thermal retrofits in six public buildings were reviewed as part of this study. Energy savings information is not available for most of these buildings. Investment costs vary widely, depending on the scope of the retrofit, but could reach as high as about BYR 4 billion (Appendix Table C.2).

Appendix Table C.2: Selected Public Buildings Receiving Thermal Retrofits

City	Floor area (m^2)	Primary heating source	Measures taken	Cost	Heat consumption for heating purposes before renovation	Heat consumption for heating purposes after renovation	Savings
Oblast-level Hospital in Baranovichi (2014)	5,409	DH	▪ Thermal insulation of the building façade with mineral wool boards and decorative plaster	BYR 3,691 million	313 tce (heat and hot water)	277 tce	12%
Republican level therapeutic institution in Minsk (2006)	16,108	DH	▪ Exterior wall repair, thermal insulation and painting with façade paint. ▪ Repair and painting of the main entrance doorway interior. ▪ Construction of perimeter pavement around the building. ▪ Renovation of porches, basement entrances and areaways. ▪ Thermal insulation of the basement service rooms. ▪ Replacement of old wooden windows for double-glazed EE windows throughout the building.	BYR 875,086 (in prices of 1991), including BYR 661,885 for thermal renovation	Information not available	Information not available	Information not available

City	Floor area (m^2)	Primary heating source	Measures taken	Cost	Heat consumption for heating purposes before renovation	Heat consumption for heating purposes after renovation	Savings
Regional-level polyclinic in Minsk (2012)	7,649	DH	▪ Thermal insulation of the building exterior walls, base, entryway, roofing and roof ventilation shafts with a light plaster system. ▪ PZh150 mineral wool boards and PPT-35B Styrofoam board are used as materials for thermal insulation. ▪ Replacement of old windows for double-glazed EE windows throughout the building (thermal transfer resistance 1 m^2 x°C/W), ▪ Repair of roof of the 7 and 3-floor parts of the building Replacement of windows and doors at all entrances to the building and roof access.	BYR 1,254,137,000 (in prices of 2006), including BYR 1,174,022,000 for thermal renovation	Information not available	Information not available	Information not available
Oblast-level kindergarten in Sloboda agrotown (2012)	764	DH	▪ Window replacement	BYR 420 million	Information not available	Information not available	Information not available
Oblast-level secondary school in Minsk (2009)	4,275	DH	▪ Termoshuba-style exterior wall insulation system ▪ PPT-15N Styrofoam boards ▪ PPT-35B Styrofoam roofing ▪ Insulated triple-pane glazed units ▪ Relaying of heating pipelines ▪ Individual heating station in the maintenance building, and hot water heater ▪ Automatic heating control	BYR 55 billion – full scope BYR 3.9 billion – thermal renovation	Information not available	0.183 Gcal/hour	Information not available

City	Floor area (m^2)	Primary heating source	Measures taken	Cost	Heat consumption for heating purposes before renovation	Heat consumption for heating purposes after renovation	Savings
Regional-level administrative building in Minsk (2007)	380	DH	▪ Replacement of existing wooden windows with new triple-pane glazed units of the B.1.036.7-143.03 series. The existing EE window units remain. ▪ Thermal insulation with a light plaster Termoshuba-style system with PPT-15N-A 60 mm Styrofoam boards according to STB 1437-2004. DOILID paints for finishing of exterior facades. ▪ A drywall ceiling is planned for offices.	BYR 90,563,000 (in prices of 1991), including BYR 67,450,000 for construction and assembly	Information not available	Information not available	Information not available

Source: Authors.

Appendix D: Possible Investment Mechanisms in the Residential Sector[50]

Option	Description	Market conditions	Examples	Pros	Cons
EE Funds	Independent entity providing financing for EE (e.g., loans, ESA, guarantees)	• Local commercial banks unable/unwilling to enter EE market	Bulgaria, Greece, Romania, Slovenia	• Can be sustainable; mandated to promote EE • Can develop specialized products; centralized experience and lessons	• May distort market • Could create monopoly • May not operate efficiently • Can be captured by political interests
Commercial Bank Financing	Commercial banks provide loans for EE	• Developed financial market familiar with EE • Creditworthy customers	Austria, Belgium, Bulgaria, Czech Republic, Germany, Lithuania, Netherlands, Poland, Romania, Spain, UK	• Sustainable • Allows for competition of financing and builds off existing credit system	• Only serves creditworthy customers • May involve high interest rates • Banks may lack incentive to market aggressively
Partial Credit Guarantees	Partial coverage of potential losses from EE loan defaults	• Developed financial market familiar with EE • Creditworthy/marginally creditworthy clients • Banks willing to provide EE loans	Bulgaria, Greece, Romania, Slovenia	• Encourages commercial banks to finance EE • Helps overcome risk perception of banks • Can lead to sustainable commercial financing	• Requires mature banking sector interested in EE financing • May need substantial capacity building of banks • May serve only creditworthy customers
Utility EE programs	Utility implement EE in residential buildings in the form of DMS or an EEO scheme	• Payment discipline and adequate billing practice • Financial capacity of utilities to provide upfront financing • Effective delivery mechanism to implement programs	Belgium, Denmark; France, Ireland, Italy, Netherlands, UK	• Can be done sustainably • Builds off of utility relationships and services • Allows for simple collections (on-bill repayment)	• Utilities lack incentives to reduce energy sales • Regulations may limit new utility services, billing • Can create a monopoly

[50] "Western Balkans: Scaling Up Energy Efficiency in Buildings." 2013. The World Bank Group.

Appendix E: Possible Investment Mechanisms in the Public Sector[51]

Option	Description	Market conditions	Examples	Pros	Cons
Grants	Public budget, IFI/ donor funds provided to public entities to cover 100% of EE project costs	• No market capacity, need to pilot and demonstrate EE benefits • Availability of grant funds • Limited creditworthiness	Armenia, Belarus, FYR Macedonia, Kazakhstan, Kosovo, Montenegro, Serbia	Builds market capacity, easy to implement, can directly finance municipalities (incl. uncreditworthy/ budgetary independent entities)	Not sustainable/scalable, relies on limited grant resources
Budgets/ Grants w/ co-financing	Partial budget support/grants with some co-financing (loans, equity) from public entities	• Low market capacity, some co-financing is available • Availability of grant funds • Limited creditworthiness	Bosnia & Herzegovina, FYR Macedonia, Lithuania, Montenegro, Poland, Serbia	Builds market capacity, easy to implement, can directly finance municipalities that may not be able to borrow, co-financing increases ownership	Not sustainable or scalable, relies on limited grant funds
MOF financing w/ budget capture	Budget financing to public agencies/municipalities, with repayment through reduced future budgetary outlays	• Underdeveloped public/ municipal credit markets • Limited equity among public agencies • High commercial bank lending rates and low tenors • Availability of budgetary space for MOF financing	Belarus, FYR Macedonia (MSIP), Hungary, Kosovo, Lithuania	Builds market capacity, relatively easy to implement, can directly finance municipalities that are not able to borrow, could allow funds to revolve (if MOF reinvests reflows), no repayment risks	Requires MOF to allocate substantial budget for financing, sustainability relies on MOF PIU, scale relies on PIU and borrower capacities, reducing future budget provisions can be complex
Utility (on-bill) financing	Utility borrows and finances EE investments in public clients; recovers investments through customers' utility bills	• Requires regulations for utility participation • Strong financial position and financial management of utilities • Payment discipline among public clients, adequate energy pricing and billing practices	Brazil, China, India, Mexico, Sri Lanka, Tunisia, United States, Vietnam	Streamlined repayments, lower repayment risk if risk of utility disconnection, builds off of utility relationships and services, can be done on a sustainable and scalable basis	Requires changes in utility regulations and billing systems, creates potential for monopolistic behaviors, financing competes with local banks, may be easier for power utilities than heating ones
EE revolving funds	Independent, publicly-owned entity provides financing for EE to	• Underdeveloped public/ municipal credit market • Access to public budget or IFI	Armenia, Bulgaria, India, FYR	Builds market capacity, can directly finance municipalities that are not	Recovering operating costs in early years is difficult, using private fund manager

[51] "Western Balkans: Scaling Up Energy Efficiency in Buildings." 2013. The World Bank Group.

Option	Description	Market conditions	Examples	Pros	Cons
	public clients, repayments based on estimated energy cost savings	loans to capitalize fund • Credible and proactive fund manager can be recruited • Public agencies able to enter into multiyear obligations and retain energy cost savings	Macedonia (proposed), Romania, Serbia (proposed), Uruguay	able to borrow, can better leverage funds by pooling, greater potential for bundling of projects and development of simple ESCOs, centralized implementation and procurement can lower costs, can recover operating costs through fees	to oversee public funds may not be politically desirable, heavy reliance on good fund manager, need mechanisms to help ensure public client repayment, fund can act monopolistic
Super ESCO	Publicly owned company that provides financing for EE projects with public entities with repayments based on energy cost savings	• Underdeveloped public/ municipal credit market • No local, active, capable ESCOs • Rigid public procurement rules make ESCO hiring difficult • Credible public entity exists with demonstrated capacity to subcontract/manage subprojects	Armenia, China, Croatia, Poland, Ukraine, United States, Uruguay	Builds ESCO market capacity through subcontracting, helps address public procurement and financing issues, centralized implementation and procurement can lower costs, greater potential for bundling of projects and development of simple ESCOs models	Super ESCO can be monopolistic and may be subject to public sector bureaucracies (procurement, staffing, budgeting), appropriate exit strategy may be needed if private ESCO/ESPs enter the market, super ESCO requires access to long-term financing
Credit line with municipal (development) bank	Dedicated municipal bank lending to public agencies for EE, using government or IFI funds	• Underdeveloped public/ municipal credit market • High commercial bank lending rates and low tenors • Existence of credible municipal or development bank willing to lend for EE and assume repayment risks • Municipalities must have ability and willingness to borrow • Public agencies able to retain energy cost savings, pay based on consumption	Brazil, India (municipal infrastructure fund), Mexico, Turkey (proposed)	Builds commercial lending market by demonstrating public agencies can repay, allows public agencies to undertake own procurement/implementation which can allow for greater scale, allows for lower interest rates, funds can revolve (if bank relends reflows for EE) making it more sustainable	Relies on strong banking partner with incentive and ability to proactively develop pipeline and offer good financial products, serves only creditworthy municipalities, some municipal banks do not do proper risk assessments and appraisals or take risks
Credit line with commercial bank(s)	Selected commercial bank(s) lending to public agencies for EE, using government or IFI funds, or purchase of account receivables from private ESCOs	• Good banking partners willing to lend and assume risks • Municipalities must have ability and willingness to borrow • Public agencies able to retain energy cost savings, pay based on consumption	China, Germany, India, Poland, Serbia, Turkey, Tunisia	Builds capacity of commercial banks to market and appraise EE projects, mobilizes commercial financing which can deliver scale and be sustainable, allows public agencies to	Relies on strong banking partner with incentive and ability to proactively develop pipeline and offer good financial products, serves only creditworthy municipalities able to

Option	Description	Market conditions	Examples	Pros	Cons
	(i.e., factoring)	• Reasonable, competitive lending rates, reasonable tenors, collateral requirements		undertake own procurement/implementation	borrow, requires complementary TA to work well, EE investments have to compete with other investment for limited capital, some credit lines distort the market
Partial credit guarantee	Risk-sharing facility that can offer partial coverage to commercial lenders from EE loan defaults	• Good banking partners willing to lend and assume some risks • Municipalities must be marginally creditworthy and willing to borrow • Public agencies able to retain energy cost savings, pay based on consumption • Reasonable, competitive lending rates	Bulgaria, CEEF (regional), China, FYR Macedonia, Hungary, Philippines, Poland, Tunisia	Allows banks to expand their potential customer base, mobilizes commercial financing which can deliver scale and be sustainable, can allow more banks to participate thereby increasing competition, can help address overcollateralization/short tenor issues, allows public agencies to undertake own procurement/ implementation	Relies on network of strong banking partners with ability to proactively develop pipeline and assume some risks, partial risk coverage may only allow lending to a few additional municipalities, can create moral hazard depending on risk coverage
Commercial financing, bonds	Municipalities take commercial bank loans or issue bonds to finance EE investments	• Requires well-developed municipal credit and rating systems • Financiers willing and able to lend to public sector for EE projects • Large municipalities with strong technical capacity willing to bundle many EE projects together	Bulgaria, Denmark, India, United States	Mobilizes commercial financing which can deliver scale and be sustainable, elements of competition can help lower financing costs, can help address overcollateralization/short tenor issues, allows public agencies to undertake own procurement/ implementation	Only makes sense for very large bundles of projects, only highly creditworthy municipalities can use these schemes, relatively high transactions costs
Vendor credit, leasing	Equipment suppliers that provide energy-efficient equipment under lease contract, usually with lease payments based on estimated energy savings	• Large, credible local and/or international vendors able and willing to finance public EE projects • Local bank financing available for vendor leasing • Creditworthy municipalities able to sign long-term vendor contracts • Public agencies able to retain	China, EU, United States	Mobilizes commercial financing which can deliver scale and be sustainable, can help address overcollateralization/short tenor issues, financing and procurement in one contract, lease may not count against public debt	Relies on local banks and leasing companies to provide reasonable cost financing and assume credit risks, serves only very creditworthy public agencies, vendors must be able to take on substantial debt and offer long-term financing to municipalities,

Option	Description	Market conditions	Examples	Pros	Cons
		energy cost savings, pay based on consumption			financing tied to certain products/brands, only some building components suited for leasing (lighting, solar water heaters, boilers)
Advanced commercial or project financing (ESCOs)	ESCO finances and implements public EE projects, often with at least part of repayment tied to energy savings over contract duration	• Large, credible local and/or international ESCOs able and willing to finance and bid on public EE projects • Local bank financing available for ESCO lending, municipal lending against performance guarantees or ESCO refinancing • Creditworthy municipalities able to sign long-term contracts w/ ESCOs • Public agencies able to retain energy cost savings, pay based on consumption • Municipalities must have capacity to procure and negotiate complex ESPCs	Canada, Czech Republic, Germany, Hungary, India, Japan, South Korea, United States	Mobilizes commercial financing which can deliver scale and be sustainable, can help address overcollateralization/short tenor issues, full project cycle (audit through commissioning) outsourced to one firm, ESPC may not count against public debt, public agency shifts technical risks to third party	Relies on local banks and ESCOs to provide reasonable cost financing and assume credit risks, serves only very creditworthy public agencies, ESCOs must be able to take on substantial debt and offer long-term financing to municipalities, financing many be tied to certain products/brands (if ESCO is equipment supplier), transaction costs make only very large projects feasible, ESCO industry is very difficult to develop, public procurement issues take time to solve, new ESCOs often not credible to clients and banks, require clear ‘rules of the game’ (M&V protocols)

Source: Based on ESMAP, 2012, op.cit.; Singh et al., 2010, op.cit.

Appendix F: Calculating Potential of ESM Packages for Residential Buildings

This appendix describes the methodology for calculating the potential of the ESM packages outlined in Section 3.2. As such, this appendix focuses only on “<5 Floor” and “>5 Floor” residential buildings, and excludes “Single Family” buildings. Section F.1 describes how total annual consumption for each building type was calculated. Section F.2 discusses the determination of potential energy savings for the packages. Section F.3 describes how total investment costs (CAPEX) was determined. Section F.4 describes how the supply curves were created.

F.1 Total Annual Consumption by Building Type

The first step is to determine the total annual energy consumption for heating by each building type. Baseline consumption (in kWh/m^2) was estimated based on building materials and thermal protection standards for each building type, and compared against actual consumption in a sample of buildings in Minsk. The estimated baselines were found to be about two to eight percent off of the actual consumption numbers, depending on the building type. The estimated baselines were adjusted to bring them into line with the sample observations. For <5 Floor buildings, the weighted average baseline consumption is 183 kWh/m^2; for >5 Floor buildings, the weighted average baseline consumption is 137.5 kWh/m^2. These are baseline numbers assuming an internal temperature of 18°C, but the temperature within apartments is often substantially higher. Therefore, in order to determine how much energy savings the ESM packages could achieve, baseline consumption numbers were adjusted to a more realistic internal temperature of 24°C. Appendix Table F.1 shows the baseline and adjusted baseline for both types of buildings.

Appendix Table F.1: Baseline and Adjusted Baseline Consumption in pre-1996 Residential Buildings

Building Type	Baseline Consumption (weighted average, kWh/m^2)	Baseline Adjusted to Internal Temperature of 24°C (weighted average, kWh/m^2)
<5 Floor	183	246
>5 Floor	137.5	184

Source: Authors.

Total consumption for each building type was calculated by taking the adjusted baseline consumption and multiplying by the number of buildings and average floor area per building for each building type. Appendix Table F.2 shows the results of these calculations.

Appendix Table F.2: Total Annual Consumption in pre-1996 Residential Buildings

Building Type	Adjusted Baseline Consumption (kWh/m^2)	Total Floor Area (thousand m^2)	Number of Buildings (thousands)	Average Floor Area per Building (m^2)	Total Annual Consumption (GWh)
<5 Floor	246	60,954	371.74	163.97	14,998
>5 Floor	184	100,601	23.98	4,195.01	18,477

Source: Authors.

The total annual consumption for <5 Floor buildings is 14,998 GWh. For >5 Floor buildings, it is 18,477 GWh. These total annual consumption numbers are used as the basis for determining the potential energy savings of each ESM package.

F.2 Potential Energy Savings of Each ESM Package

The percentage of potential energy savings of each individual ESM (installation of TRVs and HCA; replacement of windows; and insulation of walls and roofs) were estimated based on expert assessments and actual savings achieved in buildings where these measures have already been implemented. Appendix Table F.3 shows the weighted average percentage savings for each type of building.

Appendix Table F.3: Relative Energy Savings from Implementation of ESMs

Building Type	TRV and Allocator Savings	Window Replacement Savings	Wall and Roof Insulation Savings
<5 Floor	12%	6.21%	26.99%
>5 Floor	12%	8.61%	23.6%

Source: Authors.

It is also necessary to take into account buildings that have already received these measures, or that cannot receive them for technical reasons. Appendix Table F.4 shows what percentage of buildings would actually receive each ESM.

Appendix Table F.4: Applicability of ESMs

ESM	% Buildings Where ESM Already Implemented	% Buildings Where ESM Cannot Be Applied	% Buildings Receiving the ESM
TRVs and HCA	N/A	21%	79%
Window Replacement	4%	N/A	96%
Wall/Roof Insulation	4%	N/A	96%

Note: Assumption was that about 21 % of buildings have radiators within the walls, making installation of TRVs and allocators impossible.

Source: Authors.

To determine the amount of energy saved by each ESM package, it is first necessary to determine the potential savings by each individual ESM. These can then be combined into packages as necessary. Energy savings are calculated by multiplying the total consumption of each building type by the relative savings provided by the ESM and the percentage of buildings receiving the ESM. Appendix Table F.5 shows these calculations.

Appendix Table F.5: Potential Annual Energy Savings of Individual ESMs

Building Type	Total Annual Consumption (GWh)	ESM	Relative Savings by ESM (%)	Buildings Receiving ESM (%)	Potential Annual Energy Savings (GWh)
<5 Floor	14,998	TRVs and Allocators	12%	79%	1,412
		Windows	6.21%	96%	893
		Walls and Roofs	26.99	96%	3,878
>5 Floor	18,477	TRVs and Allocators	12%	79%	1,740
		Windows	8.21%	96%	1,525
		Walls and Roofs	23.6%	96%	4,178

Source: Authors.

The energy savings of the individual ESMs are combined into packages in Appendix Table F.6. These packages assume that TRVs and allocators are implemented first; savings from window replacement and wall and roof insulation take prior savings from TRVs into account.

Appendix Table F.6: Potential Annual Energy Savings of ESM Packages

Package	Building Type	Annual Savings, GWh
End-User Heat Control	<5 Floor	1,412
	>5 Floor	1,740
Simple Renovation	<5 Floor	2,315
	>5 Floor	3,199
Deep Renovation	<5 Floor	5,466
	>5 Floor	6,591

Source: Authors.

F.3 CAPEX for ESM Packages

In order to determine the cost of each package, it is necessary to know the unit cost of each measure: the cost per TRV and allocator, the cost per m^2 of window area and the cost of insulation per m^2 of wall area and roof area. These are shown in Appendix Table F.7.

Appendix Table F.7: Cost of Implementing ESMs

Measure	Unit Cost
Thermal insulation of walls	94 USD/m^2
Thermal insulation of roofing	33 USD/m^2
Window replacement	230 USD/m^2
Introduction of TRVs	26 USD each
Introduction of HCA	22 USD each

Source: Authors.

These unit costs are then multiplied by the total relevant units in each building type: wall area, roof area, window area and number of heaters. These are shown in Appendix Table F.8.

Appendix Table F.8: Number of Heaters and Area of Walls, Roofs and Windows by Building Type

Building Type	Number of heaters (thou.)	Window area (thousand m^2)	Roof area (thousand m^2)	Wall area (thousand m^2)
<5 Floor	3,802	6,567	25,870	40,258
>5 Floor	6,233	1,251	15,312	51,253

Source: Authors.

These numbers can be multiplied by the unit cost to determine the total CAPEX for each individual ESM. They must also be multiplied by the percentage of buildings that will receive the measure as shown in Appendix Table F.4. The totals for each individual ESM can then be combined into packages, as was done with energy savings in Appendix Table F.6. Appendix Table F.9 shows the results of the calculations for individual ESMs.

Appendix Table F.9: CAPEX for Individual ESMs by Building Type

Building Type	ESM	Unit Cost* (USD)	Relevant Unit	Value (thousands)	% Buildings Receiving ESM	Total CAPEX (million USD)
<5 Floor	TRVs and allocators	48	# heaters	3,802	79%	143.16
	Window replacement	230	Window area, m^2	6,567	96%	1,446.94
	Wall/Roof Insulation	94 33	Wall area, m^2 Roof area, m^2	40,258 25,870	96%	4,443.12
>5 Floor	TRVs and allocators	48	# heaters	6,233	79%	234.72
	Window replacement	230	Window area, m^2	1,251	96%	2,478.95
	Wall/Roof Insulation	94 33	Wall area, m^2 Roof area, m^2	51,253 40,258	96%	5,099.46

Note: * Unit cost for TRVs and allocators simply combines the individual cost of TRVs (26 USD each) and allocators (22 USD each) into a single number. For walls and roofs, the top number represents walls and the bottom number represents roofs.

Source: Authors.

Appendix Table F.10 shows the CAPEX for the ESM packages. Simple and Deep Renovation both include the cost of End-User Heat Control twice, because TRVs and allocators need to be replaced after 10 years.

Appendix Table F.10: CAPEX for ESM Packages by Building Type

Package	Building Type	CAPEX (million USD)
End-User Heat Control	<5 Floor	143.16
	>5 Floor	234.72
Simple Renovation	<5 Floor	1,733.27
	>5 Floor	2,948.39
Deep Renovation	<5 Floor	6,176.39
	>5 Floor	8,047.84

Source: Authors.

F.4 Supply Curves

Supply curves offer a convenient visual way of analyzing the relationship between investment cost and savings. The levelized cost of energy saved is the cost of reducing a unit of energy demand (USD per kWh), discounted over the life of the implemented measure. This cost can then be compared to the current tariff as well as the full cost tariff, in order to determine which of the energy savings measures are financially viable, given current energy costs.

The first step in creating a supply curve is to calculate the levelized cost of energy saved. Levelized cost is calculated by taking the total investment cost and dividing by the present value of the energy saved, with an assumed discount rate and asset life (Appendix Table F.11).

Appendix Table F.11: Key Assumptions for Supply Curve Analysis

Parameter	Assumption
Discount rate	25% opportunity cost of capital
Asset life	20 years for insulation and windows 10 years for TRVs and allocators
Construction period	1 year

Source: Authors.

Using those assumptions and the investment costs and potential savings of each package allows the calculation of levelized cost for each building type for each package (Appendix Table F.12).

Appendix Table F.12: Levelized Cost for Each Package by Building Type

Package	Building Type	CAPEX (million USD)	Annual Savings (GWh)	Levelized Cost (USD/kWh)
End-User Heat Control	<5 Floor	143.16	1,412	0.02840
	>5 Floor	234.72	1,740	0.03779
Simple Renovation	<5 Floor	1,733.27	2,315	0.18933
	>5 Floor	2,948.39	3,199	0.23310
Deep Renovation	<5 Floor	6,176.39	5,466	0.28577
	>5 Floor	8,047.84	6,591	0.30883

Source: Authors.

To make a supply curve for each package, the levelized costs of each building type must be ranked from lowest to highest, and cumulative annual savings calculated by starting with the savings for the building type with the lowest levelized cost, and then adding the savings of the next building type (Appendix Table F.13). In this case, <5 Floor buildings always have a lower levelized cost than >5 Floor buildings.

Appendix Table F.13: Cumulative Annual Savings for Each Package

Package	Building Type	Levelized Cost (USD/kWh)	Cumulative Annual Savings (GWh)
End-User Heat Control	<5 Floor	0.02840	1,412
	>5 Floor	0.03779	3,152
Simple Renovation	<5 Floor	0.18933	2,315
	>5 Floor	0.23310	5,514
Deep Renovation	<5 Floor	0.28577	5,466
	>5 Floor	0.30883	12,057

Source: Authors.

The levelized cost for each building type can then be plotted against the cumulative annual savings on an area chart to create a supply curve.[52]

In addition, a supply curve was made for Deep Renovation using low-cost financing and a capital subsidy to make it financially viable. To do this, a levelized cost was calculated using a 2.07 percent rate in place of the 25 percent discount rate used in the other supply curves. For the capital subsidy, CAPEX was reduced by seven percent (Appendix Table F.14).

Appendix Table F.14: Calculations for Deep Renovation with Low-Cost Financing and Capital Subsidy

Building Type	CAPEX (million USD)	% Capital Subsidy	CAPEX with Subsidy (million USD)	Annual Savings (GWh)	Cumulative Annual Savings (GWh)	Levelized Cost with 2.07% rate (USD/kWh)
		10%	5,558.75			0.06261
<5 Floor	6,176.39	20%	4,941.11	5,466	5,466	0.05565
		40%	3,705.84			0.04174
		10%	7,243.06			0.06766
>5 Floor	8,047.84	20%	6,438.27	6,591	12,057	0.06015
		40%	4,828.70			0.04511

Source: Authors.

[52] The method for making these charts on Excel can be found at http://peltiertech.com/variable-width-column-charts/

Appendix G: Regional Experience Implementing Apartment Level Consumption-Based Billing (Croatia)

About 150,000 households in Croatia are connected to the DH network. Most of the apartment buildings served by DH have vertical piping systems that limit options for apartment-level metering and consumption except through the use of HCAs. At present, only 6 percent of residential customers, mostly in the cities of Rijeka and Karlovac are billed by the heat they consume, while the rest are billed using building level heat meters with heat costs being allocated by apartment floor area. To increase the uptake of HCAs, the Government of Croatia (GoC) enacted the Heating Energy Market Law which requires the installation of HCAs in all centrally heated multi-family buildings.

Based on experiences from Rijeka and Karlovac, as well as several new EU member states, installing HCAs has reduced building heat consumption by 15 – 30 percent, lowered heating bills for most households, and improved comfort and service levels of individual apartments, improving customer satisfaction. According to DH company estimates, the average total cost of the HCA billing scheme was EUR 390 – EUR 525 (based on the typical lifecycle of a HCA battery).[53] The estimated payback period for the installed cost of the HCA/TRV package is five years or less.[54] Since close to 50 percent of the capital cost is subsidized by grants from local governments and the Environmental Protection and Energy Efficiency Fund (EPEEF), the payback period is only about two and a half years for households.

Implementation arrangements varied slightly between Rijaka and Karlovac cities. In Rijaka, individual HOAs directly contracted one of two HCA suppliers (Brunata and Siemens) working in the local market. In Karolovac, a public tender was issued for HCA supply, installation and billing service, from which Brunata was selected. Both of these implementation approaches required strong HOAs, standardized procedures and contracts, and up-to-date market information. The key advantage of the Rijeka approach was the flexibility it afforded to HOAs by allowing them to contract directly.[55] For Karlovac, a large public tender had the potential of reducing cost. To qualify for grant funding from EPEEF, HOAs needed to obtain a 70 percent sign up rate amongst households in each apartment building.

[53] The exchange rate used was 1 EUR = 7.63 HRK, and estimates vary by city.

[54] Assuming 9 MWh of baseline (before HCA installation) heat consumption per household per heating season, the estimated energy cost savings per household at current tariff levels may range from 65 (15% savings) to 130 (30% savings) Euro per household per heating season in Rijeka and Karlovac.

[55] Keep in mind that this approach requires HOA capacity to be high.

Appendix H: Summary of Survey Results

A survey was conducted to understand households' perceptions of current thermal comfort levels and attitudes towards thermal retrofits in multi-apartment buildings. Interviews were conducted in the cities of Minsk, Baranovichi, Novopolotsk, and Smolevichi in buildings that have received thermal renovations in the last three years, and buildings that have yet to receive renovations. A total of 83 households in buildings without thermal renovation were surveyed, and 86 households in buildings that had received thermal renovations in the last three years.

H.1 Current Levels of Thermal Comfort and Coping Mechanisms

As shown in Appendix Table H.1, there are high levels of perceived indoor comfort in buildings with and without thermal renovation, based on those surveyed.

Appendix Table H.1: Perceived Indoor Temperature in Buildings with and without Thermal Retrofits

	Households without thermal renovation	Households with thermal renovation
Above 18C	65.5%	83.7%
About 18C	29.8%	10.5%
Below 18C	4.7%	3.5%
Did not answer	-	2.3%

Source: Authors.

In households that had not received thermal renovations, only 25 percent were unsatisfied with the level of thermal comfort in their home and 22.6 percent of households used alternative sources of heat such as electric space heaters to improve thermal comfort. Amongst these, 70.2 percent had spent their own money to replace windows and entry doors. By contrast, in buildings that had started to receive thermal renovations, 57 percent of households had spent their own money to improve the thermal comfort in the winter time.

Nevertheless, in buildings that had received thermal renovations, 81 percent of respondents perceived improved thermal comfort, 66.6 perceived improved building asset value and 10.1 percent noticed reduced heating costs.

H.2 Concern about Increases in Heating Cost

Households from buildings with and without thermal renovation expressed concern about a twofold and fourfold increase in heat tariffs. Amongst households in renovated buildings and households in buildings that have not received renovations, 82.5 percent and 66.7 percent of households were concerned about a twofold increase in the tariff. When asked about a fourfold increase, 94.3 percent of households in buildings that have received renovations and 97.6 percent of households in buildings that did not said that they were very concerned.

It is worthwhile to note that 11.6 percent of respondents from households that received thermal retrofit pay extra monthly contributions (in addition to the regular major repairs deduction) for thermal renovation.

H.2.1 Preferred Coping Strategies against Tariff Increases

As follow up questions, respondents were asked whether they would prefer normative or consumption based tariffs to cope with tariff increases, and whether they would prefer to be able to control the temperature in their apartments. Respondents were then asked if they were willing to pay for the installation of a heat control and cost allocation device with a payback of 5 years. Their responses are summarized in Appendix Table H.2.

Appendix Table H.2: Coping Strategies against Increases in Heat Tariffs

Preferred coping strategies against tariff increases	Households without Thermal Renovation	Households with Thermal Renovation
Billing for actual consumption of heat	77.4	73.3
Control over room temperature	77.4	67.4
Installation of heat control and cost allocation device	48.8	40.7

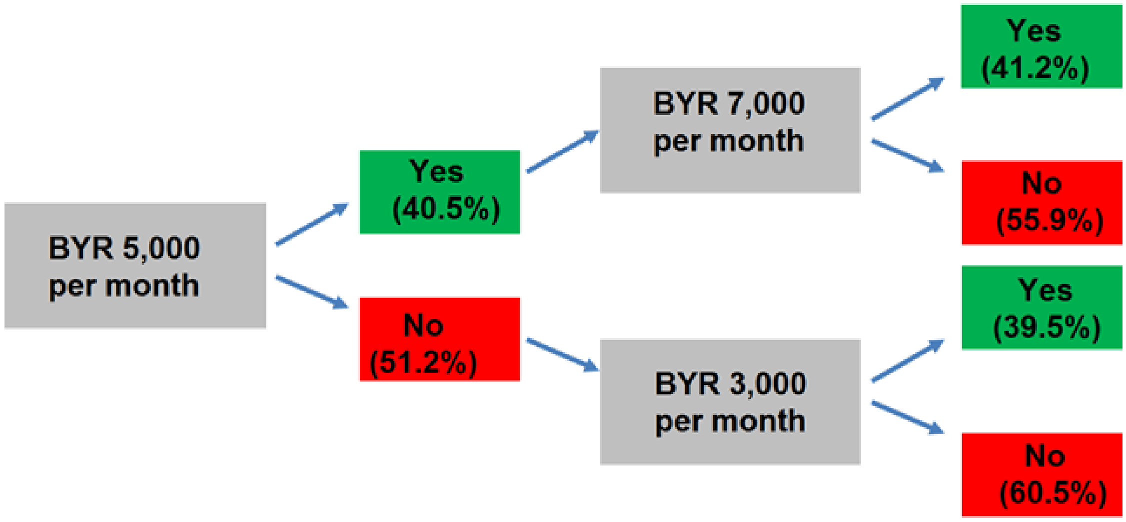
Source: Authors.

H.3 Willingness to pay for thermal retrofits

Households without thermal renovation were asked about their willingness to pay for thermal retrofits. Of the 83 respondents, 58.3 percent said they were willing to pay for some part of thermal renovations to their buildings. When given a more specific scenario which asked if households were willing to pay for 60 percent of the thermal retrofit, using Lithuania as an example, 47.6 percent of households said that they were willing to pay. As a follow up question, households were asked if they would be in favor of a scheme where they could pay off the cost of the thermal renovation over 10 – 20 years, 61.9 percent said yes.

Respondents were finally asked about their willingness to pay installments each month. First, respondents were asked if they were willing to pay 5000BYR/m2 a month, over a period of 15 years, 40.5 percent said ‘yes’. If respondents said yes, enumerators asked if they were willing to pay 7000BYR/m2/month. About 40 percent of the respondents who said ‘yes’ to BYR 5000/m2/month said ‘yes’. If they said no to BYR 5000/m2/month, enumerators asked if they were willing to pay 3000BYR/m2/month. Amongst the 51.2 percent that said no to BYR 5000/m2/month, 39.5 percent agreed to BYR 3000/m2/month. The results of this survey are shown in Appendix Figure H.1. Where figures do not add up to 100 percent, a portion of respondents have refused to answer the question.

Appendix Figure H.1: Willingness to Pay for Thermal Renovations



Source: Authors.

Constraints on paying a higher tariff

Amongst households in buildings without thermal renovation, 42.9 percent said that they were unwilling to pay more than indicated for thermal retrofits because they could not afford it. In households that received thermal retrofits, the main reason cited was lack of information on the specific cost of the equipment, followed by high costs. Respondents who were of pension age stated that they are hesitant to take on long-term loans.

Perceived benefits of thermal retrofits

The benefits that households foresee in receiving thermal benefits are as follows from the most important to least important: Improved thermal comfort, improved building asset value, and reduced heating costs. Seventy four percent of respondents saw improved thermal comfort as key benefit of thermal retrofits while only 40.5 percent saw reduced energy bills as a key benefit. Drawbacks foreseen also in order of importance are: High cost and inconvenience of having the work done.

Household access to credit

Respondents from buildings without thermal renovations were asked about their borrowing preferences. About 54 percent of respondents stated that they have borrowed money from a bank, or friends and family. Amongst these respondents, 80 percent had applied to a bank for a loan, and 20 percent borrowed from friends and family. These funds were mostly spent on consumer goods, and mortgages.

H.4 Feedback on thermal retrofits

Amongst household that lived in household that have had thermal retrofits, 74.4 percent experienced improvements in thermal comfort. In addition, 53.5 percent of respondents whose buildings received renovations said they perceived improved market value of their apartment and a 9.3 percent reduction in their heating bills.

A majority of respondents were satisfied with the implementation process of thermal retrofits but also had suggestions for future renovations. Some suggestions include increasing household awareness about EE, and improvements to the quality of renovation.

H.5 Household Demographics

Appendix Table H.3 below summarizes the demographics of the sample.

Appendix Table H.3: Summary of Sample Demographics

	Buildings without Thermal Renovation	Buildings with Thermal Renovations
	%	
Sex		
Male	21.7	39.5
Female	78.3	58.1
Level of Education		
Secondary/Technical	47.6	36.1
University	41.7	51.2
Post-graduate	4.8	3.5
Employment Status		
Employed	44.0	43.0
Unemployed/Pension Age	54.8	53.5

Source: Authors.

H.6 Building Characteristics of Sample

Appendix Table H.4,

Appendix Table H.5 and Appendix Table H.6 provide an overview of the buildings surveyed.

Appendix Table H.4: Characteristics of Buildings Surveyed

	Households without thermal renovation	Households with thermal renovation
Buildings built before 1970	53.6%	47.7%
1970 to 1979	6.0%	10.5%
1980 to 1989	32.1%	14.0%
1990 - 1995	7.1%	23.3%
Did not answer	1.2%	4.5%

Source: Authors.

Appendix Table H.5: Primary Material of Building

	Households without thermal renovation	Households with thermal renovation
Brick	56.0%	44.2%
Concrete	42.9%	47.7%
Other	-	3.5%
Did not answer	1.2%	4.6%

Source: Authors.

Appendix Table H.6: Building Type by Number of Floors

	Households without thermal renovation	Households with thermal renovation
Low-rise (1–3 floors)	21.4%	5.6%
Mid-rise (4-5 floors)	64.3%	69.8%
Multi-floor (6-9 floors)	8.3%	22.1%
Increased number of floors (10-16 floors)	6%	-
High-rise (more than 17 floors)	-	-
Did not answer	-	2.3%

Source: Authors.

Appendix I: Summary of In-depth Interview Results

Interviews were conducted with public building stakeholders to understand their attitudes toward adopting new financing and delivery models for thermal retrofit in Belarus. Interviews were also conducted with contracting companies with experience implementing thermal retrofits in order to assess their capacity for handling more thermal retrofits and to understand their perceptions of barriers or problems in the retrofit process. Section I.1 contains information from the interviews with public building stakeholders. Section I.2 contains information from the interviews with thermal retrofit contractors.

I.1 Interviews with Public Building Stakeholders

Public building stakeholders interviewed as part of this study include representatives of hospitals in Baronovichi; representatives of hospitals, schools and Housing and Utilities in Smolevichi; and representatives from Novopolotsk.

Willingness to participate in a thermal retrofit program

Participants were asked whether their cities would be willing to participate in a program that allowed budget-supported entities to use their energy savings to pay for the costs of thermal retrofit. Respondents from Smolevichi all expressed their willingness to take part in such a program. Respondents in Baranovichi and Novopolotsk stated that such a program is not possible given current Belarus law that requires energy payments to be made according to actual metered consumption, and for all payments to be made via the Treasury. The Baranovichi respondents believed they would be willing to participate in such a program if adjustments for the duration of the heating season, new equipment startup and temperature factor would be taken into account.

Perceptions of ESCO participation in a thermal retrofit program

Participants were also asked about ESCOs, and whether schools and hospitals would be willing to pay an ESCO on a monthly basis the equivalent of the heating bills before renovation over 10 years, thus paying for the renovation. The ESCO would guarantee the level of energy services. Several respondents from Smolevichi explained that they have insufficient funds to participate in such a program. Respondents from Novopolotsk said that such a program might work for businesses, but not entities funded from the city budget, where accumulation of funds is impractical. Respondents from Baranovichi also said it was impractical, as the hospital there carries out EE measures on its own. The representatives of Housing and Utilities in Smolevichi said that much would depend on the ESCO, and whether it would provide high quality services throughout the contract period. They also wondered who would monitor the contract, and who would be responsible for losses due to inflation over the course of the contract.

I.2 Interviews with Thermal Retrofit Contractors

Thermal retrofit contractors interviewed as part of this study to understand local capacity to undertake thermal retrofits. Representatives of nine companies in Minsk, Baranovichi, Novopolotsk and Smolevichi were interviewed.

Past renovation projects

Contractors were asked how much thermal renovation work they had done over the period from 2012 to 2014. Answers that were given in total area ranged from 560 m^2 for a company in Smolevichi to over 50,000 m^2 for two companies in Minsk. A Baranovichi company carried out major upgrades in eight buildings. A company in Novopolotsk reconstructed the main and obstetrical units of the Central City Hospital. Contractors were also asked how much thermal renovation they could implement in one year. A Smolevichi company answered only 250 m^2 of thermal renovation per year. One Minsk company answered between 20,000 and 25,000 m^3. Two other Minsk companies had answers ranging from 25,000 to 35,000 m^2. A state-owned company replied that could retrofit as much as 102,000 m^2 per year.

Perceptions of M&V institutions, and payment processes

Contractors were asked whether the responsible municipal agency carried out inspections to guarantee the quality of repair work. Six of the eight contractors who answered the question said yes. A Novopolotsk company identified the agency that carried out the inspection but said that it was "not adequately principled." A Smolevichi contractor replied that no inspection had been done, but the residents were satisfied with the work.

Six contractors provided answers to a question on the timeliness of contractual payments. Three reported that payments were made on time, according to the contract schedule. The other three respondents said that 70 to 80 percent of payments were on time, with two to three month delays for the remaining payments.

Common problems faced while undertaking thermal retrofits

Respondents were asked what problems or issues they have faced in reconstruction projects so far. One company in Minsk cited the fact that unplanned work might come up during a renovation and require additional costs and certificates. Another Minsk company said that omissions in design for some types of work was a problem. Another company cited the insufficiency and inadequacy of regulations on design and use of construction materials and technology. They also said that low awareness among designers, developers and contractors was a problem that resulted in lack of trust. Finally, a company in Novopolotsk cited construction quality, workplace discipline and site management.

The quality and availability of insulation materials and new windows were assessed by six respondents. All said that the quality was adequate and compliant with standards.

Appendix J: Calculating the Potential of ESM Packages for Public Buildings

The methodology for determining the potential of ESM packages in public buildings is identical to that of residential buildings, as described in Appendix F. This appendix provides the inputs needed to apply that methodology to public buildings. Section J.1 provides tables for total annual consumption for each public building type. Section J.2 provides tables for potential energy savings of the packages in public buildings. Section J.3 provides tables showing total investment costs (CAPEX) in public buildings. Section J.4 provides tables needed to create supply curves for public buildings.

J.1 Public Sector Annual Consumption Tables

In public buildings, baseline consumption is given in heated volume (in kWh/m^3), rather than floor area. As with residential buildings, in order to determine how much energy savings the ESM packages could achieve, baseline consumption numbers were adjusted to a more realistic internal temperature of 23°C. Appendix Table F.1 shows the baseline and adjusted baseline for public buildings.

Appendix Table J.1: Baseline and Adjusted Baseline Consumption in Public Buildings

Building Type	Baseline Consumption (weighted average, kWh/m^3)	Baseline Adjusted to Internal Temperature of 23°C (weighted average, kWh/m^3)
Educational	59	84
Health	43	61
Administrative	34	48

Source: Authors.

Appendix Table J.2 shows the total consumption for each building type.

Appendix Table J.2: Total Annual Consumption in Public Buildings

Building Type	Adjusted Baseline Consumption (kWh/m^3)	Total Heated Volume (thousand m^3)	Number of Buildings (thousands)	Average Heated Volume per Building (m^3)	Total Annual Consumption (GWh)
Educational	84	46,514	4,619	10,070	3,908
Health	61	21,623	1,718	12,586	1,310
Administrative	48	31,490	1,841	17,105	1,504

Source: Authors.

J.2 Public Sector Energy Savings Potential Tables

The percentage of potential energy savings of each individual ESM (installation of TRVs; replacement of windows; and insulation of walls and roofs) were estimated. Appendix Table J.3 shows the weighted average percentage savings for each type of building.

Appendix Table J.3: Relative Energy Savings from Implementation of ESMs, Public

Building Type	TRV Savings	Window Replacement Savings	Wall and Roof Insulation Savings
Educational	9.3%	11.5%	35.5%
Health	9.3%	11.8%	35.7%
Administrative	5%	12.9%	37.9%

Source: Authors.

Appendix Table J.4 shows the calculations for the potential annual energy savings of each ESM.

Appendix Table J.4: Potential Annual Energy Savings of Individual ESMs, Public

Building Type	Total Annual Consumption (GWh)	ESM	Relative Savings by ESM (%)	Potential Annual Energy Savings (GWh)
Educational	3,908	TRVs	9.3%	363
		Windows	11.5%	451
		Walls and Roofs	35.5%	1,389
Health	1,310	TRVs	9.3%	122
		Windows	11.8%	155
		Walls and Roofs	35.7%	468
Administrative	1,504	TRVs	5%	75
		Windows	12.9%	194
		Walls and Roofs	37.9%	570

Source: Authors.

The energy savings of the individual ESMs are combined into packages in Appendix Table J.5. These packages assume that TRVs are installed first; savings from window replacement and wall and roof insulation take into account the prior savings from TRVs.

Appendix Table J.5: Potential Annual Energy Savings of ESM Packages, Public

Package	Building Type	Annual Savings, GWh
	Educational	363
End-User Heat Control	Health	122
	Administrative	75
	Educational	771
Simple Renovation	Health	262
	Administrative	260
	Educational	2,030
Deep Renovation	Health	686
	Administrative	801

Source: Authors.

J.3 Public Sector CAPEX Tables

The unit cost of each measure (the cost per TRV and allocator, the cost per m^2 of window area and the cost of insulation per m^2 of wall area and roof area) are identical to those for residential buildings. This is shown in Appendix Table F.7.

The wall area, roof area, window area and number of heaters for each type of building are shown in Appendix Table J.6.

Appendix Table J.6: Number of Heaters and Area of Walls, Roofs and Windows by Public Building Type

Building Type	Number of heaters (thou.)	Window area (thousand m^2)	Roof area (thousand m^2)	Wall area (thousand m^2)
Educational	1,104.56	2,468.89	5,624.03	7,026.82
Health	531	862.29	1,658.3	2,586.87
Administrative	759	1,233	1,897	3,699

Source: Authors.

Appendix Table J.7 shows the investment costs for individual ESMs.

Appendix Table J.7: CAPEX for Individual ESMs by Public Building Type

Building Type	ESM	Unit Cost (USD)	Relevant Unit	Value* (thousands)	Total CAPEX (million USD)
Educational	TRVs	26	# heaters	1,104.56	28.72
	Window replacement	230	Window area, m^2	2,468.89	567.85
	Wall/Roof Insulation	94 33	Wall area, m^2 Roof area, m^2	7,026.82 5,624.03	846.11
Health	TRVs	26	# heaters	531	13.81
	Window replacement	230	Window area, m^2	862.29	198.33
	Wall/Roof Insulation	94 33	Wall area, m^2 Roof area, m^2	2,586.87 1,658.3	297.89
Administrative	TRVs	26	# heaters	759	19.73
	Window replacement	230	Window area, m^2	1,233	283.59
	Wall/Roof Insulation	94 33	Wall area, m^2 Roof area, m^2	3,699 1,897	410.31

Note: * For walls and roofs, the top number represents walls and the bottom number represents roofs.

Source: Authors.

Appendix Table J.8 shows the CAPEX for the ESM packages. Simple and Deep Renovation both include twice the cost of End-User Heat Control, because TRVs need to be replaced after 10 years.

Appendix Table J.8: CAPEX for ESM Packages by Public Building Type

Package	Building Type	CAPEX (million USD)
End-User Heat Control	Educational	28.72
	Health	13.81
	Administrative	19.73
Simple Renovation	Educational	625.28
	Health	225.94
	Administrative	323.06
Deep Renovation	Educational	1,471.4
	Health	523.83
	Administrative	733.37

Source: Authors.

J.4 Public Sector Supply Curve Tables

The assumptions used to calculate the levelized cost of energy saved are the same as for residential buildings, except for discount rate used (Appendix Table J.9).

Appendix Table J.9: Key Assumptions for Supply Curves in Public Buildings

Parameter	Assumption
Discount rate	12.45% (based on Government of Belarus 1-year bond yield as of June 2015)
Asset life	20 years for insulation and windows 10 years for TRVs and allocators
Construction period	1 year
Tariff for supply by MHU (natural gas)	0.07739 USD/kWh

Source: Authors.

The levelized cost for each building type for each package is shown in Appendix Table J.10.

Appendix Table J.10: Levelized Cost for Each Package by Public Building Type

Package	Building Type	CAPEX (million USD)	Annual Savings (GWh)	Levelized Cost (USD/kWh)
End-User Heat Control	Educational	26.51	363	0.01424
	Health	13.81	122	0.02043
	Administrative	19.73	75	0.04730
Simple Renovation	Educational	597.01	771	0.11164
	Health	225.94	262	0.11872
	Administrative	323.06	260	0.17131
Deep Renovation	Educational	1,407.59	2,030	0.09981
	Health	523.83	686	0.10509
	Administrative	733.37	801	0.12602

Source: Authors.

Appendix Table J.11 ranks the building types by levelized cost for each package, and calculates the cumulative annual savings.

Appendix Table J.11: Cumulative Annual Savings for Each Package, Public

Package	Building Type	Levelized Cost (USD/kWh)	Cumulative Annual Savings (GWh)
	Educational	0.01424	363
End-User Heat Control	Health	0.02043	485
	Administrative	0.04730	561
	Educational	0.11164	771
Simple Renovation	Health	0.11872	1,033
	Administrative	0.17131	1,293
	Educational	0.09981	2,030
Deep Renovation	Health	0.10509	2,716
	Administrative	0.12602	3,517

Source: Authors.

A supply curve was made for Deep Renovation using low-cost financing to make it financially viable. To do this, a levelized cost was calculated using a 2.07 percent rate in place of the 12.45 percent discount rate used in the other supply curves (Appendix Table J.12).

Appendix Table J.12: Calculations for Deep Renovation in Public Buildings with Low-Cost Financing and Capital Subsidy

Building Type	CAPEX (million USD)	Annual Savings (GWh)	Cumulative Annual Savings (GWh)	Levelized Cost with 2.07% rate (USD/kWh)
Educational	1,407.59	2,030	2,030	0.04464
Health	523.83	686	2,716	0.04700
Administrative	733.37	801	3,517	0.05636

Source: Authors.

Appendix K: Estimated Fiscal Cost and Effectiveness of Expanding Social Protection Mechanisms in Belarus

Appendix Table K.1: Benefit Coverage, Targeting Accuracy and Fiscal Cost of GASP and H&U Benefits

		Benefit coverage		Targeting accuracy		Budget per year, % GDP	
		2015	2017	2015	2017	2015	2017
Expand GASP (20% of population)	1st decile	52	51	42	41	0.43	0.36
	2nd decile	48	52	21	24	0.22	0.22
	3rd-10th deciles	12	12	37	35	0.38	0.31
	Total	20	20	100	100	1.03	0.89
Expand GASP (10% of population)+ Top up GASP (10% of population)	1st decile	100	100	59	59	0.26	0.25
	2nd decile	81	83	20	23	0.09	0.1
	3rd-10th deciles	2	2	21	18	0.09	0.08
	Total	20	20	100	100	0.44	0.43
Old H&U benefit	1st decile	5	21	48	25	0.002	0.01
	2nd decile	1	10	15	12	0.001	0.01
	3rd-10th deciles	1	5	37	63	0.002	0.03
	Total	1	7	100	100	0.005	0.05
Refined H&U benefit	1st decile	27	61	84	60	0.012	0.04
	2nd decile	3	18	12	16	0.002	0.01
	3rd-10th deciles	0	3	5	25	0.001	0.02
	Total	3	10	100	100	0.014	0.07

Source: World Bank, "Heat Tariff Reform and Social Impact Mitigation: Recommendations for a Sustainable District Heating Sector in Belarus", 2014.

Appendix L: Heat Consumption of Housing Stock by Standard Series of Residential Buildings

Building Type	Description	Baseline		
		Estimated parameter of specific heat consumption for heating and ventilation, kWh/(m²·year)	Actual parameter of specific heat consumption for heating and ventilation, kWh/(m²·year)	Relative deviation between actual and estimated value,%
Type 1	Separate standalone wooden buildings			
	- one floor	**288.6**	-	-
	- 2-3 floors	**192.8**	-	-
Type 2	2 floors standalone buildings			
	- brick	**181.7**	141.0	**22%**
	- concrete blocks	**181.3**	141.0	**22%**
Type 3	3 floors multi-apartment buildings			
	- brick	**184.6**	181.5	**2%**
	- concrete blocks	**184.6**	181.5	**2%**
	- concrete panels	**184.6**	181.5	**2%**
Type 4	5 floors multi-apartment buildings			
	- brick	**138.7**	128.9	**7%**
	- concrete blocks	**138.7**	128.9	**7%**
Type 5	5 floors multi-apartment buildings			
	- concrete panels	**138.7**	128.9	**7%**
	- modular blocks	**138.7**	128.9	**7%**
Type 6	9 floor brick multi-apartment buildings	**136.5**	125.1	**8%**
Type 7	9 floor multi-apartment buildings			
	- concrete panels with thermal resistance coefficient below 2,4	**136.5**	125.1	**8%**
	- modular blocks	**136.5**	125.1	**8%**
Type 8	9 floor multi-apartment buildings with thermal resistance coefficient above 2,4	**81.7**	-	**-**
Type 9	12 floor multi-apartment buildings			
	- concrete panels	**135.8**	119.7	**12%**
	- modular blocks	**135.8**	119.7	**12%**
Type 10	12 floor multi-apartment			

Building Type	Description	Baseline		
		Estimated parameter of specific heat consumption for heating and ventilation, kWh/(m²·year)	Actual parameter of specific heat consumption for heating and ventilation, kWh/(m²·year)	Relative deviation between actual and estimated value,%
	buildings			
	- brick	**135.8**	119.7	**12%**
	- monolithic	**135.8**	119.7	**12%**