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KEEPING WARM:

Urban Heating Options in Tajikistan

Summary Report

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List of Abbreviations

CAPEX	Capital expenditures
CEF	Cost efficiency factor
CHP	Combined heat and power
DH	District heating
DHW	Domestic hot water
ECA	Europe and Central Asia
ESCO	Energy service company
Gcal	Giga-calorie
GDP	Gross domestic product
h	Hour
HOA	Homeowners association
HOB	Heat only boiler
JSC	Joint stock company
KMK	Khojagiyu Manziliyu Kommunali
kWh	Kilowatt hours
LCHS	Levelized cost of heat supply
LPG	Liquefied petroleum gas
m	Meter
MW	Megawatt
MWel	Megawatt electric
MWth	Megawatt thermal
OPEX	Operating expenses
PVC	Polyvinyl chloride
SUE	State unitary enterprise
TBA	Tebian Electric Apparatus
UNESCO	United Nations Educational, Scientific and Cultural Organization
UPS	Uninterruptible power supply
US$	Dollars American
VAT	Value added tax
VSD	Variable speed drive
yr	Year

Acknowledgements

This report was initiated based on the findings and results of the World Bank Report on Tajikistan's Winter Energy Crisis (2012), which showed that measures targeting improvements of the heating sector in Tajikistan are important to help the country addressing its recurrent winter energy shortages. It further complements the Assessment of Household Energy Deprivation in Tajikistan, which was conducted by the World Bank in 2014 and evaluated the social impacts of energy depreviation on the population. The content of this report is based on a technical assessment of the urban heating sector in Tajikistan, which was conducted by Fichtner – Engineering and Consulting.

This summary report was prepared by Ani Balabanyan (Task Team Leader), Kathrin Hofer (co-Task Team Leader), and Joshua Finn and Denzel Hankinson (both DH Infrastructure). Overall guidance was provided by Ranjit Lamech and the Country Management Unit in Tajikistan. The team would like to thank the peer reviewers, Peter Johansen and Gevorg Sargsyan, for their valuable suggestions and comments. The report also benefitted from analytical input, editing and contributions provided by Chris Parcels and Jessica Merrill (all DH Infrastructure), and the expertise and contributions provided by Yuriy Myroshnychenko, Furkat Kadyrov, Pekka Salminen, Marat Iskakov, Nigina Alieva, Sunil Koshla, Gailius Draugelis, Heather Worley and Sascha Djumena and Dung Kim Le (all World Bank).

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Executive Summary

Access to reliable and affordable heating is essential for the wellbeing of the population and delivery of public services in Tajikistan. Given the cold climate and long heating season, lasting one-quarter to more than one-half of the year, access to reliable heating services is essential in Tajikistan. However, due to insufficient and unreliable heat and electricity supply in winter, a substantial amount of the public and residential heat demand remains unmet; in Dushanbe and Khujand alone, unmet heat demand in public and residential buildings is estimated at 20 to 30 percent. This negatively impacts the well-being of the population and public service delivery, as demonstrated during the winter energy crisis of 2007-2008 when access to basic health care declined significantly and school attendance rates dropped by 40 to 50 percent.

District Heating (DH) and small Heat-only-Boilers (HOBs) cover only 8 percent of the households in Tajikistan and are characterized by poor service quality and supply reliability. The majority of the DH system in Tajikistan is no longer in operation due to rising natural gas prices, interruptions of natural gas supply and the poor condition of the heating infrastructure. Radiators and building-internal heating infrastructure have been dismantled in about 80 percent of the urban buildings previously connected to the DH system as a result of the deteriorating supply reliability. Most of the remaining DH assets operate at a fraction of their design capacity and are characterized by high losses, increasing pollution and low efficiency, partly due to the conversion of HOBs from gas to coal without modern flue-gas cleaning systems.

Low tariffs contribute to the decay of heating assets. Tariffs for heat and electricity are well below cost-recovery levels. As a result, most heat suppliers operate at a loss and don't have sufficient funds for proper maintenance and rehabilitation. This contributes to the continued decay of assets, and results in inefficiency, poor quality of services and deteriorating supply reliability. Consequently, the heating sector has become highly dependent on direct subsidy from national or municipal governments to cover more than 50 percent of the estimated sector revenue requirements.

As a result of the deterioration of DH services, almost 50 percent of households in urban areas rely on electricity for heating, which accentuates winter power shortages. The high reliance on electricity for heating is a key driver for the increase in winter electricity consumption. In Dushanbe alone, electricity consumption during winter months increased by more than 90 percent between 2009 and 2013. Combined with the poor condition of the ageing power infrastructure and low hydropower output during winter, this increase in electricity load aggravates winter power shortages.

With limited fuel alternatives, and lack of access to DH or reliable electricity supply, more than one-third of urban households use inefficient and polluting coal- or biomass-fired stoves. Outside of Dushanbe, around 37 percent of urban households rely on traditional wood and coal stoves. Use of these stoves is associated with detrimental social impacts due to low efficiency of the stoves and human exposure to indoor smoke and particulate matter. Tajikistan ranks among the 25 worst-affected countries for diseases resulting from indoor air pollution according to the World

Health Organization. Inefficient heating solutions also force households to spend more on fuel than they would spend using more efficient heating alternatives – household expenditures for solid fuel account for around 10 percent of the total expenditures in urban households, and around 15 percent in rural households.

The energy performance of residential and public buildings is poor, aggravating the gap between heat supply and customers' needs. The age of the building stock, the lack of maintenance, and the absence of proper insulation result in high heat losses and low comfort levels in many buildings. Based on the results of energy audits, there is significant potential (30 to 40 percent of consumption) for improving the energy efficiency of the residential and public building stock.

A mix of supply- and demand-side investments are needed to meet residential and public heat demand. The levelized cost assessment (see Figure 0.1 and Figure 0.2) indicates that heat supplied by the CHP continues to be an economically viable heating solution[1] for buildings currently served by the DH system. Small HOBs are a viable option for multi-apartment and public buildings with an existing building-internal heating network, but no access to DH supplied by the CHP. For individual houses, the most viable option would be to replace traditional coal- and wood-fired stoves and boilers with more efficient models. The economic assessment also shows that implementing energy efficiency measures ranks among the most viable options for meeting heat demand.

Figure 0.1: Levelized Cost of Heating Options (Dushanbe)

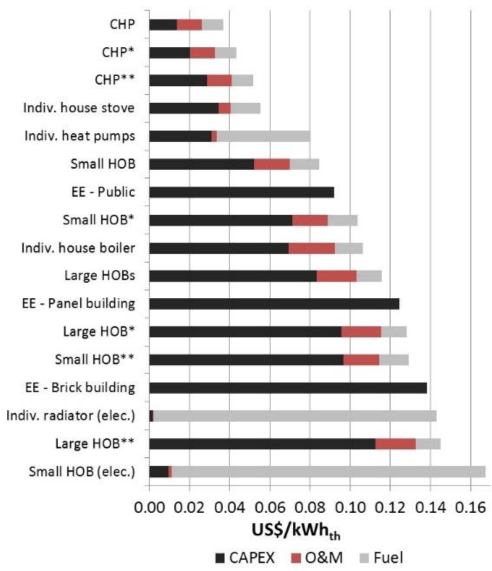
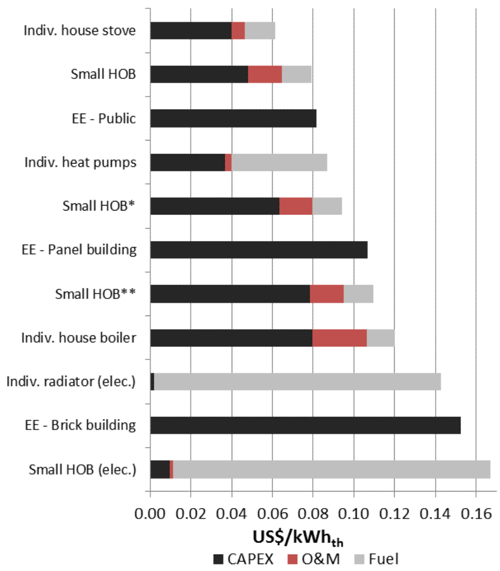


Figure 0.2: Levelized Cost of Heating Options (Khujand)



* Indicates the levelized cost of a heating option assuming that the existing building-internal heating systems are upgraded

** Indicates the levelized cost of a heating option assuming that new building-internal heating systems are constructed

[1] The levelized cost for the CHP excluded generation costs because the new CHP2 plant is already under construction (and thus is a sunk cost), but included some basic reliability and efficiency DH network upgrades.

The investments and related policy and implementation measures need to be customized for different residential and public buildings. Specific recommendations to improve the reliability and efficiency of heat supply to residential and public buildings were identified based on a multi-criteria assessment, which compared economic, technical, institutional, environmental and social advantages and disadvantages associated with different investment measures. Heating options are further customized to different consumer segments, taking into account their primary heat supply infrastructure and available alternatives. The identified priority recommendations include the following:

- **Implementation of a scalable program to replace inefficient individual heating systems.** Such a program would target the replacement of: (i) inefficient and polluting coal- and biomass-fired stoves with more efficient models to reduce fuel consumption and expenditures, improve comfort levels and reduce indoor air pollution; and (ii) electric heaters with efficient heat pumps to reduce electricity consumption for heating purposes by up to 70 percent, and help mitigate winter power shortages.
- **Implementation of a targeted rehabilitation and construction program for small HOBs in urban areas**, focusing on public buildings and multi-apartment buildings with high heating loads to reduce fuel or electricity consumption, improve comfort levels, and reduce indoor/outdoor air pollution (if efficient small HOBs with modern flue gas cleaning systems replace traditional solid fuel-fired stoves or inefficient small HOBs).
- **Introduction of a national energy efficiency program.** As a priority, energy efficiency investments should be implemented in buildings where the heating systems will be upgraded. The experience in other ECA countries demonstrates that linking improvements of heating systems with building energy efficiency measures generates significant operational and financial synergies. It is also recommended that the Government introduces a broader energy efficiency program with targeted financing and implementation mechanisms, starting with public buildings, such as schools and hospitals. This would help to reduce heat losses and complement the limited supply options, improve comfort levels and operation of key public services during cold winter months, demonstrate the benefits of energy efficiency, and build local market capacity.
- **Rehabilitation of the DH network served by the new CHP plant in Dushanbe.** This would help to reduce the reliance on electric heating and polluting solid fuel-fired stoves, while improving the service quality and heat supply reliability for residential and public customers in Dushanbe. The economically most viable investments include: installation of modern building-level substations, including heat and hot water meters; the replacement or re-insulation of dilapidated pipelines; and the installation of variable speed drives at pumping stations.
- **Implementation of electricity and heat tariff reforms, along with social assistance reforms**. Tariff reforms are important to enable investments to improve the reliability and service quality of heat and electricity supply, improve the financial performance of the energy sector, and incentivize the more efficient use of scarce energy resources in Tajikistan. To ensure that a basic level of heat consumption

remains affordable to the poor, the targeting of the social assistance program needs to be improved.

The required investments to ensure reliable heat supply are sizable and should be carefully planned and sequenced, but the time for action is now. The investments recommended for Dushanbe and Khujand alone are estimated at roughly US$200 million in the short-term and close to US$700 million in the medium- to long-term. The investments would need to be carefully prioritized and financed through a combination of public (including concessional donor funding) and private sources. However, actions need to be taken now to help address recurrent winter energy shortages affecting more than 70 percent of the people in Tajikistan. The current heating situation in the country is not sustainable and has serious repercussions on the living and working conditions of the population during winter months. There is also a significant risk that the benefits expected from the construction of the CHP 2 will be limited and short-lived without accompanying efficiency and reliability improvements of the related DH network.

1 Introduction

This report identifies the most viable heating options and related investment measures to meet heating demand in urban residential and public buildings in Tajikistan. The report provides an overview of the condition and performance of the urban heating sector and building stock, and assesses, in detail, the situation in Dushanbe and Khujand. The two cities were selected for the following reasons:

- The cities collectively account for more than one-third of the total urban population of the country;
- Dushanbe and Khujand have a building stock that is typical of urban areas in Tajikistan in terms of building types and heat demand;
- Sixty-five percent of the total urban area is located within the same two climatic zones as Dushanbe and Khujand;
- The heating systems in use in the two cities are representative of the situation in other urban areas, including the high reliance on individual heating solutions (e.g., coal stoves, electric oil radiators), limited coverage of small Heat only Boilers (HOBs) in both cities and the District Heating (DH) system in Dushanbe, which is the only remaining DH system still in operation.

The report begins with an overview of the physical, institutional and regulatory characteristics of the urban heating sector in Tajikistan (Section 2) and includes an analysis of the urban building stock. Sections 3 and 4 describe the heat supply and demand characteristics of Dushanbe and Khujand and estimate the unmet heating demand in these cities. Section 5 evaluates the available supply- and demand-side heating options and investment measures that could be implemented to improve the heating sectors in the target cities. Section 6 recommends priority investment measures for each building type, identifies related policy actions to facilitate implementation of the recommended investments, highlights key implementation issues and describes the next steps necessary to implement them.

2 Overview of the Urban Heating Sector

Roughly 25 percent of Tajikistan's 7.8 million people live in urban areas. About 10 percent (720,000) reside in the capital city, Dushanbe. Other large cities include Khujand (160,000), Kurgan-Tube (80,000), Kulyab (100,000) and Istaravshan (60,000). Figure 2.1 below shows the country's administrative divisions.

Figure 2.1: Administrative Divisions of Tajikistan

Tajikistan's climate is continental, with large seasonal and daily changes in temperature and relative humidity. The country has four basic climatic zones. Roughly 65 percent of the total urban area is located within climatic region III (Dushanbe, Khujand, Istaravshan, Pendzhekent). The climatic zones are described in Table 2.1.

Table 2.1: Climatic Zones of Tajikistan

Climatic region	Urban areas	Average temperature of heating period [t_{ht} °C]	Length of heating period [Z_{ht} day]	Degree-days of heating period [D_d °C*day]
I	Murgob	-6.20	276	7,231
	Khorog	-0.30	166	4,896
	Ishkashim	0.10	182	3,622
II	Faizabad	3.80	131	2,122
	Darvoz	2.58	142	2,474
	Rasht	0.80	147	2,822
III	Pendzhekent	3.04	140	2,380
	Istaravshan	2.16	151	2,694
	Dushanbe	5.76	110	1,566
	Khujand	3.74	122	1,981
IV	Kurgan-Tube	5.02	100	1,500
	Pyandj	2.25	90	1,760
	Kulyab	5.32	97	1,456
	Hamadoni	5.47	100	1,453
	Danghara	4.65	111	1,704

Source: Technical Background Report prepared by Fichtner.

2.1 Overview of the Urban Building Stock

In urban areas, there are 167,474 residential buildings, which consist of individual family houses and multi-apartment buildings. Individual family houses make up 44 percent of urban households and 55 percent of the residential building floor space. The remaining households in urban areas live in multi-apartment buildings, consisting of 215,655 apartments and over seven million m^2 of floor space. In addition, there are about 6,626 public buildings.

Most residential and public buildings in Tajikistan are characterized by low energy performance due to the lack of investment in maintenance and rehabilitation and insufficient thermal insulation. In many cases, the internal heating systems of buildings connected to DH systems or HOBs are in poor condition, which leads to uneven heating within buildings and contributes to under-heating.

2.1.1 Residential buildings

In 2012, the aggregate floor space of residential buildings in Tajikistan, including individual family houses and multi-apartment buildings, amounted to 88.98 million m^2, of which 28 percent was located in urban areas.[2]

Most of the urban population (54 percent) lives in individual family houses, which account for 94 percent of the urban building stock and 55 percent of the floor space. The remaining 46 percent of the population lives in multi-apartment buildings. Table 2.2 shows the number of buildings, the floor space and the population for each housing type in urban areas.

Table 2.2: Urban Residential Building Statistics

	Buildings		**Floor space**		**Households**		**Population**	
	Number	Share	'000 m^2	Share	Number	Share	Number	Share
Multi-apartment buildings	9,236	6 %	7,257,322	45%	215,655	56%	910,656	46%
Individual family houses	158,238	94 %	9,011,801	55%	170,794	44%	1,069,598	54%
Total	167,474		16,269,123		386,449		1,980,254	

Source: Statistical Agency of the Republic of Tajikistan.

There are seven building types in Tajikistan's urban areas – five types of apartment buildings and two types of single-family homes:

- **Brick masonry apartments (type 1 and 2).** These buildings are made from masonry of traditional, metric perforated bricks. The standard thickness of the outside wall is 38-51 cm, depending on the level of the floor. The walls have exterior lime-cement render with paint finish or exposed masonry. There is almost no additional thermal insulation.
- **Panel apartment buildings (type 3 and 4).** These buildings are most commonly made with a three-layer wall panel and an integrated intermediate thermal insulation layer. They have a wall thickness of 30 cm.
- **Monolithic concrete and concrete frame apartment buildings (type 5).** These buildings typically have outside walls made of expanded clay concrete with expanded clay as a thermal insulating additive. The outside walls have a thickness of about 30 cm. There is almost no additional thermal insulation.
- **Newly constructed apartment buildings (type 6).** These buildings usually have a skeleton structure with brick wall filling. Some have sandwich panels, with and without insulation. The outside walls have a thickness of about 25-30 cm.

[2] Statistical Agency of the Republic of Tajikistan.

- **Clay individual family houses (type 7).** This type of individual family house is made from mud bricks/blocks or cob.[3] The thickness of the outside wall is typically 30 to 40 cm. The walls are sometimes plastered by a straw/clay mixture and are coated with an aqueous solution of slaked lime.
- **Brick masonry individual family houses (type 7).** This type of house is made from traditional solid bricks. The standard thickness of the outer walls is 38 cm. The walls have exterior and interior lime-cement render and lime paint finish or exterior exposed masonry. There is almost no additional thermal insulation of walls.

2.1.2 Public buildings

According to national statistics there are 6,626 public buildings in Tajikistan, about six percent of which are located in the capital, Dushanbe. Schools and polyclinics account for more than 80 percent of public buildings. The number of each building type is shown in Table 2.3 below.

Table 2.3: Public Buildings in Tajikistan

<table>
<tr><th>Type of the public institution</th><th>Number of buildings (National)</th><th>Number of buildings (Dushanbe)</th></tr>
<tr><td>Educational buildings</td><td>4,436</td><td>265</td></tr>
<tr><td>Kindergartens</td><td>494</td><td>100</td></tr>
<tr><td>Schools</td><td>3,791</td><td>136</td></tr>
<tr><td>Professional schools</td><td>51</td><td rowspan="3">29</td></tr>
<tr><td>Universities</td><td>33</td></tr>
<tr><td>Technical schools</td><td>67</td></tr>
<tr><td>Health facilities</td><td>2,130</td><td rowspan="3">41</td></tr>
<tr><td>Hospitals</td><td>441</td></tr>
<tr><td>Polyclinics</td><td>1,689</td></tr>
<tr><td>Administrative buildings</td><td>N/A</td><td rowspan="2">N/A</td></tr>
<tr><td>Cultural facilities</td><td>60</td></tr>
<tr><td>Other</td><td>-</td><td>64</td></tr>
<tr><td>Total</td><td>6,626</td><td>370</td></tr>
</table>

Source: Data based on Statistical Agency of the Republic of Tajikistan and other publicly available sources.

Note: One building per facility is assumed.

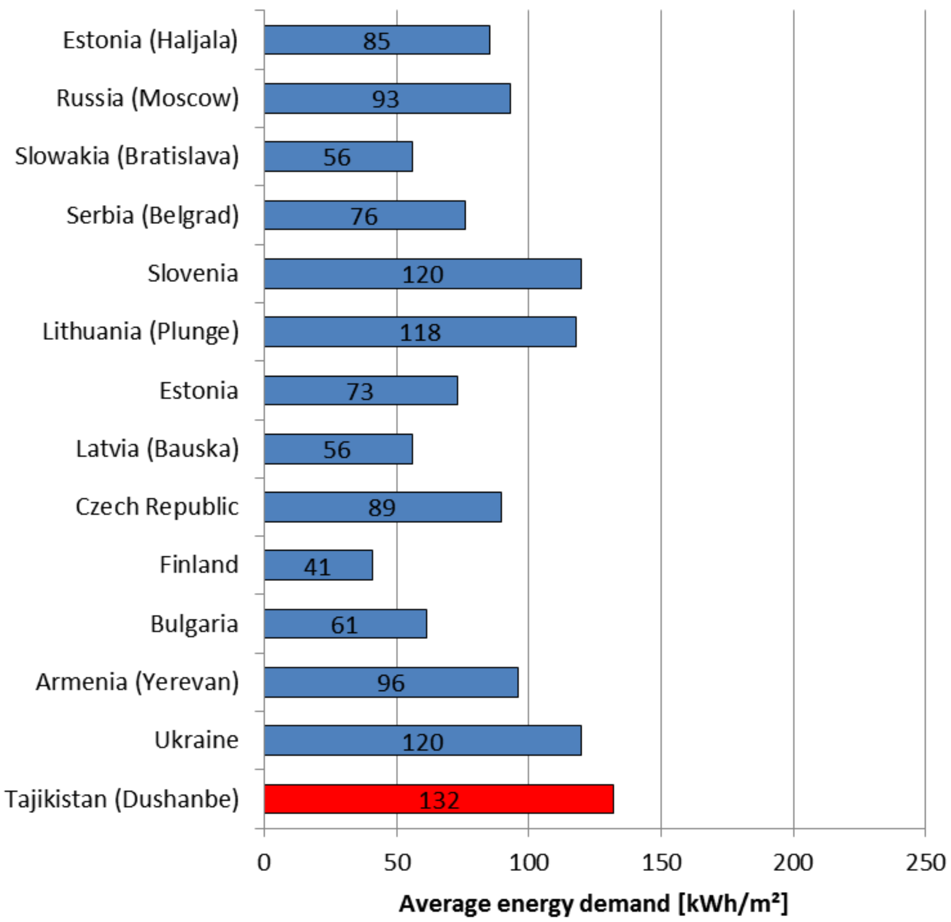
[3] Cob is a mix of clay, sand and straw.

2.1.3 Energy performance of the building stock

Residential buildings

The residential sector in Tajikistan accounts for about 44 percent of electricity and about 17 percent of final energy consumption.[4] As described in Section 2.3, space heating accounts for around 70 percent of the annual electricity consumption of an average household. Average heat demand varies between 110 kWh/m^2 and 350 kWh/m^2 depending on the building type. The average estimated energy demand in Tajikistan is substantially higher than in many other countries in Europe and Central Asia (ECA). It is ten percent higher than its closest comparator (Ukraine) and 136 percent higher than Slovakia and Latvia.

Figure 2.2: Average Energy Demand in Multi-apartment Buildings in ECA



Source: Technical Background Report prepared by Fichtner.

Note: Energy demand for multi-apartment buildings in different ECA countries is degree days adjusted to Dushanbe and based on international studies and reports.

The energy performance of the existing building stock is poor, especially in multi-apartment buildings built before 2000. Table 2.4 shows that there is wide variation in the amount of energy consumed in different building types. Some buildings – such as

[4] World Bank, Tajikistan's Winter Energy Crisis: Electricity Supply and Demand Alternatives, 2012; IEA, Balances of Non-OECD countries, 2013 edition.

single family houses – have significantly higher specific energy demand than the average multi-apartment building.

Table 2.4: Annual Energy Consumption by Residential Building Type

Type	Construction type	Number of floors	Main construction period	Average heat demand (kWh/m^2/yr)
Type 1	Brick; multi-apartment buildings	2-3	1930-50s and 1960-70s	180-250
Type 2	Brick; multi-apartment buildings	4		148-193
Type 3	Panel; multi-apartment buildings	4-5	1970-80s	182-217
Type 4	Panel; multi-apartment buildings;	9-12	1980-90s	156-159
Type 5	Monolith; multi-apartment buildings;	9- 12	1970-80s	140
Type 6	Brick, light concrete blocks, monolith concrete; multi-apartment “Elite houses”;	9+, 12+, or 16	after 2000’s	110
Type 7	Individual family house (clay or brick)	1-2	1960 – 80s	250-350

Source: Technical Background Report prepared by Fichtner.

One of the main drivers for the high demand in residential buildings in Tajikistan is the low efficiency of the aging building stock. More than 60 percent of the multi-apartment buildings were constructed between the 1960s and the 1980s. Many buildings are in poor condition. They are characterized by high heat losses due to the lack of insulation, high air permeability through windows and doors and insufficient maintenance. In apartment buildings, heat losses are especially high on the first and top floors because basements are not heated, and roofs are poorly insulated. Windows are also typically in poor condition, both within dwelling areas and in communal areas. The walk-through energy audits conducted as part of this assessment indicate that there is significant energy savings potential in residential buildings, estimated to range between 30 and more than 40 percent.

Public buildings

Similar to residential buildings, the energy performance of the aging public building stock is poor and characterized by high specific heat demand per m^2. Most public buildings were constructed 25 to 60 years ago during the Soviet period. The main drivers for the poor energy performance include the use of energy-inefficient construction materials and designs, the lack of thermal insulation, poor conditions of windows and limited refurbishment and rehabilitation efforts since construction.

Walk-through energy audits confirm that there is substantial energy savings potential (up to 50 percent) in public buildings. However, the findings of the energy audits also demonstrate that many public buildings, such as schools, hospitals and kindergartens are severely under-heated. As a result, some of the efficiency potential is expected to be offset by the need to increase comfort levels in public buildings.

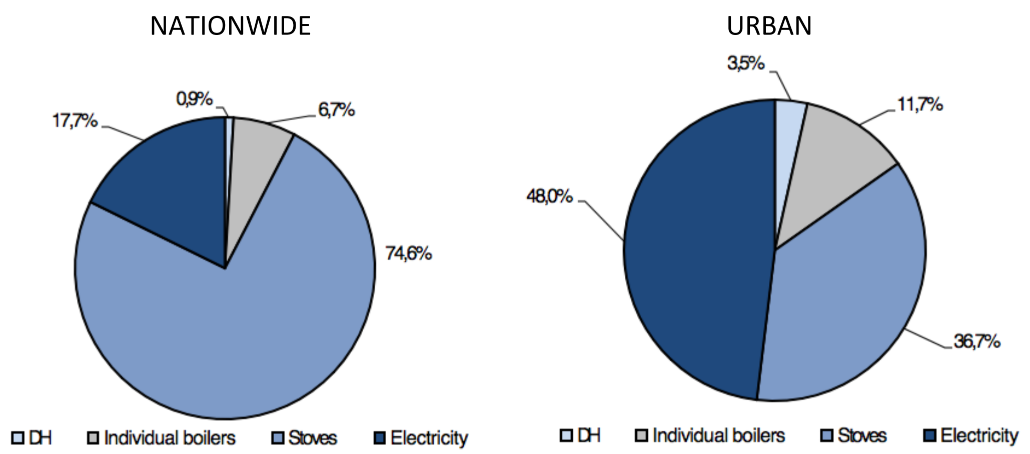
The low comfort levels in public buildings, mainly resulting from high losses and insufficient or unreliable supply of heat and electricity, can also have negative repercussions on the provision of basic public services. According to the findings of a recent World Bank Report,[5] access to basic health care services and school attendance rates have dropped significantly during rough winters, as unreliable or even unavailable heat and electricity supply have forced public buildings to operate at low comfort levels or restrict service hours.

2.2 Overview of Heat Supply Systems

Heat in Tajikistan is supplied by systems ranging in size from large, centralized DH systems to individual, portable heating devices. Coal, natural gas, heavy fuel oil, electricity (which mostly comes from hydropower) and biomass (including wood and dung) are used in heating. Section 2.3 provides more details about the fuel used in heating.

Nationwide, the most prevalent primary source of heat supply is small coal- or biomass-fired stoves, used by more than 74 percent of total households, followed by electricity (18 percent), individual boilers and DH. In urban areas, around 48 percent of households rely on electricity for heating, followed by stoves (37 percent), individual boilers and DH. Figure 2.3 shows the major sources of heating nationwide and in urban areas only.

Figure 2.3: Means of Space Heating (Proportion of Households) – Nationwide and in Urban Areas



Source: Statistical Agency of the Republic of Tajikistan (2010).

[5] World Bank, Assessment of Household Energy Deprivation in Tajikistan, June 2014.

2.2.1 District heating

Heat supply provided by DH systems fell dramatically after the country's independence in 1991 and the subsequent disintegration of regional energy cooperation. In the past, the heat demand of around 35 percent of urban households was met by DH systems available in Dushanbe, Khujand, Kulyab, Chkalovsk, Yavan and Kurgan-Tube. In Dushanbe and Yavan, CHPs and large HOBs provided heat supply, while large HOBs operating mostly on natural gas supplied the other cities. Except for Dushanbe, the major DH systems in Tajikistan were decommissioned and dismantled in the 1990s and early 2000s due to rising gas prices, interruptions of gas imports from Uzbekistan and the deterioration of the DH infrastructure, which was driven by insufficient investments and lack of adequate maintenance.

Today, DH supplies only about 3.5 percent of the urban households. This includes mainly households living in Dushanbe, where DH is generated by the CHP 1 plant as well as large HOBs in the "East" and "West" boiler houses (see further description in Section 3.1). In addition, small centralized heating systems are available in the cities of Vahdat, Vose, Gesar, Zafarabad, Rudaki, Temurmalik and Khujand. Heat in those cities is generated by small HOBs (see description below).

Overall, the remaining DH systems are in poor condition due to their age, lack of investment in rehabilitation and modernization, insufficient maintenance and supply of untreated water (in particular during the 1990s). As a result of the deteriorating DH supply reliability, many of the urban households previously connected to a DH system have dismantled radiators and supply pipes. This is a major challenge for resuming heat supply even after rehabilitation of generation facilities.

There are three main entities that provide DH services in Tajikistan, as shown in Table 2.5.

Table 2.5: DH Companies and Responsibilities

Company	Ownership	Operational responsibilities	City/Cities
Dushanbe CHP Joint Stock Company (JSC)	Barki Tojik JSC	Heat generation by the CHP plant and by Eastern and Western boiler houses in Dushanbe and transmission of this heat	Dushanbe
Dushanbe Teploset JSC	Dushanbe City Government	Distribution network (with heat supply from Dushanbe CHP); Heat generation and distribution supplied by small HOBs	Dushanbe
Khojagiyu Manziliyu Kommunali State Unitary Enterprise ("KMK" SUE)	Government of Tajikistan	Heat generation from small HOBs and related distribution infrastructure	Vahdat, Vose, Gesar, Zafarabad, Rudaki, Temurmalik, Khujand

Source: Technical Background Report prepared by Fichtner.

2.2.2 Small heat-only boilers

Small HOBs primarily provide heating for public buildings, as well as some residential multi-apartment buildings. Most of the small HOBs serve one to three buildings and are operated by the government-owned company “KMK” SUE. The company covers areas outside of Dushanbe. It previously owned 56 small boilers houses, but only nine are still operational, as indicated in Table 2.6 below. Most of the small HOBs were originally designed to use gas as a fuel but were converted to coal due to the unavailability and high price of natural gas. As a result, the efficiency of these boilers decreased substantially to about 40 to 50 percent, while local pollution increased due to poor flue gas cleaning systems (if installed at all). Despite the rehabilitation of some boiler houses in recent years (for example: Gissar, Khujand, Rudaki and Vahtad under the World Bank-financed Emergency Project), the poor condition or dismantling of the building-internal heating infrastructure represents a major challenge for resuming heat supply.

Table 2.6: Small HOBs Operated by “KMK” SUE

Location	Type of fuel used	Consumers supplied	Installed capacity [Gcal/h]
Vahdat	Coal	Residential	80
Vahdat	Coal	Residential	4.8
Vose	Electricity	Kindergarten	0.6
Gesar	Coal	Hospital	1.9
Zafarabad	Coal	Hospital	2.4
Rudaki	Coal	Hospital	1.9
Temurmalik	Mazut	Orphanage	2.7
Khujand	Coal	Hospital	1.8
Khujand	Coal	Hospital for children	1.8
Khujand*	Coal	Residential	1.2
Total			**99**

Source: “KMK” SUE;

Note: *one of the boiler houses is not operational because heat cannot be delivered to the residential buildings (with about 200 apartments) where the building internal heating infrastructure has been largely dismantled.

In addition, some government institutions own and operate their own small HOBs (with an estimated installed capacity of 0.6 to 4 Gcal/h), either fueled by coal or electricity. Only 182 of the more than 1,000 publicly owned boiler houses are operational.

Table 2.7: Small HOBs Owned and Operated by Government Ministries

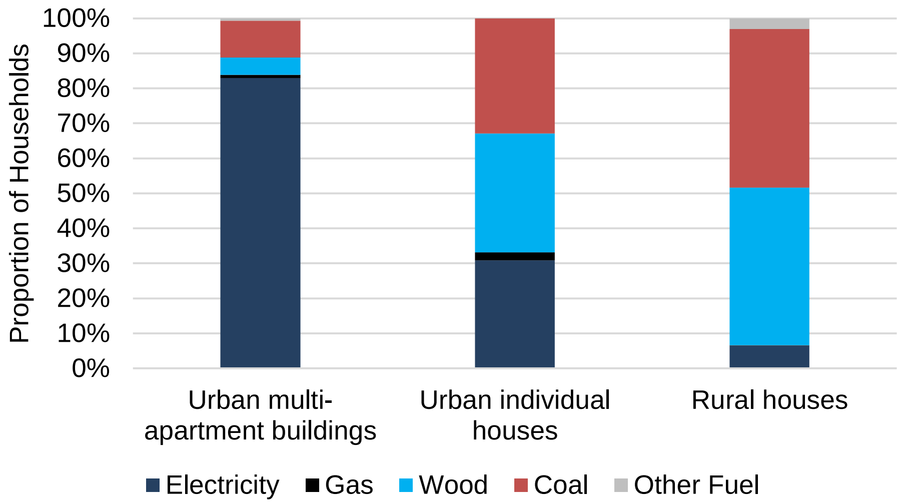
Owner	Number of Boiler Houses		Fuel
	Total	In Operation	
Ministry of Education	878	135	Coal, electricity
Ministry of Healthcare	176	44	Coal
Ministry of Defense	5	3	N/A
Total	**1,059**	**182**	

Source: State Service for Supervision in the Energy Sector.

2.2.3 Individual heating systems

Because of the decrease in availability and reliability of heat supplied by DH systems and small HOBs, more than 80 percent of the households in urban areas rely on individual heating solutions, such as electricity (48 percent of households) or stoves (37 percent of households). Individual heating systems for space heating in urban areas include electric oil radiators, air conditioning units that can be used as heat pumps, individual coal boilers, small coal stoves, individual space heaters and hot water boilers. As shown in Figure 2.4 below, the type of individual heating systems and related fuel use differ by type of building and location. Households not connected to DH and living in multi-buildings rely mostly on electricity for meeting their heating needs, while individual family houses generate about a third of heating each from electricity, wood and coal.

Figure 2.4: Primary Heating Source by Building Type and Location



Source: World Bank, Assessment of Household Energy Deprivation in Tajikistan, June 2014.

The high reliance on electricity for heating aggravates the recurrent winter power shortages Tajikistan is facing (see Section 2.3 for further explanations), while the use of inefficient and polluting coal- or biomass-fired stoves has detrimental health and environmental impacts for the population. Specifically, Tajikistan ranks among the 25 worst-affected countries for diseases resulting from indoor air pollution according to the World Health Organization. Tajikistan is one of the few countries where indoor air pollution causes more death and disability than smoking. In 2010, 64 per 100,000 deaths were due to household air pollution from solid fuels, making this the third leading cause of death in Tajikistan.

2.3 Fuel Supply for Heating in Tajikistan

The collapse of the Soviet Union and the Unified Energy System significantly altered the use of fuels for heating in Tajikistan. While the heat supply system was designed for natural gas, unreliable gas supply and substantial price increases since the 1990s have resulted in massive fuel switching for heating. During the last decade, many boilers originally designed for firing natural gas have been converted to fire coal, causing a significant decrease in the efficiency and capacity of these boilers.

Coal

Tajikistan has significant indigenous coal reserves with about 40 deposits under exploration. There are 14 coal companies that extract coal and bring it to market within the country. Coal production has been rising in recent years. Between 2003 and 2009, it doubled to 106 thousand tons per year. However, high depreciation of the existing mining equipment, lack of financing and working capital and the lack of transportation infrastructure to bring coal from remote areas of the country to the end-users constrain coal production in Tajikistan. Coal is mostly transported from mines by truck. As a result, transportation costs are estimated to be two to three times higher than the cost of coal extraction itself.[6]

Gas

Natural gas consumption significantly decreased from 1,863 million m^3 in 1991 to about 230 million m^3 in 2011[7] and further dropped since then. In 2012, Uzbekistan shut off natural gas supplies to Tajikistan, resulting in price spikes and natural gas shortages in Tajikistan.

Electricity

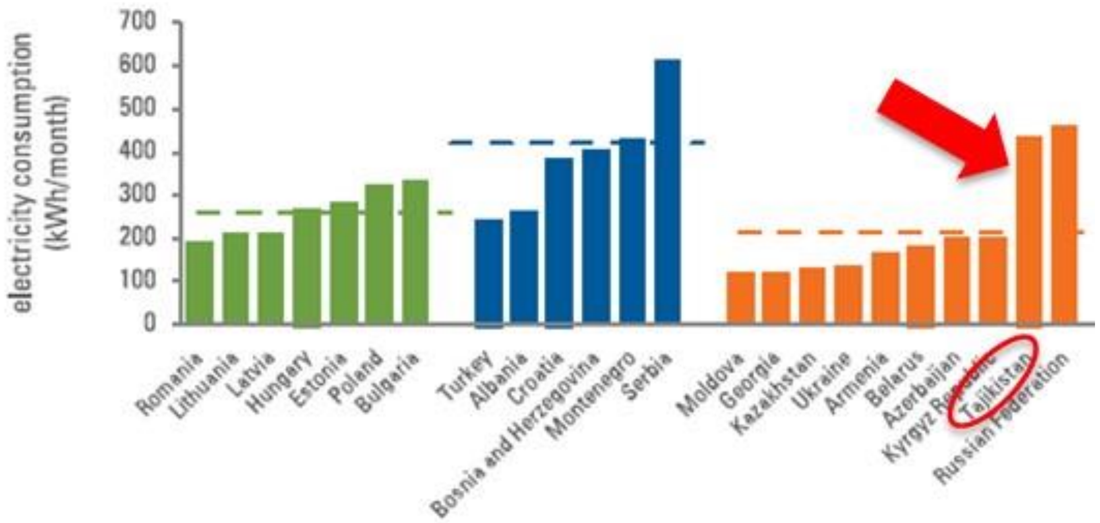
Hydropower is the main source of electricity in Tajikistan. It makes up over 90 percent of the installed capacity in the country. Residential electricity consumption varies considerably over the year due to the heavy reliance on electricity for heating purposes. As a result of the excessive use of electricity for heating, estimated electricity consumption per household is substantially higher than in many other countries in ECA (Figure 2.5 below).The high demand for heating in winter coincides with the minimum availability of electricity generation from hydropower plants (due to hydrological conditions). Combined with the poor condition of the aging power infrastructure and the loss of electricity imports since 2009 and gas imports since 2012, this situation results in significant power shortages during winter months. Unmet electricity demand was estimated at 3,100 GWh during winter in 2012,

[6] Energy Charter, In-depth review of the investment climate and market structure in the energy sector of Tajikistan, 2010.

[7] Indexmundi

equaling a gap of about 24 percent. As a result, for about 70 percent of the population, access to electricity is limited to four to six hours per day during the winter with serious repercussions on their well-being.[8]

Figure 2.5: Estimated Electricity Consumption per Household



Source: World Bank, Balancing Act, 2013.

2.4 Overview of Institutional, Legal and Regulatory Framework of the District Heating Sector

One of the main policy issues facing the heating sector are the low heat and electricity tariffs, which are well below cost recovery levels. This has led to a chronic lack of funding for new investments and even routine maintenance. The main heat and power supply entities rely on direct government subsidies to pay for their operational expenditures.

Building energy efficiency norms and standards do exist, but the standards are not enforced and do not address the low efficiency of the existing building stock.

2.4.1 Energy policy and laws

There are three pieces of legislation that define the regulatory responsibilities, principles and specific energy saving targets for the heating sector in Tajikistan:

- **The Energy Law (2000)** lays out the principles guiding energy sector development and establishes the government bodies responsible for the regulation of the sector in Tajikistan.
- **The Law on Energy Savings (2002)** was enacted to promote the efficient use of energy in the country.

[8] World Bank, Tajikistan's Winter Energy Crisis: Electricity Supply and Demand Alternatives, November 2012.

- **The Law on the Use of Renewable Sources of Energy (2010)** regulates the legal relationships between government agencies, individuals and legal entities to ensure the effective use of renewable resources in Tajikistan.

In the building sector there are also a number of standards relevant to building performance:

- **The Building Climatology Standard (2007)** stipulates the climate parameters that must be incorporated into the design of new buildings and structures.
- **The Standard for Residential and Public Buildings Parameters of Indoor Enclosures (1999)** establishes the indoor temperature range that buildings must meet during the heating season.
- **The Standard for Thermal Performance of Buildings** contains mandatory energy efficiency indicators and rules for evaluating energy efficiency for the design, construction and operation of buildings in Tajikistan.
- **The Standard for Heating, Ventilation and Air Conditioning** stipulates the requirements for reliability and energy efficiency of heat supply systems, heating, ventilation and air-conditioning units of buildings and structures.

These laws and standards provide a relatively comprehensive framework for the heating and buildings sectors, but implementation and enforcement to date have been limited and ad hoc. There are a number of technical, institutional, financial, regulatory and policy barriers which explain this implementation gap and impede energy efficiency investments in the residential and public building sector in Tajikistan. Among these barriers are: the low market capacity for preparing, implementing and financing energy efficiency investments (e.g., energy auditing companies, design companies, financial institutions, construction companies, etc.); lack of awareness among the population and public institutions; lack of access to affordable financing for energy efficiency; the low financial viability and lack of incentives to invest in energy efficiency due to the low energy tariffs and norm-based billing practices; and the incomplete regulatory and enforcement framework for energy efficiency (e.g., standards for energy efficient appliance and materials, enforcement of building codes).

In addition, a specific barrier to energy efficiency in the residential sector is a misalignment of incentives and responsibilities within multi-apartment buildings. Common spaces in residential buildings and centralized building-level heating systems often account for a large portion of energy savings potential. Simple repairs to doors, windows and hallways in common areas as well as heating system upgrades can yield substantial savings in heating costs to individual apartments. Experience from other countries in the ECA region indicates that low-cost weatherization can raises the indoor temperature by three to five degrees Celsius. More elaborate measures can save up to seven degrees Celsius. Homeowner associations (HOAs) in multi-apartment buildings could facilitate the implementation of energy efficiency improvements. However, even where HOAs exist, the contributions of tenants to repair funds are generally very low. A large proportion of tenants refuse to make any payments into these funds. Furthermore, similar to other countries in ECA, it is very difficult for HOAs to gain access to financing for improvements. Banks are reluctant to lend because they cannot foreclose on residents if they do not repay their loans.

Institutional framework

The heating sector is at the intersection of three major industries: energy, construction and housing and many different institutions are involved in the sector. Multiple ministries and governmental agencies are involved in the regulation of the heating sector. Table 2.8 below sets out the responsibilities of the government bodies involved.

Table 2.8: Key Responsibilities of the Governmental Bodies Involved

	Policy	Laws, norms and standards	Supervision	Asset ownership	Tariffs	Other
Ministry of Energy and Water Resources	X	X	X	X	X	X
State Service for Supervision in the Energy Sector			X			
Ministry of Health				X		
Ministry of Education				X		
Antimonopoly Service					X	
Agency for Architecture and Construction		X	X			
Local government				X	X	

2.4.2 Tariff regulation

Heat and electricity tariffs are well below cost recovery levels. This results in a shortage of funding for routine maintenance and capital improvements in both the heat and electricity sectors, and accentuates the poor operational and financial performance of sector companies.

Electricity tariffs for public and residential customers are set as increasing block rate tariff. Tariffs for power use above 2.5 kW are set at double the baseline rate for residential and public customers to discourage the use of large electric boilers. However, the tariff structure has had an unintended consequence: buildings are often heated by individual radiators (each smaller than 2.5 kW) in each room, as this is less expensive than introducing a more efficient, electricity-based system for the whole building. Electricity tariffs in Tajikistan are well below cost-recovery levels – as part of the World Bank Winter Energy Crisis Report for Tajikistan, the economic cost of electricity supply was estimated at US$0.14/kWh (0.77 Somoni/kWh).

Table 2.9 shows the electricity tariff schedule for public and residential customers.

Table 2.9: Tariffs for Electricity for Residential and Public Consumer Groups

Consumer group	Tariff (Somoni/kWh)
Budget entities, utilities and sport complexes	0.122
Population (VAT inclusive)	0.126
Consumers financed from the state budget that use electric boilers and equipment for heating and hot water supply	0.224
Other consumers using electric boilers and equipment for heating and hot water supply	0.758

Notes: 1 Somoni=US$0.21

There are two tariff schedules for DH: A wholesale tariff for customers that purchase directly from DH generation companies such as Dushanbe CHP (see Table 2.10) and retail tariffs for residential, commercial and budgetary customers that purchase heat from Dushanbe Teploset JSC (see Table 2.11).

Table 2.10: Wholesale Tariffs for Thermal Energy

Customer group	VAT	Tariff (Somoni/Gcal)
For institutions and administration bodies financed from the state budget	excluded	43.80
For wholesale buyers supplying the population with thermal energy	excluded	5.70
For all other consumers	excluded	168.50

Note: 1 Somoni=US$0.21

Retail tariffs for residential customers are set based on standard assumptions for the total area of the apartment (for heat) and number of residents in the household (for hot water). The tariffs for public buildings are based on the calculated consumption for the volume of the building.

Table 2.11: Residential Tariffs for DH and Hot Water Supply (2013) in Dushanbe

Type of consumer	Unit	Tariff
Residential DH	Somoni / m^2	0.90
Residential domestic hot water (DHW)	Somoni / person	6.20
DH for public entities	Somoni / Gcal	90.00
DH for commercial entities	Somoni / Gcal	100.00

Source: “Dushanbe Teploset” JSC

Because heat tariffs are so far below cost recovery levels, Dushanbe Teploset JSC and Dushanbe CHP JSC rely on national government and city government subsidies to cover more than 50 percent of their revenue requirements. Dushanbe Teploset JSC relies on subsidies from the city budget to cover costs, and Dushanbe CHP JSC receives a subsidy from state-owned Barki Tojik JSC to meet the costs not covered at the wholesale heat supply tariff.

2.5 Affordability of Heat Supply

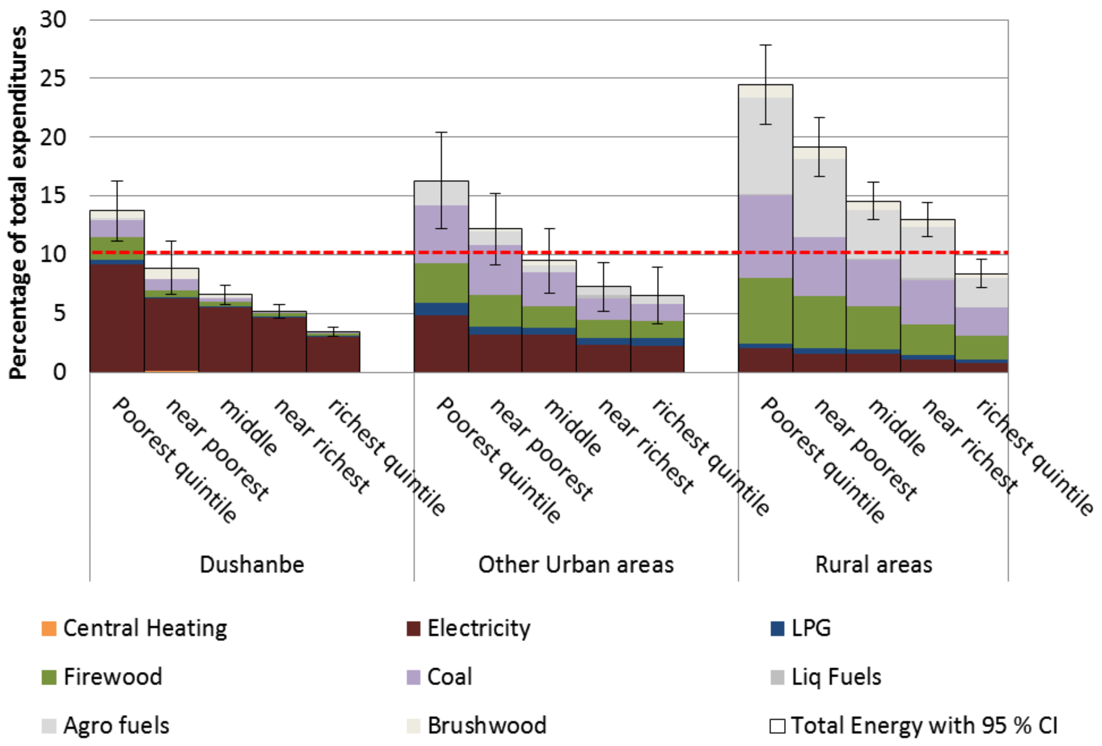
Roughly 34 percent of the population of Tajikistan lives in poverty (with a poverty line defined at US$2.50 per day), giving Tajikistan the second highest poverty rate in the ECA region. Energy affordability is therefore an important concern, in particular during Tajikistan's harsh winter months when energy needs are highest. Tajikistan has the highest prevalence of energy poverty in former Soviet Union countries and one of the highest in the ECA region. Roughly 60 percent of households spend more than 10 percent of their monthly expenditures on energy.[9] Households in rural areas spend on average almost 10 percent of their total expenditures on energy, but this reaches 15 percent during the heating season. In Dushanbe the annual average is five percent but increases to seven percent in the heating season. In other urban areas, households spend an average of 6.5 percent of their total consumption on energy and 11 percent in the heating season.[10]

Figure 2.6 shows the estimated percentages of household income spent on energy by different income groups in Dushanbe, other urban areas and rural areas. It also shows the different resources that different groups use for heat supply. It appears that higher use of non-electricity based fuels for heating correlates with higher energy expenditures as a portion of total household expenditures.

[9] Households are considered to be energy poor if they spend more than 10 percent of their monthly expenditures on energy.

[10] World Bank, Assessment of Household Energy Deprivation in Tajikistan, June 2014.

Figure 2.6: Percentage of Total Household Spending Used on Energy

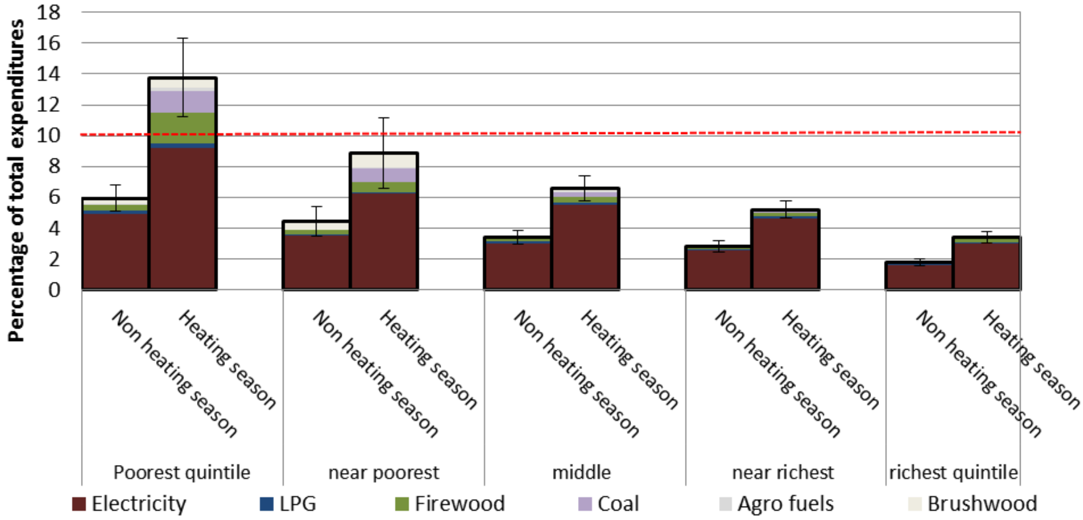


Source: World Bank, Assessment of Household Energy Deprivation in Tajikistan, June 2014

The financial burden of energy costs increases significantly for all households during the winter. In urban areas, energy costs are especially difficult for households in the poorest quintile. In urban areas outside Dushanbe, these households spend approximately 15 percent of their income on energy, while in Dushanbe this figure is 14 percent. The poorest and near poorest fifths of the population in rural areas spend 24 percent and 19 percent respectively of their total consumption on energy during the heating season.[11] Figure 2.7 compares energy expenditures by income quintiles during the off-season and the heating season.

[11] World Bank, Assessment of Household Energy Deprivation in Tajikistan, June 2014.

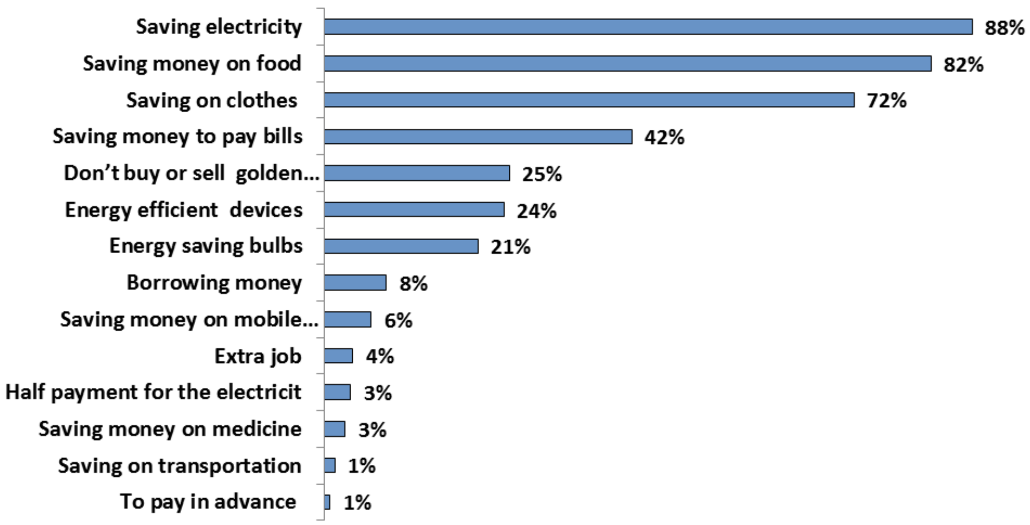
Figure 2.7: Energy Expenditures during the Non-Heating and Heating Season in Urban Areas by Income Quintile



Source: World Bank, Assessment of Household Energy Deprivation in Tajikistan, June 2014.

Social support mechanisms for energy are decentralized and vary quite considerably across regions, but overall are small and poorly targeted. In the past, energy-related benefits covered less than two percent of the population and were not sufficiently targeted towards the poor households. According to a recent survey, households use different strategies to cope with the higher energy expenditures in winter, as shown in Figure 2.8.

Figure 2.8: Urban Households' Coping Strategies to Reduce Energy Expenditures during the Heating Season



Source: World Bank, Assessment of Household Energy Deprivation in Tajikistan, June 2014.

Energy scarcity and high cost also affect public consumers, such as hospitals and schools. Most public buildings in Tajikistan use electricity and coal for heating as the supply of electricity outside of Dushanbe is unreliable and as there is no functioning DH system. So-called "red lines" exist to provide uninterrupted electricity supply to some schools and hospitals in densely populated areas, but there are often illegal connections to these lines, which can disrupt service.

The shortage of electricity and the use of indoor stoves for heat in public buildings have caused local government funds to be diverted to covering energy expenditures for these facilities. Local government funds have been used for the purchase of coal and for repairs to walls and equipment from long-term exposure to smoke. Energy shortages have forced hospitals to restrict hours, which has decreased access to health care and contributed to temporary school closures. During the winter of 2008, UNESCO reported that school attendance rates dropped by 40 to 50 percent. Anecdotal evidence collected through in-depth interviews also suggests that parents often contribute to heating expenses in schools. **Box 2.1** provides a qualitative analysis of the current situation in a hospital and two schools in Tajikistan.

Box 2.1: Access to Energy in Social Buildings

General clinic, Khujand. This clinic has an unlimited electricity supply due to its central location in the biggest city of Sughd region. The main heating source is electricity, and every room has an electric radiator. The original central heating system no longer functions. The local government authority of Khujand and the clinic pay the electricity bill, which is highest during November through February, and declines in the summer, despite use of air conditioning. The amount allocated for electricity is enough for a year. During the past two years there have been no electricity shortages, but the clinic previously experienced shortages of two or three hours per day.

Secondary school, Vose (rural Khatlon). The school's main energy sources are electricity, coal, firewood, dung, dried cotton sticks and shrubbery growing in the schoolyard. The school receives annual state funding based on the number of students. This money is typically used for fuels and other sources of energy, school improvements and repairs and teaching supplies. In winter, the school faces the same electricity supply limits as the residential sector. The main source of heating is coal. Annual state funding provides 10-12 tons of coal – enough for only 1.5 to 2 months. As a result, a parents' association was organized to supply the school with additional dung, firewood or dried cotton sticks. It was claimed that parents provide around 40 percent of winter heating supplies, especially in elementary schools. The 'on-duty' teacher and student arrive early in the morning and heat the classroom. This is common in rural areas.

Secondary school, Dushanbe. The main energy sources are electricity, coal and wood. The school budget comes from two sources: state funds and payments for extra classes. These are collected by the school cashier and sent to the Raion financial department and then to the bank. Some funds are returned to the school. Sixty percent is for school staff salaries and the remainder is used to improve school infrastructure and buy fuels. This year the school experienced some electricity supply shortages and had to rely on their 16kW generator.

Source: World Bank, Assessment of household energy deprivation in Tajikistan, 2014.

3 Heat Supply and Demand in Dushanbe

Dushanbe is the capital and largest city of Tajikistan, and also has the status of a region. It has a population of 764,300 people with an historical growth rate of about 2.4 percent per year. Dushanbe has a continental climate and belongs to climatic region III, with 1,566 degree days.[12] The average length of the heating season is 110 days long.

The residential building stock in Dushanbe consists of 31,735 individual family houses that house 20 percent of the population and make up 20 percent of the residential floor space, as well as 3,275 apartment buildings where the rest of the population lives. These buildings make up the rest of the residential floor space. The city also has around 370 public buildings. All residential and public buildings are characterized by poor energy performance, and individual family houses have particularly high specific energy demand levels.

Most of the space heating in Dushanbe is provided by individual electric heating systems. CHP, large and small HOBs, and individual solid fuel-fired stoves are also used. There is a sizable gap between heat demand and supply in Dushanbe, with an estimated heat supply gap of 23 percent of overall demand in residential and public buildings.[13] The space heat supply gap is greatest in public buildings, where 27 percent of space heat demand goes unmet each year. The gap is the result of the poor energy efficiency of most buildings, as well as insufficient and unreliable heat and electricity supply.

This section describes the current state of the heating sector in Dushanbe. It provides an overview of the heating systems in place and describes their condition. It also describes the challenges currently facing Dushanbe's heating sector and provides an estimate of the current space heating supply-demand gap in the city.

3.1 Heat Supply in Dushanbe

Heat in Dushanbe is provided by the following systems:

- CHP, including one existing and one planned plant
- Large HOBs (boiler house "East" and boiler house "West")
- Other small HOBs (building-level boilers)
- Individual heating systems (mostly electric)

DH or small building-level HOBs supply about ten percent of the multi-apartment buildings and less than one percent of individual family houses. This means that around eight percent of all households living in Dushanbe receive some form of centralized heat. The remaining 90 percent of multi-apartment buildings and 99 percent of individual houses (comprising 92 percent of all households) rely on individual systems to heat their homes. Twenty-seven percent of public buildings are

[12] Days with a 5.76°C average outdoor air temperature during the heating season; 20°C normative indoor air temperature.

[13] Hot water demand numbers were not available, so the heat supply gap analysis was only conducted for space heat demand.

heated by the DH system or small HOBs, while the rest use individual heating systems. Table 3.1 provides an overview of the coverage by different heating systems.

Table 3.1: Coverage of Public and Residential Buildings by Heating System Types

	DH (CHP)		DH (large HOBs)		Small HOBs		Individual		Total
	Value	%	Value	%	Value		Value	%	Value
Multi-apt. bldgs. (number)	246	8%	78	2%	2	<1%	2,949	90%	3,275
Individual houses (number)	0	0%	37	<1%	0	0%	31,698	99%	31,735
Residential area (million m^2)	0.495	6%	0.157	2%	0.004	<1%	7.514	92%	8.17
Households (number)	11,960	6%	3,894	2%	97	0.1%	175,002	92%	190,953
Public buildings (number)	79	21%	7	2%	15	4%	269	73%	370
Total heat supply (Gcal)	77,037	12%	1,043	<1%	5,620	<1%	541,827	87%	625,526*

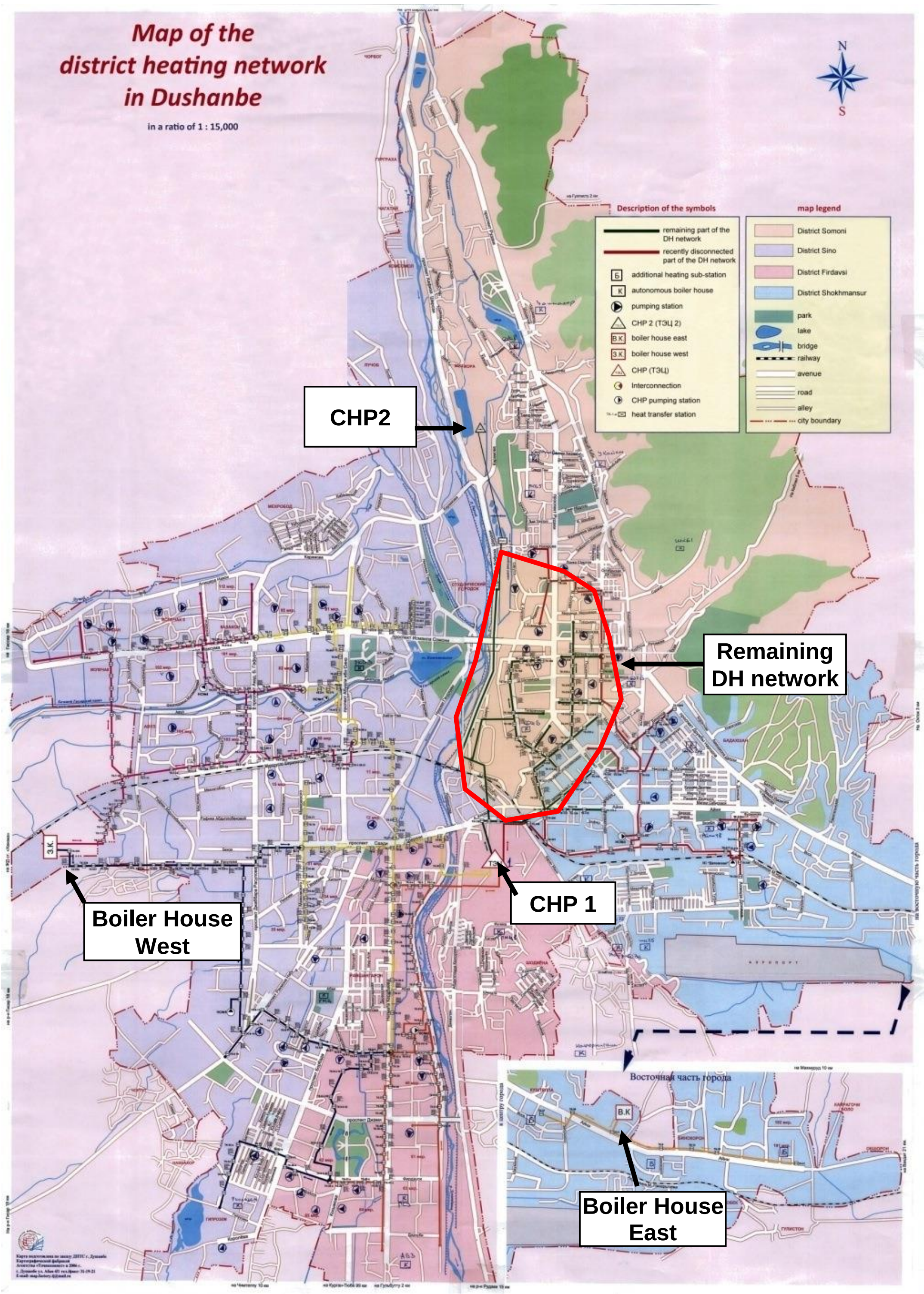
Note: * This total may not match the sum of the other items in this row due to rounding.

Source: Technical Background Report prepared by Fichtner.

3.1.1 The DH system

The DH system in Dushanbe consists of two CHPs, two large HOBs and the related heating networks. Most of the heating infrastructure was constructed more than 30 years ago and has not been in use for the last decade due to its poor condition and the lack of heat supply. A map of the system specifying the location of the major assets is shown in Figure 3.1.

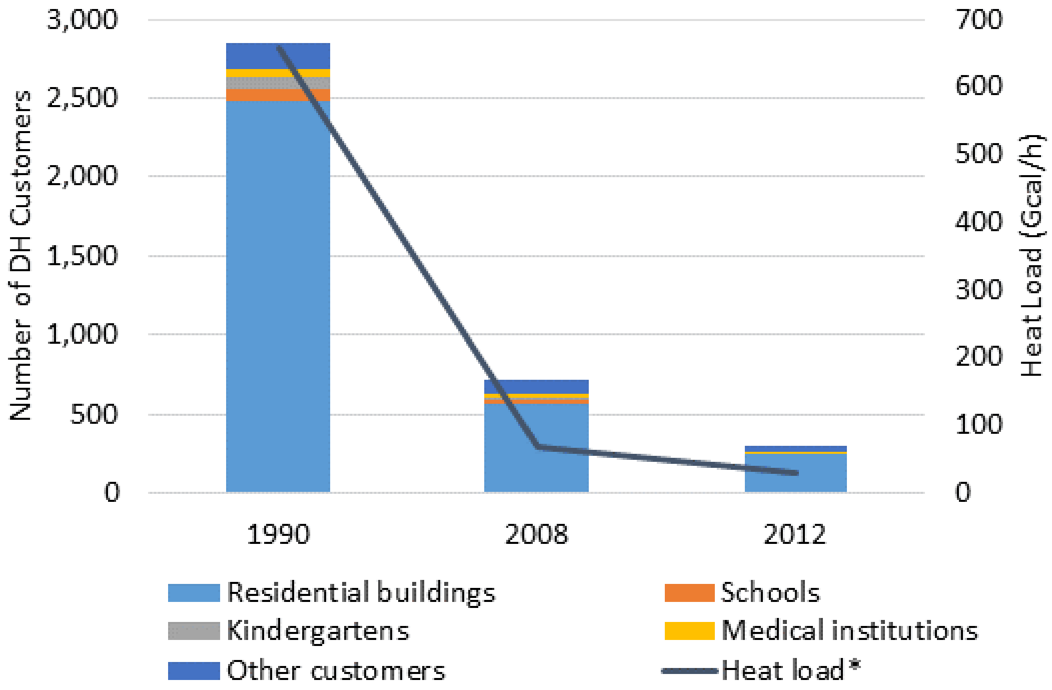
Figure 3.1: DH System in Dushanbe



Since 1990, the amount of heat supplied by the DH system has decreased significantly. Heat supply capacity of the system decreased from about 657 Gcal/h in 1990 to an estimated available capacity today of about 75 Gcal/h at the CHP and the Boiler House East. This decline over the past 25 years is mainly due to the following reasons: (i) poor reliability and high cost of natural gas; (ii) the poor condition of the DH assets resulting from age, severe under-maintenance and lack of investment in modernization; and

(iii) the fact that residents have dismantled the DH infrastructure within about 80 percent of the residential buildings. As a result, the number of customers served by DH declined by almost 90 percent between 1990 and 2012. Figure 3.2 shows the number of customers of different types served by the DH system in 1990, 2008 and 2012.

Figure 3.2: Customers of the DH System between 1990 and 2012



Source: "Dushanbe Teploset" JSC;

Notes: *1990 values include supply by CHP. 1990 supply total according to design; 2008 and 2012 figures are actual supply.

The CHP 1 plant

The CHP 1 plant first began operations in 1961. It is in poor condition as a result of its age and severe under-maintenance. Only about 30 percent of the original design capacity (613 MW) is still operational and heat output is less than half of the plant's design capacity. Four of the seven boilers are non-operational because of a lack of fuel and the need for extensive repair. Only one of the four steam turbines at the plant is in operation, although the other three are in working condition. The plant also has three boilers for process heat but these have not been in operation since the 1990s. While the plant was designed to run on gas, it currently runs on fuel oil (mazut) and gas.[14] Table 3.2 shows key data on the CHP 1 plant.

[14] Based on data from 2012.

Table 3.2: Key data on CHP 1 (Dushanbe)

Design Capacity (1961)	
Installed Capacity	357 Gcal/h (415 MWth)
Electrical Output	170 Gcal/h (198 MWel)
Thermal Output	N/A
Available Capacity (2012)	
Available capacity	153 Gcal/h heat (177.78 MWth)
Electrical Output	25 Gcal/h (29 MWel)
Thermal Output	65 Gcal/h (75.53 MWth)
Supply	
Heat	114,798 Gcal (133,395 MWhth)
Electricity	42,589 Gcal (49,589 MWh)
Customers	
Direct supply	About 23 customers connected directly to transmission pipelines
Final customers	246 residential buildings, 56 public and other institutions
Supply and return temperature	
Design	Supply: 120 degrees C Return temperature: N/A
2012	Supply: 60-70 degrees C (max) Return temperature: 40 degrees C

Source: "Dushanbe CHP" JSC

Table 3.3 shows the number of residential and public customers that receive heat from CHP 1, as well as the heated area/volume and the heat and hot water supplied in 2012.

Table 3.3: Customers Supplied by CHP 1 (2012)

Type of customer	Number customers	Number buildings	Area or volume	2012 Hot Water Supply (Gcal)	2012 Space Heat Supply (Gcal)
Residential (multi-apartment)	11,960	246	494,704 m^2	23,013	20,203
Public	19	19	282,058 m^3	584	4,737
Other customers	37	37	n/a	0	5,500
Industrial and commercial	23	23	n/a	0	23,000
Total	**12,039**	**325**	**-**	**23,597**	**53,440**
Grand total				**77,037**	

Source: Technical Background Report prepared by Fichtner.

Boiler House West

Boiler House West has two gas boilers that have not been in operation since the early 1990s because of the lack of a reliable and affordable gas supply. It also has three boilers that were converted from gas to coal. These are no longer operational because a lack of maintenance and rehabilitation has damaged almost all technical systems. Heat generated at the boiler house West was previously sold to Dushanbe Teploset and supplied residential and other customers.

There are two new HOBs under construction, which will use liquefied coal. Each HOB is rated at 35 MWth. The boilers are designed to supply heat to residential and public buildings in the western part of the city not served by the CHP 1. The liquefied coal technology is an experimental technology that has been developed and is produced in Russia, but has never been used on a larger scale as proposed in Dushanbe. The expected commissioning date of this plant is not yet known because there is currently insufficient funding to complete the plant. Table 3.4 provides key data on boiler house West.

Table 3.4: Key Data on Boiler House West (Dushanbe)

Design Capacity
3 boilers x 224 MWth
2 boilers x 210 MWth
Available Capacity
3 boilers x 116 MWth (not in operation)
2 boilers x 0 MWth
2 boilers x 35 MWth (under construction)

Source: “Dushanbe CHP” JSC

Boiler House East

Boiler House East was designed to run on gas, but was converted to run on gasified hard coal in 2012. However, only one gasification unit and one of the two boilers are in operation. The conversion to gasified coal reduced the operating capacity of the plant to only 34 percent of the original design capacity. Significant maintenance and service efforts are required to keep the remaining boiler running. Despite the high operating costs, conversion of the second unit of this plant was planned for 2013/2014. No meters are installed at the outlet of the boiler house making it difficult to track the output of the boiler. Table 3.5 provides key data on Boiler House East.

Table 3.5: Key Data on Boiler House East (Dushanbe)

Design Capacity	2 boilers x 40 MW = 67 Gcal/h (80 MWth)*
Available Capacity (2012)	2 x ca. 6 MW = 10 Gcal/h (12 MWth)**
Heat Supply (2012)	1,300 Gcal (1,511 MWh/a)
Customers (2012)	Dushanbe Teploset JSC 115 residential buildings, seven educational buildings (schools & kindergartens)
Supply and return temperature – design	150° C and return temp 70° C
Supply and return temperature – 2012	70° C and return temp 30-32° C

Source: "Dushanbe CHP" JSC

Note: * Based on natural gas; ** Based on coal gasification and synthesis gas

Table 3.6 shows the number of residential and public customers supplied by Boiler House East, as well as the heated area/volume and amount of space heat supplied in 2012.

Table 3.6: Customers Supplied by Boiler House East (2012)

Type of customer	Number of customers	Number of buildings	Area or volume	2012 Space Heat Supply (Gcal)
Residential (multi-apartment)	3,797	78	157,059 m^2	802
Residential (individual houses)	37	37	1,850 m^2	23
Public	7	7	103,916 m^3	218
Total	**5,598**	**1,879**	**-**	**1,043**

Source: Technical Background Report prepared by Fichtner.

The CHP 2 plant

The CHP 2 plant, financed by the Chinese Eximbank and Bank of Development of China is under construction. This project is being implemented by the Chinese company Tebian Electric Apparatus and has a reported cost of US$30 million.

The first unit of this new plant (50 MW) was commissioned in autumn 2013, and pipelines to connect the CHP 2 to the main network have been installed. Two more units of 150 MW each are expected to become operational in 2016. CHP 2 will be fueled by coal, with the potential to switch to gas. It will only operate during the heating season. Although the new CHP will increase heat supply capacity in Dushanbe, the poor condition of the main transmission and distribution network, including the building-internal heat infrastructure, may prevent the full utilization of the new CHP (see below).

DH transmission and distribution networks

The transmission and distribution networks operated by Dushanbe CHP and Dushanbe Teploset JSC consist of three independent networks that distribute heat from the CHP 1 and the two large HOBs (boiler houses East and West). The networks are two-pipe 'open' systems for space heating and DHW. As shown in Table 3.7, only 14 percent of the DH transmission and eight percent of the distribution network are still in service today. Within the last six years a large portion of the network has been taken out of service.

Table 3.7: DH Network (Dushanbe)

Pipelines	Original design	2008	2012/2013
Transmission pipelines (operated by Dushanbe CHP)	123 km	N/A	15-20 km
Distribution pipelines (operated by Dushanbe Teploset)	422 km	90 km	34 km
- underground	308 km	60 km	25 km
- overground	113 km	30 km	9 km
Total:	545 km	90 km	49-54 km

Source: Dushanbe Teploset JSC.

Transmission network losses are reported by the DH companies to be about nine percent. However, these losses are based on norms due to the lack of metering.[15] Given the state of the system the DH companies are likely underestimating the magnitude of losses on the system. Total distribution and transmission network heat losses are in the range of 20 to 30 percent as a result of leakages within the network and the poor condition of the insulation layer seen in Figure 3.3. Make-up water was not properly prepared during the 1990s and this has resulted in thick deposits inside the pipelines, which were observed during inspections performed as part of this assessment.[16]

[15] The lack of installed heat meters between the transmission network operated by Dushanbe CHP and the distribution network operated by Dushanbe Teploset also results in significant discrepancies between the reported amounts of thermal energy supplied.

[16] Make-up water is water supplied to compensate for evaporation and leakages of water within the DH system. If this water is not properly treated before use, it can damage DH infrastructure.

Figure 3.3: Poor Condition of Insulation Layers of Transmission Pipelines

It is estimated that about 90 percent of the transmission and distribution network is in urgent need of replacement or repair. Recent rehabilitation measures applied to the distribution network have included only minor replacement of pipelines. Current plans will replace only a few km of the underground pipelines in the city center.

Further, the open system (providing both space heat and hot water) impedes the efficient operation and maintenance of the DH system, obstructs the introduction of modern controls and shortens the lifetime of the entire system (e.g., through high corrosion of the network pipes due to poor water quality/treatment). The open system is a limiting factor in using the full heat supply capacity of the new CHP by limiting the maximum flow temperature in the network, and thus the transmission and distribution capacity. Without investments in the transmission and distribution network, the network will not be able to absorb the additional heat supplied by the new CHP. Accordingly, the sizeable investment in the CHP 2 may not generate the full potential benefits for the population, public service delivery and businesses.

Dushanbe Teploset JSC operates five DH pumping stations with a total installed heat and DHW capacity of 367 MWth. The average reported efficiency of the pumps is 64 percent. The pumping stations and other equipment examined during the walk-through audits were assessed to be in good condition, particularly relative to the condition of the transmission and distribution pipelines. Pumping stations are typically situated in small buildings that protect equipment from weathering.

Building-level DH infrastructure

Most of the residential buildings connected to the DH are heated through direct connection to the DH system with building-level hydro-elevator or through group substations. The production-driven mode, where the quality of heat delivered to consumers is controlled by supply temperature from the heat source, leaves customers no or limited options to regulate their heat consumption. Building-level metering and apartment-level temperature controls and heat cost allocators are largely non-existent. This significantly affects the quality of service and comfort levels, resulting in frequent under- or over-heating of buildings. It also means that end-consumers are billed based on their floor area rather than consumption. Combined with the low tariffs and the lack of temperature control devices, these billing practices provide no incentives to end-consumers to save energy.

For buildings previously served by a DH system, it is estimated that about 80 percent of the building internal DH infrastructure (such as radiators and piping inside the buildings) has been dismantled by residents because a large part of the DH system has been out of operation for so long. As a result, even if the operational generation capacity of the DH system were increased, most buildings would not be able to use the heat unless their internal infrastructure was rebuilt. This represents a major challenge for reconnecting buildings to the DH network given the associated investment costs, and various institutional issues (e.g., collective decision-making to reconnect multi-apartment buildings, access to individual apartments for replacing radiators and piping, etc.).

3.1.2 Small HOBs

Small HOBs are small boilers that serve one or more buildings through a short distribution network. Dushanbe Teploset JSC owns 24 small HOBs, of which 15 are still operational (with total capacity of 20.34 Gcal/h or 23.64 MWth) as listed in below. These HOBs supply public buildings, such as hospitals, kindergartens, and schools, and a residential area that includes two multi-apartment buildings. The HOBs were originally gas-fired but were converted to coal between 2008 and 2010, resulting in a significant reduction in their efficiency (estimated between 45 and maximum 60 percent). Nine small HOBs (comprising 26 gas-fired boilers) are no longer operational because of the lack of supply and the high cost of natural gas.

Table 3.8: HOBs Owned by Dushanbe Teploset JSC and Still Operational

Location	Type of boiler	Rehabilitation date	Fuel	Number of boilers	Installed capacity [Gcal/h]
School Nr.38	Universal-5	2008	coal	4	1.2
	Universal-6	2009	coal	2	1.0
City hospital Nr.5	Gefest-2.5	2009	coal	3	6.45
School Nr.75	Universal-5	2008	coal	2	0.6
Kindergarten Nr.72	Universal-5	2008	coal	2	0.6
School Nr.61	Universal-5	2008	coal	2	0.4
"Giprozem" JSC	Universal-6	2009	coal	4	2.4
Kindergarten Nr.8	KChM	2009	coal	2	0.13
Kindergarten Nr.24	Universal-5	2009	coal	2	0.44
Hospital "Sestrinskogo Uhoda"	Universal-6	2010	coal	2	0.7
GMZ Nr.1	Universal-5	2010	coal	2	0.4
Children's Tuberculosis hospital	E 1/9	2010	coal	1	0.39
GK IAP RT	E 1/9	-	gas	2	1.24
	Tansu	-	gas	1	0.62
	Tansu	-	gas	2	0.76
School Nr.17	EKV-250	-	electricity	2	0.43
Ambulance hospital	E 1/9	-	coal	2	0.78
NMZ (Kara-balo)	Universal-6	-	coal	6	1.80

Source: Dushanbe Teploset JSC.

Table 3.9 shows the number of residential and public customers supplied by Dushanbe Teploset small HOBs. About 84 percent of the heat from small HOBs is based on coal.

Table 3.9: Customers Supplied by Small HOBs Owned by Dushanbe Teploset (2012)

Type of customer	Number of buildings	Area or volume	Supply (Gcal)	Share of supply electric boilers	Share of supply coal boilers	Share of supply gas boilers
Residential (multi-apartment buildings)	2	4,022 m²	236	3%	84%	13%
Public buildings	15	222,677 m³	5,383			
Total	**17**	**-**	**5,620**			

Source: Technical Background Report prepared by Fichtner.

In addition to the small HOBs listed above there are some other small HOBs, which have the same owner as the building to which they supply heat. No data are available on these HOBs, but they do not play a significant role in Dushanbe's heat supply.

3.1.3 Individual heating systems

Residents and occupants of public buildings who are not connected to the DH system or small HOBs use individual heating systems as their primary source of heat. Overall, more than 90 percent of the residential buildings and more than 70 percent of the public buildings are heated by individual systems, such as oil or spiral radiators, coal or wood burning stoves and boilers and combination heat pumps/air conditioning units.

Based on yearly residential electricity and heat consumption data, it is estimated that about 91 percent of residential heat in Dushanbe (432,769 Gcal) is supplied by individual electric systems with five percent (22,745 Gcal) from coal-based stoves or individual boilers in houses.

Table 3.10 shows the number of buildings, amount of heat supplied and share of total heat supply that comes from individual systems in Dushanbe.

Table 3.10: Heat Supplied by Individual Systems in Dushanbe by Fuel Type (2012)

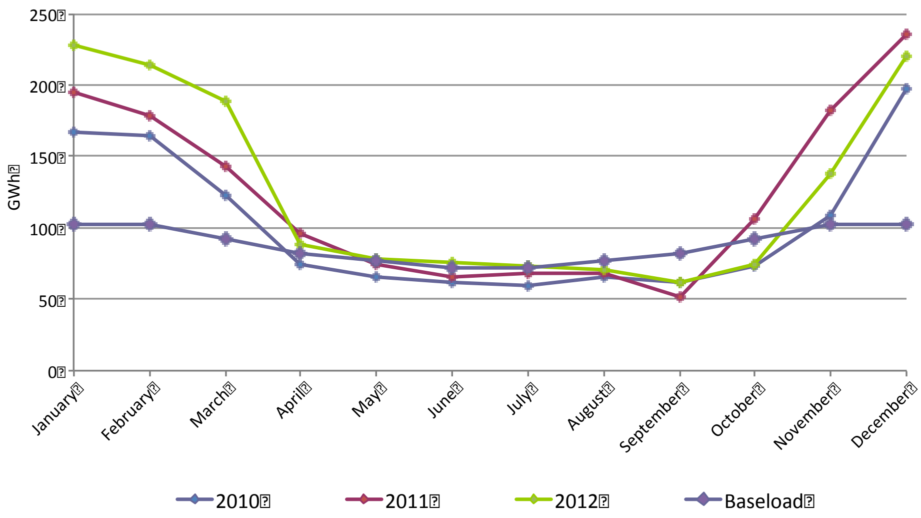
Type of customer	Number of buildings		Supply from individual systems (Gcal/yr)	Share of total 2012 heat supply for each building type supplied by individual systems		
	Total	Using ind. systems as primary heating source		Electricity	Coal or Wood	Gas
Multi-apartment building	3,275	2,949	282,655	93%	0%	0%
Individual houses	31,735	31,698	172,859	87%	13%	0%
Public buildings	370	329	86,314	89%	0%	0%
Total	**35,380**	**34,976**	**541,827**			

Note: Buildings may supplement DH-based heat supply with individual heating systems, which is why all buildings are shown in the "Total" column. Only those buildings listed in the "Using ind. systems as primary source of heat" column rely exclusively on individual systems for heating. The supply column shows all heat supplied by individual systems, whether primary or supplementary (for "topping-up").

Source: Technical Background Report prepared by Fichtner.

The use of electrical heating systems contributes to high residential electricity consumption during the winter months. In 2012, residential electricity consumption in January and December was about three times as high as in June. As described in Section 2, the high reliance on electricity for heating aggravates recurrent winter power shortages – the electricity system supplying Dushanbe suffers from limited outages, but the Tajik system as a whole is subject to frequent shortages during the winter months as a result of low hydrological flows, high demand for heating purposes and poor condition of the power sector assets. Figure 3.4 shows monthly electricity consumption in the residential sector for 2010 to 2012.

Figure 3.4: Residential Sector Electricity Consumption (Dushanbe)



Source: Barki Tojik

3.2 Heat Demand in Dushanbe

Heat demand was estimated for Dushanbe for 2012 and was compared to the amount of heat supplied to these buildings to help understand the magnitude of unmet heating demand. The residential housing stock in Dushanbe consists of 35,010 residential buildings with a total residential area of 8.17 million m². Individual family houses account for more than 90 percent of the number of residential buildings, but only 20 percent of the floor space.

Table 3.11 provides a breakdown of Dushanbe's housing stock area, population, and households by building type.

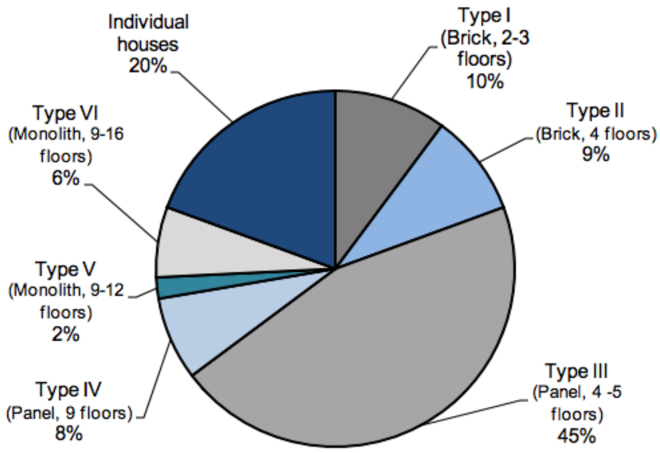
Table 3.11: Housing Stock (Dushanbe)

Parameter	Value
Total residential area (m^2)	8,170,000
Total population	764,300
Total residential area per capita (m^2/person)	11
Total number of households	190,963
Individual houses	
Number of houses	31,735
Total residential area (m^2)	1,584,000
Average size of house (m^2)	50*
Population	148,183*
Average size of household	4.7
Multi-apartment buildings	
Number of buildings	3,275
Total residential area (m^2)	6,586,000
Number of flats	159,218
Flats per building	48*
Average size of flat (m^2)	41*
Population	616,117*
Number of households	159,218*
Average size of household	3.9

Source: Statistical Agency of the Republic of Tajikistan (2013); Note: *calculated value

Panel buildings constructed in the 1970s and 1980s are the most prevalent form of multi-apartment buildings, followed by brick buildings that were constructed in the 1930s to 50s. Figure 3.5 displays the percentage of total residential area in Dushanbe, by building type.

Figure 3.5: Share of Residential Buildings by Area (Dushanbe)



Source: Technical Background Report prepared by Fichtner

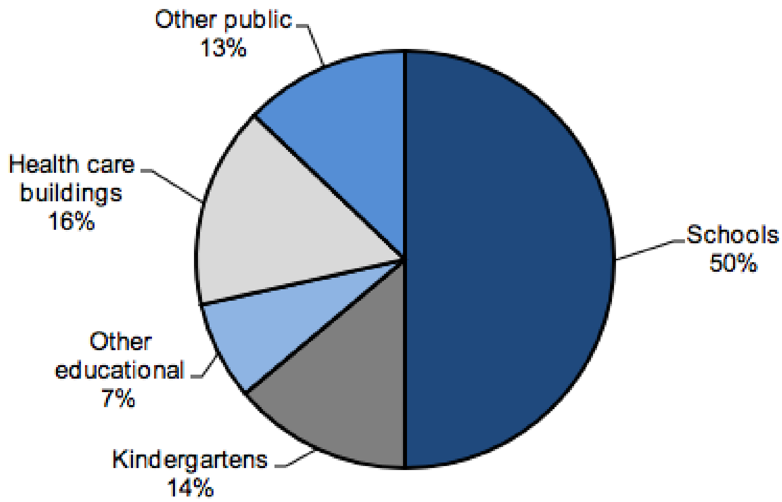
The housing stock is generally in poor condition and energy inefficient. Based on walk-through energy audits performed as part of this study, only a limited share of apartments has replaced old wooden frame windows with PVC frame windows over the last decade. Insulation of walls, roofs and basement ceilings is nearly non-existent.

Maintenance, repair and energy efficient retrofits in multi-apartment buildings are very limited for the following reasons: (i) lack of incentives given low electricity and heat tariffs and lack of consumption-based billing practices; (ii) lack of funds to finance major repairs and costs of routine maintenance, management and cleaning services; (iii) lack of HOAs and/or institutionalized decision-making structures in most multi-apartment buildings, making it difficult to organize improvements in maintenance and repair; and (iv) lack of professional management services – most residential buildings are managed by one of the tenants/owners.

The public buildings stock in Dushanbe includes some 370 public facilities, such as schools (136), kindergartens (100), other educational buildings (29), health facilities (41), cultural and other buildings.[17] The total estimated volume of these buildings is 5.5 million m^3 with schools accounting for about half of the total. Figure 3.6 shows the percentage of Dushanbe's total public building volume by building type.

[17] Statistical Agency of the Republic of Tajikistan

Figure 3.6: Share of Volume by Public Building Type (Dushanbe)



Source: Technical Background Report prepared by Fichtner; Dushanbe Teploset JSC.

A standardized set of assumptions about the amount of heat demand per unit of area was developed for each type of residential and public building described in Section 2.1. Heat demand assumptions were based on walk-through audits of residential and public buildings. Heat demand by building type and total heat demand for Dushanbe was calculated by combining these assumptions with data on the area of each building type in Dushanbe.

Table 3.12 and Table 3.13 show the heat demand assumptions for space heat and hot water for different types of residential and public buildings for a typical year in Dushanbe.

Table 3.12: Total Heat Demand of Residential Buildings (Dushanbe, Average Year)

Type	No. of bldgs.	Avg. heated area (m^2)	Specific demand for space heating (kWh/m^2)	Specific demand for DHW (kWh/m^2)	Total specific heat demand		Total heat demand* (Gcal/yr)
					(kWh/m^2)	($Gcal/m^2$)	
Type I	921	900	74	75	149	0.13	107,757
Type II	540	1,400	55	75	130	0.11	83,160
Type III	1,426	2,600	59	75	134	0.12	444,912
Type IV	237	2,599	65	75	140	0.12	73,916
Type V	60	2,600	54	75	129	0.11	17,160
Type VI	91	5,725	40	75	115	0.10	52,098
Indiv. family houses	31,735	50	145	75	220	0.19	301,483
Total	**35,010**						**1,080,485**

Note: * This column includes demand for both space heat and hot water. The total may not match the sum of the other items in the column due to rounding.

Source: Technical Background Report prepared by Fichtner.

Table 3.13: Total Heat Demand of Public Buildings (Dushanbe, Average Year)

Type	No. of bldgs.	Avg. heated vol. (m^3)	Specific demand for space heat (kWh/m^3)	Specific demand DHW (norm) (kWh/m^3)	Total specific heat demand		Total heat demand (Gcal/yr)*
					(kWh/m^3)	($Gcal/m^3$)	
Schools	136	20,200	24	-	24	0.021	57,691
Kinder-gartens	100	7,600	26	5	31	0.027	20,520
Other edu.	29	14,500	31	-	31	0.027	11,354
Health care	41	21,000	19	22	41	0.035	30,135
Other public	64	11,000	27	-	27	0.023	16,192
Total	**370**						**135,892**

Note: * This column includes demand for both space heat and hot water.

Source: Technical Background Report prepared by Fichtner.

The total demand for space heat and hot water in residential buildings in Dushanbe amounts to 1,080,485 Gcal per year, as shown in

Table 3.12. About 50 percent of residential heat demand is for hot water. Individual family houses account for about 30 percent of total current demand, which is significantly more than their 20 percent share by area.

Heat and hot water demand for public buildings amounts to 135,892 Gcal per year, as shown in Table 3.13. It is assumed that heat for DHW preparation is used only in hospitals and kindergartens. About 65 percent of public building heat demand is from educational buildings.

Current total peak heat demand for residential and public buildings is estimated at almost 1,200 MW.

Table 3.14 below summarizes the space heating demand by customer segment in a typical year based on the analysis above.

Table 3.14: Space Heat Demand by Customer Segment in Dushanbe (Average Year)

Customer segment	**Space heat demand (Gcal/yr)***
Multi-apartment buildings	336,171
Individual family houses	197,832
Public buildings	115,301
TOTAL	649,304

Note: * This table only shows space heat demand; demand for hot water is not included.

Source: Technical Background Report prepared by Fichtner.

3.3 Heat Supply-Demand Gap

The estimated amount of heat demanded in 2012 was calculated and compared to the estimated amount of heat supplied in that year to help understand the magnitude of unmet heating demand in Dushanbe—the heat supply gap. The heat supply gap was calculated based on data for 2012. Tajikistan had a substantially colder than average winter in 2012; there were 15 percent more heating degree-days than in a typical year. Therefore, in order to more accurately calculate the supply gap that occurred in 2012, adjustments had to be made to the demand numbers for an average year (as presented in Section 3.2) to account for the colder temperatures. These adjusted demand numbers were then used in the calculations to determine the heat supply-demand gap.

The heat supply gap was estimated for 2012 as follows:

- Total heat demand in residential buildings was estimated based on the characteristics of the building stock in 2012, taking into account the specific number of the degree days in Dushanbe in that year and the normative requirements for indoor temperature.
- The amount of heat supplied in 2012 was then estimated based on the data on the heat supply provided by the DH and electricity supply companies. Estimates of the amount of electric top-up heating were made based on available statistical data.

- The supply gap or unmet demand is assumed to be the difference between the calculated demand level and the amount of heat supplied as of 2012.

Table 3.15 below shows the amount of space heat supplied to residential and public buildings by each heating source in Dushanbe.

Table 3.15: Space Heat Supplied to Each Customer Segment by Heat Supply System

	DH by CHP*	**DH by large HOBs**	**Supply by small HOBs**	**Supply by ind. heating systems**	**Total**
	Gcal/yr				
Multi-apartment buildings	20,203	802	236	282,655	**303,896**
Individual family houses	0	23	0	172,859	**172,882**
Public buildings	4,737	218	5,383	86,314	**96,652**
Total	**24,940**	**1,043**	**5,620**	**541,827**	**573,429****

Note: * This column excludes supply to industrial/commercial and other customers. ** This total may not match the sum of the other items in its column and row due to rounding.

Source: Technical Background Report prepared by Fichtner.

Table 3.16 shows the difference between the amount of space heat demanded (adjusted from the baseline demand for an average year shown in Table 3.14) and the amount of space heat supplied for residential and public buildings in Dushanbe in 2012.

Table 3.16: Space Heat Supply-Demand Gap in Dushanbe (2012)

	Space Heat Demand*	Space Heat Supply	Supply-Demand Gap	Supply-Demand Gap (as a percentage of demand)
	Gcal/yr			%
Multi-apartment buildings	387,198	303,896	83,302	22
Individual family houses	227,445	172,882	54,564	24
Public buildings	132,790	96,652	36,138	27
Total**	**747,434**	**573,429**	**174,005**	**23**

Note: * This table shows demand numbers that have been adjusted from baseline to account for the colder-than-average winter in 2012. ** The totals in this row may not match the sum of the items in each column due to rounding.

Source: Technical Background Report prepared by Fichtner.

The above analysis shows that the space heat supply gap is 23 percent of overall demand in residential and public buildings.[18] The space heat supply gap is greatest in public buildings, where 27 percent of space heat demand goes unmet each year. This confirms earlier findings of severe under-heating and low comfort levels in both public and residential buildings.

4 Heat Supply and Demand in Khujand

Khujand is the second-largest city in Tajikistan and the largest industrial and cultural center of northern Tajikistan. It is also the capital of Sughd, the northernmost province of Tajikistan. The official population is 167,400 people with an historical growth rate of about three percent. Khujand has low humidity with warm summers and moderately mild winters. It belongs to climatic region III with 1,984 heating degree days.[19] The average length of the heating season is 122 days.

The residential building stock in Khujand consists of 10,600 individual family houses that house 30 percent of the population (and which make up 30 percent of the residential floor space), as well as 598 apartment buildings where the rest of the population in Khujand lives. These make up the rest of the residential floor space. The city also has around 147 public buildings.

There is no DH system in Khujand. Individual heating systems provide almost all of the space heating, although some public buildings use small HOBs. There is a space heat supply gap estimated at 29 percent of overall demand in residential and public

[18] Hot water demand numbers were not available, so the heat supply gap analysis was only conducted for space heat demand.

[19] 3.74°C average outdoor air temperature during the heating season; 20°C normative indoor air temperature.

buildings. Like in Dushanbe, the space heat supply gap is the result of the poor energy efficiency of most buildings and the undersupply of heat. The gap is greatest in multi-apartment buildings, where 30 percent of space heat demand went unmet in 2012.

This section describes the current state of the heating sector in Khujand. It provides an overview of the heating systems in place and describes their condition. It also provides an estimate of the current space heating supply-demand gap in the city.

4.1 Heating Systems in Khujand

Heat in Khujand is supplied by the following systems:

- small HOBs
- individual heating systems.

There is no operational DH system remaining in Khujand. All but a small number of public buildings are supplied with space heating and DHW preparation from individual heating systems. Table 4.1 shows the coverage of public and residential buildings by different heating systems.

Table 4.1: Coverage of Public and Residential Buildings by Different Heating Systems

	Small HOBs		Individual		Total
	Value	%	Value	%	
Multi-apt. bldgs. (number)	0	0%	598	100%	**598**
Individual Houses (number)	0	0%	10,600	100%	**10,600**
Residential area (million m^2)	0	0%	2,459	100%	**2,459**
Households (number)	0	0%	52,334	100%	**52,334**
Public buildings (number)	20	14%	127	86%	**147**
Total Heat Supply (Gcal)	**2,115**	**1%**	**173,249**	**99%**	**175,364**

Source: Technical Background Report prepared by Fichtner.

4.1.1 Small HOBs

In 1993, "KhMK Khujand" JSC (the local subsidiary of "KMK" SUE) operated 16 boiler houses to supply heat to all apartment blocks and all public buildings in Khujand. Today, the company has only three operational small HOBs. Two HOBs supply heat to hospitals, and one recently rehabilitated HOB was designed to supply multi-apartment buildings but is not in operation. The reason heat cannot be delivered to the multi-apartment buildings is that the internal heating systems in the buildings have been dismantled and the residents cannot/are unwilling to finance the rehabilitation. The total capacity of the two HOBs in operation is 3,600 Gcal/h (4,187 MWth). While the small HOBs were designed to operate on gas, they have been converted to run on coal and as a result are relatively inefficient. Table 4.2 below presents key data on the existing "KhMK Khujand" heat supply systems.

Table 4.2: HOBs Owned by "KhMK Khujand" JSC

Installed capacity:	Boiler house (Hospital No.1): 1,800 Gcal/h (2,093 MWth) Boiler house (Hospital for children): 1,800 Gcal/h (2,093 MWth) Boiler house (Residential block "Khlopzavod"): 1,200 Gcal/h (1,396 MWth)
Supply (2012)	Boiler house (Hospital No.1): 628 Gcal (730 MWhth) Boiler house (Hospital for children): 136 Gcal (158 MWhth) Boiler house (Residential block "Khlopzavod"): not operational
Customers (2012)	2 hospitals and four multi-apartment buildings (the latter not supplied)

Source: "KhMK Khujand" JSC.

In addition to the HOBs owned by "KhMK Khujand", some additional boiler houses are owned and operated by the public facilities they supply. Table 4.3 shows the number of customers and amount of heat supplied by small HOBs, whether owned by "KhMK Khujand" or autonomous. While all of the heat supplied by "KhMK Khujand" HOBs is coal-fired, supply by autonomous small HOBs in Khujand is 55 percent electric, 40 percent coal-fired and five percent gas-fired.

Table 4.3: Customers Supplied by Small HOBs in Khujand (2012)

Type of customer	Number of buildings	Area or Volume	Supply (Gcal)	Share of supply electric boilers	Share of supply coal boilers	Share of supply gas boilers
Small HOBs owned by KhMK Khujand						
Public buildings	4	84,043 m³	764	0%	100%	0%
Other Small HOBs (Autonomous)						
Public buildings	16	188,391 m³	1,351	55%	40%	5%
Total	**20**		**2,115**			

Source: Technical Background Report prepared by Fichtner.

Because small boilers mainly supply just one consumer each, the pipelines connected to each boiler house are usually very short (100 to 150 m), but are poorly insulated. As a result of the poor condition of the network, technical losses in 2012 were 12 percent. This is low compared to the overall losses on the DH system in Dushanbe, but it is high given the short length of the networks in Khujand.

4.1.2 Individual heating systems

All residential buildings and the majority of public buildings in Khujand rely exclusively on individual heating systems. These consist of oil or spiral radiators, coal or wood burning stoves and boilers, and/or air heat pumps that also function as air conditioning units. About 40 percent of the individual family houses use individual coal or wood burning boilers or stoves in addition to electrical heating systems. It is estimated that about 70 percent (94,627 Gcal) of total residential heat is supplied by individual electrical systems and about 30 percent (42,365 Gcal) is supplied by individual wood/coal fired systems.[20] Public buildings also rely heavily on individual electrical heating systems.

[20] Technical Background Report prepared by Fichtner. The assumptions are based on electricity consumption data provided by Barki Tojik and available statistical survey data.

Table 4.4 shows the estimated number and type of end-users that heat with individual heating systems.

Table 4.4: Heat Supplied by Individual Systems in Khujand by Fuel Type

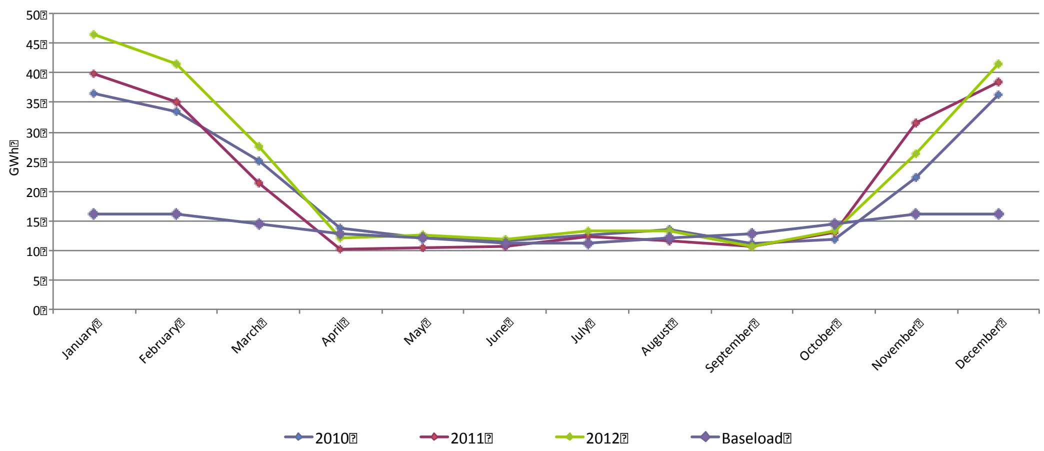
Type of customer	Number of buildings		Supply from individual systems (Gcal/yr)	Share of total 2012 heat supply for each building type supplied by individual systems		
	Total	Using ind. systems as primary heating source		Electricity	Coal or wood	Gas
Multi-apartment building	598	598	75,986	100%	0%	0%
Individual houses	10,600	10,600	61,006	31%	69%	0%
Public buildings	147	127	36,257	94%	0%	0%
TOTAL	**11,345**	**11,325**	**173,249**			

Note: Buildings may supplement DH-based heat supply with individual heating systems, which is why all buildings are shown in the "Total" column. Only those buildings listed in the "Using ind. systems as primary source of heat" column rely exclusively on individual systems for heating. The supply column shows all heat supplied by individual systems, whether primary or supplementary (for "topping-up").

Source: Technical Background Report prepared by Fichtner.

The prevalence of electricity for heating contributes to high residential electricity consumption during the winter months. In 2012, residential electricity consumption in January and December was three times as high as residential electricity consumption in June. Figure 4.1 shows monthly electricity consumption in the residential sector for the years 2010 to 2012.

Figure 4.1: Monthly Residential Electricity Consumption in Khujand (2010 to 2012)



Source: Barki Tojik

4.2 Heat Demand in Khujand

Heat demand in Khujand was estimated for 2012 and compared to the estimated amount of heat supplied to understand the magnitude of unmet heating demand in the country. The housing stock in Khujand consists of 11,198 residential buildings with a total residential area of 2.5 million m². Individual family houses account for 95 percent of the total number of residential buildings, but only 30 percent of the residential floor space. Table 4.5 provides a breakdown of Khujand's housing stock area, population, and households by building type.

Table 4.5: Housing Stock in Khujand

Parameter	Value
Total residential area (m^2)	2,459,220
Total population	167,400
Total residential area per capita (m^2/person)	15
Total number of households	52,669
Individual houses	
Number of houses	10,600
Total residential area (m^2)	742,000
Average size of house (m^2)	70**
Population	50,508*
Number of households	10,600*
Average number of people per household	4.8*
Multi-apartment buildings	
Number of buildings	598
Total residential area (m^2)	1,717,220
Number of flats	41,744
Flats per building	69
Average size of flat (m^2)	41*
Population	116,892*
Number of households	41,744*
Average size of household	2.8*

Source: Statistical Agency of the Republic of Tajikistan (2013).

Notes: *calculated value; **according to Khujand city council.

A standardized set of assumptions about the amount of heat demanded per unit of area was developed for each type of residential and public building. Heat demand assumptions were created based on walk-through audits of residential and public buildings.[21] The total heat demand and heat demand by building type in Khujand were calculated by combining these assumptions with data on the area of each building type in the city.

Table 4.6 and Table 4.7 show the heat demand assumptions for different types of residential and public buildings for a typical year in Khujand.

Table 4.6: Total Heat Demand of Residential Buildings (Khujand, Average Year)

Type	**No. of bldgs.**	**Avg. heated area (m²)**	**Specific demand for space heating (kWh/m²)**	**Specific demand for DHW (kWh/m²)**	**Total specific heat demand**		**Total heat demand* (Gcal/yr)**
					(kWh/m²)	**(Gcal/m²)**	
Type I	108	871	67	55	122	0.105	9,875
Type II	109	2,770	65	55	120	0.103	31,101
Type III	309	3,687	68	55	123	0.106	120,769
Type IV	43	2,732	78	55	133	0.114	13,391
Type V	3	2,448	68	55	123	0.106	778
Type VI	26	2,195	51	55	106	0.091	5,194
Indiv. family houses	10,600	70	122	55	177	0.152	112,784
Total	**11,198**						**293,892**

Note: * This column includes demand for both space heat and hot water.

Source: Technical Background Report prepared by Fichtner

[21] Walk-through audits were conducted in nine multi-apartment buildings in Khujand, the Housing Department building, a school, a kindergarten, two hospitals and a maternity hospital.

Table 4.7: Total Heat Demand of Public Buildings (Khujand, Average Year)

Type	No. of bldgs.	Avg. heated vol. (m^3)	Specific demand for space heat (kWh/m^3)	Specific demand DHW (norm) (kWh/m^3)	Total specific heat demand		Total heat demand* (Gcal/yr)
					(kWh/m^3)	($Gcal/m^3$)	
Schools	33	15,200	33	0	33	0.028	14,233
Kinder-gartens	34	6,500	30	5	35	0.030	6,651
Other edu.	8	14,500	40	0	40	0.034	3,970
Health care	42	21,000	20	22	42	0.036	32,004
Other public	24	12,500	34	0	34	0.030	8,874
Total	**141**						**65,732**

Note: * This column includes demand for both space heat and hot water.

Source: Technical Background Report prepared by Fichtner

Residential sector demand for space heat and hot water in Khujand amounts to 293,892 Gcal per year as shown in Table 4.6, of which DHW preparation accounts for about 40 percent. While individual family houses account for about 30 percent of the residential floor area, they make up 40 percent of total residential heat demand.

Public building demand for heat and hot water in Khujand amounts to 65,732 Gcal per year, as shown in Table 4.7. Only hospitals and kindergartens are assumed to have access to DHW. Public buildings account for about 18 percent of overall heat demand. Educational buildings account for 38 percent of the public sector demand.

Table 4.8 below summarizes the space heating demand by customer segment in a typical year based on the analysis above.

Table 4.8: Space Heat Demand by Customer Segment in Khujand, Average Year

Customer segment	Space heat demand (Gcal/yr)*
Multi-apartment buildings	99,721
Individual family houses	77,837
Public buildings	47,862
Total	**225,440**

Note: * This table shows only space heat demand; demand for hot water is not included.

Source: Technical Background Report prepared by Fichtner.

4.3 Heat Supply-Demand Gap

As in Dushanbe, heat demand figures for Khujand in 2012 had to be adjusted to account for the colder-than-average winter (see Section 3.3 for a more detailed methodology).

Table 4.9 below shows the amount of heat for space heating supplied to residential and public buildings by each heating source in Khujand.

Table 4.9: Space Heat Supplied to Each Customer Segment by Heat Supply System in Khujand (2012)

	Small HOBs ("KhMK Khujand")	**Small HOBs (Autonomous)**	**Individual Systems**	**Total**
	Gcal/yr			
Multi-apartment buildings	0	0	75,986	**75,986**
Individual family houses	0	0	61,006	**61,006**
Public buildings	764	1,351	36,257	**38,372**
Total	**764**	**1,351**	**173,249**	**175,364**

Source: Technical Background Report prepared by Fichtner.

Table 4.10 shows the difference between the amount of space heat demanded and the amount of space heat supplied for residential and public buildings in Khujand in 2012.

Table 4.10: Space Heat Supply-Demand Gap in Khujand (2012)

	Space Heat Demand*	**Space Heat Supply**	**Supply-Demand Gap**	**Supply-Demand Gap (as a percentage of demand)**
	Gcal/yr			%
Multi-apartment buildings	108,552	75,986	32,566	**30**
Individual family houses	84,730	61,006	23,724	**28**
Public buildings	52,100	38,372	17,408	**26**
Total	**245,382**	**175,364**	**73,698**	**29**

Note: * This table shows demand numbers that have been adjusted from baseline to account for the colder-than-average winter in 2012.

Source: Technical Background Report prepared by Fichtner.

The above analysis shows that the space heat supply gap is 29 percent of overall demand in residential and public buildings. The space heat supply gap is greatest in multi-apartment buildings, where 30 percent of space heat demand goes unmet each year. Overall the gap is slightly lower in public buildings and individual houses.

5 Evaluation of Measures to Improve the Heating Sectors of Dushanbe and Khujand

Based on the current infrastructure, heat loads and fuel availability, the options for meeting space heat demand in Dushanbe and Khujand are limited and range from the rehabilitation of the existing DH system to small coal-fired HOBs and individual heating solutions.

This section evaluates the economic viability of the main heating options and associated investment measures for meeting the space heat demand of residential and public buildings in Dushanbe and Khujand. The technical, institutional, environmental and social advantages and disadvantages of each measure are assessed. For each customer segment, the available heating options and investment measures are ranked based on the results of this multi-criteria assessment to inform the recommendations outlined in Section 6.

5.1 Assessment Approach

The following approach was used to select the most viable options and associated investment measures to meet heat demand in public and residential buildings in Dushanbe and Khujand:

1. **Identification of main supply- and demand-side options**. The main supply- and demand-side options for meeting residential and public heat demand were identified based on the existing heating infrastructure and the availability of fuels in each city. These options include: DH with coal-fired CHP (Dushanbe only); DH with coal-fired large HOBs (Dushanbe only); small coal-fired or electric HOBs; individual coal/solid fuel stoves or boilers; individual electric radiators; individual electric heat pumps; and energy efficiency in residential and public buildings.
2. **Identification of a long list of investment measures.** A comprehensive 'long list' of 30 specific investment measures associated with each of the main heating options was identified.[22]
3. **Development of a short list of investment measures.** An initial economic and technical viability screening was applied to the long list of measures. Measures found to have very high investment costs, low potential for improving the heat supply, or limited technical feasibility were excluded in order to develop a 'short list' of the most viable investment measures.
4. **Assessment of economic viability.** The economic viability of the 21 short listed investment measures was evaluated based on a two-tier analysis: (i) a levelized cost assessment of the main heat supply- and demand-side options to determine the most viable options for meeting the heat demand of different types of residential and public buildings; and (ii) a cost efficiency analysis of the 21 short listed specific investment measures associated with each of the main heating options.

[22] The evaluation of the long listed measures was conducted as part of the technical background report prepared by Fichtner.

5. **Assessment of non-economic advantages and disadvantages.** Non-economic advantages and disadvantages of the short-listed investment measures were also evaluated. These non-economic considerations primarily include, technical, institutional, environmental and social advantages and disadvantages.
6. **Ranking of investment measures.** The investment measures were ranked for each customer segment based on the results of the multi-criteria assessments. The most cost-efficient investment measures associated with economically viable heating options and without major social and environmental disadvantages were recommended for implementation.

Table 5.1 below lists the main heating options and the associated investment measures included in the long list.[23] Measures that were selected for the short list are highlighted in green and assigned an identifying number.

Table 5.1: Overview of Heating Options and Measures

Generation	Transmission/Distribution	End-use
	Option: DH (CHP and large HOBs)	
• Rehabilitation of CHP • Rehabilitation of large HOBs • Construction of new large HOBs • Installation of heat meters at the outlet of heat generation units • **Solar heat production for DH (M13)**	• Replacement of transmission pipelines • **Replacement of distribution pipelines (M8)** • **Re-insulation of over-ground distribution pipelines (M9)** • Construction of new transmission and distribution pipelines • **Installation of variable speed drive pumps (M10)** • Insulation of valves and related pipeline equipment • Processing of feed-water and circulating water in the DH system • Extension of the DH network (construction of new T&D facilities to extend network)	• **Installation of automatic individual substations (M6)** • **Installation of temperature and hydraulic regulation of premises service connections (M7)** • **Installation of building-level heat and DHW metering (M2)** • Hydraulic balancing of heat flow in buildings • **Rehabilitation of building-internal distribution network (M11)** • **Installation of thermostatic valves on radiators in dwellings (M3)** • **Implementation of consumption-based billing (M4)**
	Option: Autonomous Heating (small HOBs)	
• **Construction of new and replacement of existing small HOBs (M12)**	n/a	• **Rehabilitation of building-internal distribution network (M11)** • **Installation of thermostatic valves on radiators in dwellings (M3)**

[23] The evaluation of the long listed measures was conducted as part of the technical background report prepared by Fichtner.

		• Implementation of consumption-based billing (M4)
Options: Individual heating systems (various options)		
• Installation of individual efficient coal-fired heat boilers (M18) • Installation of individual efficient coal-fired heat stoves (M17) • Installation of heat pump systems (M15) • Installation of solar water heaters • Installation of electric oil radiators	n/a	n/a
Option: Energy Efficiency		
n/a	n/a	• Replacement of windows (M1) • Insulation of attics (M1) • Insulation of external walls (M1) • Insulation of cellar ceilings (M1)

The remainder of this section describes the evaluation of the heating options and related investment measures (steps 4-6 above).

5.2 Analysis of the Economic Viability of Heating Options and Associated Investment Measures

The economic viability of heating options and the related investment measures was assessed. First, the Levelized Cost of Heat Supply (LCHS) for each heating options was assessed. Then, the cost efficiency factor (CEF) of investment measures was analyzed.

5.2.1 Economic Viability of the Main Heating Options

The LCHS (see description in **Box 5.1** below) for the heating options takes into account the current heating infrastructure used by different customer segments as described in Sections 3 and 4 (i.e., individual family houses currently using different individual heating options, multi-apartment and public buildings with/without access to DH). The different heating options serving the same customer segment were compared to each other in order to determine the most viable solution for that segment.

Box 5.1: Levelized Cost of Heat Supply (LCHS)

The LCHS is the average discounted cost of a unit of heat supplied or a unit of demand reduced by a heating option over its lifetime, taking into account all capital, operating and fuel costs associated with that option. The LCHS is calculated in terms of US$ per kWh of thermal energy produced or saved by a given option. For the purposes of this report, the LCHS has been calculated based on international and regional benchmarks adjusted to local conditions (local suppliers, fuel cost, etc).

Table 5.2 shows the building types that are currently served by different heating systems, and which of the identified main options would be available for each building type and heating system.[24] The deployment of individual coal-fired heating options is limited to those buildings currently relying on coal.

Table 5.2: Heating Options and the Customer Segments They Serve

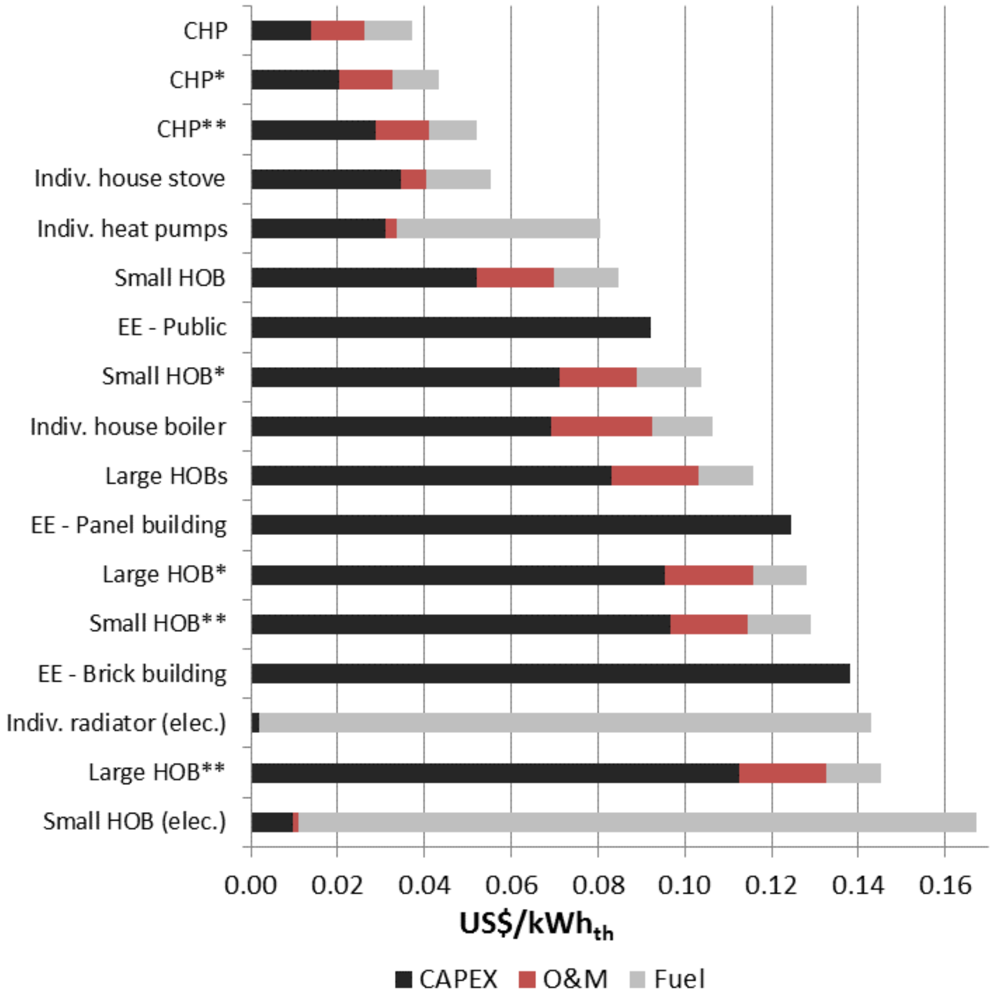
Customer segment:	Individual family houses		Multi-apartment buildings			Public buildings	
Primary heating system currently used:	Coal/ wood stoves/ boilers	Electric boilers/ radiators	DH (CHP or large HOBs)*	Small HOBs	Individual electric heating	DH (CHP or large HOBs)*	Small HOBs
Heating options to improve situation							
Coal-fired CHP			X			X	X
Coal-fired large HOBs			X			X	X
Small coal-fired HOBs	X	X	X	X	X	X	X
Small electric HOBs	X	X	X	X	X	X	X
Building energy efficiency**	X	X	X	X	X	X	X
Individual heat pumps***	X	X	X	X	X	X	X
Individual coal stoves	X						
Individual coal boilers	X						
Individual electric radiators	X	X	X	X	X		

*DH options are only available for Dushanbe, **Building energy efficiency can be applied for all residential and public buildings. However, based on the energy audits conducted, specific cost estimates were only calculated for multi-apartment brick and panel buildings and public schools. ***Heat pumps can be applied to all residential and public buildings, but based on the energy audits conducted, specific cost estimates were only calculated for multi-apartment brick and panel buildings and public buildings.

[24] The pairing of building types and heating systems is referred to as a 'customer segment'.

Figure 5.1 below shows the results of the LCHS analysis for each heating option for Dushanbe. Figure 5.2 shows the results for Khujand.

Figure 5.1: LCHS of Heating Options for Dushanbe



Notes: *Indicates the levelized cost of a heating option assuming that the existing building-internal heating systems are upgraded; **Indicates the levelized cost of a heating option assuming that new building-internal heating systems are constructed

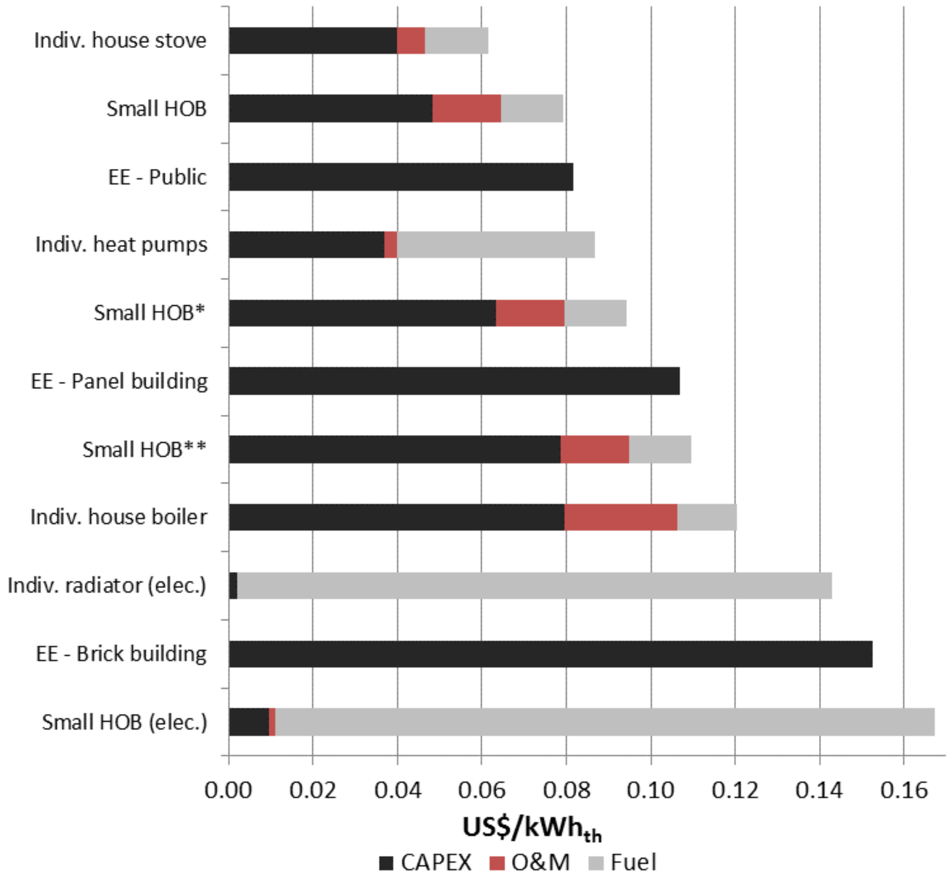
CHP costs: excludes plant CAPEX (sunk cost); includes replacement of 50 percent of over-ground T&D pipelines, re-insulation of 50 percent of over-ground T&D pipelines, replacement of 50 percent of underground T&D pipelines. Also includes the installation of automatic building-level DH substations for all buildings served by DH; and the deployment of variable speed drives at water pumps and network pumps

Large HOB costs: includes boiler replacement and the same network investment measures as for CHP.

Fuel price: Coal: US$73/t for CHP; US$83/t for large HOBs; US$100/t for small HOBs; Electricity: US$0.14/kWh (economic costs)

The LCHS of energy saved from building energy efficiency measures is calculated as if the energy efficiency measures were an energy generating resource and the energy "generated" by that resource is the amount of energy saved by the energy efficiency measures, i.e., the capital cost of the energy efficiency measures is levelized over the energy saved over the measures' lifetime.

Figure 5.2: LCHS of Heating Options for Khujand



Notes: *Indicates the levelized cost of a heating option assuming that the existing building-internal heating systems are upgraded; **Indicates the levelized cost of a heating option assuming that new building-internal heating systems are constructed

Fuel price: Coal: US$100/t for small HOBs; Electricity: US$0.14/kWh (economic costs)

The LCHS of energy saved from building energy efficiency measures is calculated as if the energy efficiency measures were an energy generating resource and the energy "generated" by that resource is the amount of energy saved by the energy efficiency measures, i.e., the capital cost of the energy efficiency measures is levelized over the energy saved over the measures' lifetime.

The heating options that are most economically viable for each customer segment based on the results presented in Figure 5.1 and Figure 5.2 are described below.

Economic viability of heating options for individual family houses

For individual family houses currently using coal stoves or boilers, the available options with the lowest LCHS is their replacement with more efficient models.

For individual family houses currently served by electric boilers or radiators, it would be more economically viable to switch to electric heat pumps and improve energy efficiency than to use electric radiators. Heat pumps, which take advantage of the heat in the outside air, can operate in colder climates. Box 5.2 describes the applicability of air-to-air heat pumps in cold climates.

Box 5.2: Applicability of heat pumps in cold climates

Air-to-air heat pumps (the type of heat pump evaluated in this report) use the heat present in the outside air to heat the air indoors. These devices use refrigerants that absorb heat from the outside air and release it indoors even when that air is as low as -30°C (as shown in Table 2.1, the average winter ambient temperature in Dushanbe and Khujand is greater than 0°C). For especially cold days, modern air-to-air heat pumps typically have a built-in "peak load" heating element.

Unlike electric resistance heaters that convert electric energy to heat energy, heat pumps use electricity to run compressors and circulate refrigerants that absorb the heat in outdoor air. Therefore, air-to-air heat pumps are capable of generating more thermal energy than is required to operate them. For instance one kWh of electric energy can be used to generate three kWh of thermal energy (based on a realistic Coefficient of Performance of 3). While the efficiency of heat pumps decreases with lower ambient temperature, even during very cold days, the coefficient of modern heat pumps does not drop below 1.5, thus being more efficient than traditional electric oil radiators.

Economic viability of heating options for multi-apartment buildings

For multi-apartment buildings currently served by DH with CHP, heat supplied by the CHP plant is the most economically viable option.

For multi-apartment buildings currently served by large HOBs, the analysis suggests that installing small HOBs would have slightly lower economic costs, but the difference in cost between the two options is relatively. Energy efficiency measures are also an economically viable option to help reduce the heat demand of this customer segment.

For multi-apartment buildings currently served by small HOBs, small HOBs appear to continue to be the most viable option. Energy efficiency measures also appear to be an economically viable option to help reduce energy demand in these buildings.

For multi-apartment buildings that rely on individual electric radiators, switching to individual electric heat pumps or installing small HOBs would both be more economically viable options for meeting demand. Given the high economic cost of the current electricity-based heat supply, energy efficiency measures are also economically viable.

Economic viability of heating options for public buildings

For public buildings served by CHP-based DH or small HOBs, the most economically viable option is to continue their current forms of heat supply. Energy efficiency measures would also be an economically viable option for helping to meet demand in public buildings. For buildings that are served by large HOBs, it appears that small HOBs have a slightly lower LCHS than large HOBs, but the difference is relatively small.

For public buildings that are currently heated with electric radiators, the installation of small HOBs and energy efficiency measures would be a more economically viable heating option.

5.2.2 Economic analysis of the short listed measures

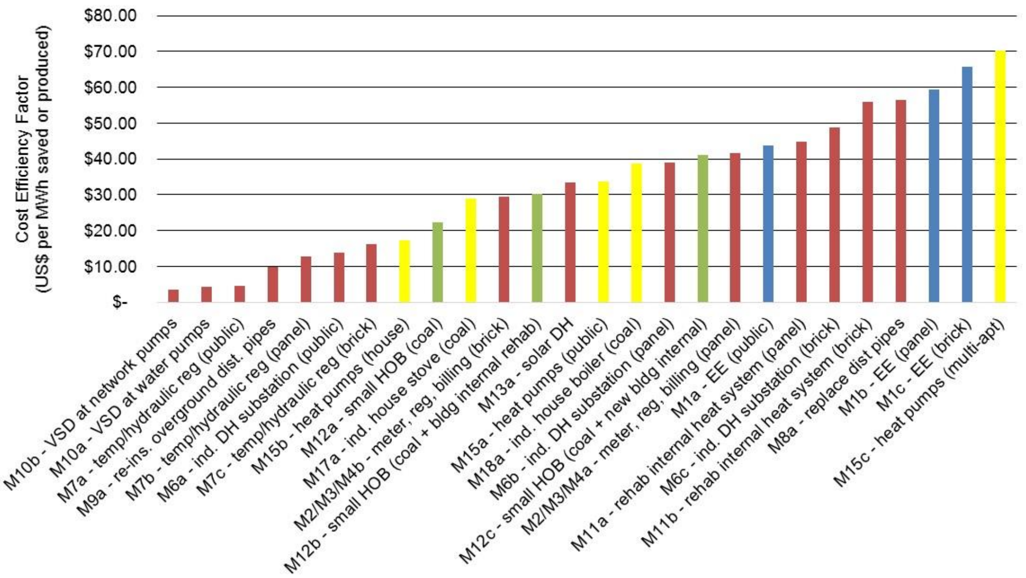
In order to determine relative economic viability of specific investment measures that are included in the short list, the CEF (see description in **Box 5.3**) of each investment measure was calculated, and the measures were compared on the basis of their CEFs. A low CEF indicates economic viability. The CEF of each measure was taken into account when selecting measures for recommendations.

Box 5.3: Cost Efficiency Factor (CEF)

The CEF evaluates the investment cost per unit of energy saved or produced by a given measure. The CEF is calculated by dividing the total investment cost of a given measure by the total amount of energy that it will save or produce over that measure's lifetime. The CEF provides a rough estimate of the cost of an energy infrastructure investment per unit of energy saved or produced. However, the CEF should be used with caution because it does not account for the operating costs of a given investment. Measures with very low capital costs but very high operating costs may appear economically viable, though they are actually high cost after operating costs are taken into account. The CEF is useful nonetheless, because it provides insight into the economic viability of the non-heat producing measures (e.g., installation of variable speed drives, transition to consumption based-billing, etc.) compared with the heat producing measures.

Figure 5.3 and Figure 5.4 show the CEFs of all measures short-listed for Dushanbe and Khujand, respectively. The analysis indicates that many of the rehabilitation measures to improve the DH system in Dushanbe are economically viable, especially the installation of variable speed drives, the re-insulation of over ground distribution pipes, the installation of building-level temperature and hydraulic regulation or the installation of building-level substations. With regards to investment measures to improve autonomous heating options and individual heating systems, the analysis suggest that the use of more efficient individual coal stoves, followed by small HOBs and individual heat pumps are the most viable investment measures. The building energy efficiency-related measures, on the other hand, have relatively high CEFs, which is largely because they are capital-intensive and the CEF only takes into account capital costs.

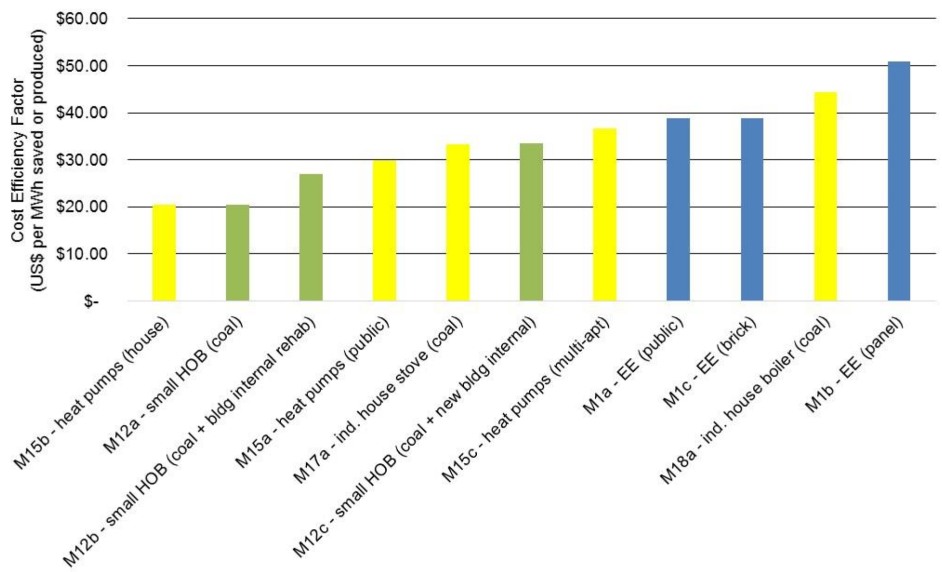
Figure 5.3: CEF by Measure (Dushanbe)



Notes: Red bars denote DH options, green bars relate to supply from small HOBs, yellow bars to individual heating options, and blue bars to energy efficiency options.

Different letters following measure numbers denote different applications of these measures (such as panel or brick multi-apartment buildings). Appendix A describes which measure number-letter combination matches each implementation.

Figure 5.4: CEF by Measure (Khujand)



Note: Green bars denote supply/distribution of heat from small HOBs, yellow bars relate to individual heating options, and blue bars to energy efficiency options.

Different letters following measure numbers denote different applications of these measures (such as panel or brick multi-apartment buildings), and a description of which measure number-letter combination matches up to which implementation of each measure is described in Appendix A.

5.3 Analysis of Environmental and Social Advantages and Disadvantages of the Short List Measures

In addition to the economic analysis, the technical, institutional, environmental and social advantages and disadvantages of each of the short list measures were evaluated. These are presented in Table 5.3.

Table 5.3: Environmental and Social Advantages and Disadvantages of the Heat Supply Options

Option	Measure	Non-economic advantages	Non-economic disadvantages
DH by CHP or large HOBs	M2 – metering, M3 – temperature regulation, M4 – consumption-based billing*	+ Allows customers to control their own energy use and bills + Pre-requisite for creating incentives related to energy efficiency measures in buildings + Improved quality of service through better indoor climate for customers	- Requires a coordinated effort among regulator, homeowners and companies, which adds complexity - Access and approval of building/apartment-owners required to install thermostatic valves at radiators in private homes - Need for suitable financing and implementation mechanisms - Reforming heat tariff-design for end-user requires broad stakeholder consultations, information campaigns and targeted mitigation measures for the poor
	M6 - Installation of automatic individual DH substation	+ Improved quality of service through better indoor climate for customers + If installed with heat exchangers, improves water quality, ensures safer operation and less corrosion of network pipelines, allows higher flow temperature and increases supply capacity	- Requires appropriate implementation arrangements given that the service connection point is common property between the building-owner and the DH company
	M7 - Temperature and hydraulic regulation of house service connections	+ Widely available technology + Installation does not require special skills	- Outdated technology compared to modern building-level substations - Requires appropriate implementation arrangements given that the service connection point is common property between the building-owner and the DH company
	M8 - Replacement of distribution pipelines	+ Longer lifetime and lower maintenance than old pipelines + Reduce heat losses and water leakages and better supply reliability (less breakdowns)	- Time and labor intensive for underground pipelines - Potential safeguard issues (e.g., asbestos)
	M9 - Re-insulation of overground distribution pipelines	+ Better supply would improve comfort levels for the population supplied by DH + No excavation in public streets necessary	- Insulation might outlive the pipelines to which they are applied

	M10 -Variable speed drive pumps	+ Reduce electricity consumption + Step-by-step implementation possible + Old worn-out pumps should be replaced anyway	
	M11 - Rehabilitation of internal heating system	+ Better indoor climate due to the increase of flow through radiators + Improved supply reliability, safer operation and avoiding 'under-heating' for customers at the end of piping network	- Close cooperation and appropriate implementation arrangements required among DH company, housing association and residents (building users) - Challenging incentive structures for financing of the measure, in particular at the absence of HOA and sufficient funds
	M13 - Solar heat production for DH	+ Reduced dependency on fuel imports + No direct emissions and low CO2 emissions	- Magnitude of output is seasonally dependent, i.e., the output of a solar DH system will be lowest in the winter when it is needed most - Availability and quality of local products
Small HOBs	M12 - Construction of new efficient autonomous small HOBs	+ For coal-based boilers, reduced dependence on imported fuels when these boilers replace gas + Improve reliability and efficiency of heat supply + Reduce electricity loads due to heating in winter + Local employment through the production, installation and operation of the HOBs + Coal boilers can be equipped with flue gas cleaning and thus reduce emissions from existing inefficient coal boilers + For existing HOBs, infrastructure within the building (piping and radiators) is the same as for the DH system	- For coal-based boilers: coal will produce flue gas emissions in the inner city and greenhouse gases; coal requires transport by truck, which can aggravate pollution and congestion in the city; financing by development partners may be challenging due to coal use
Energy efficiency	M1 - Insulation of Buildings	+ Better indoor climate/comfort levels for customers + Reduced energy bills and loads on the electricity network (in case of electric heating) + Multiple co-benefits, such as improved noise protection, reduced number of sick days, improved building aesthetics, etc. + Local job creation through labor-intensive rehabilitation works	- High upfront investments for building-owners (as other works on worn-out building structures are likely to be required) - Insufficient incentives for customers given the low tariffs - Small and dispersed projects requiring targeted financing/implementation and delivery mechanisms - Savings are dependent upon the overall condition of the building, the existing comfort level (many buildings are under-heated) and behavior patterns of the residents/users

Individual heat supply options	M15 -Installation of heat pump systems	+ Makes more efficient use of scarce electrical energy when they replace electric resistance-based heaters + Small and can be installed in nearly every room + Fully automatic with low maintenance	- No heat supply during blackouts - Electrical heat pumps are sensitive to frequency and voltage fluctuations - No local suppliers for the heat pumps - Efficiency decreases when ambient air temperature is very low - Lack of incentives for customers to switch to more efficient devices given the low electricity tariffs - Need for adequate implementation and financing mechanisms to enable and incentivize installation of more efficient pumps
	M17 - Installation of efficient small coal stoves	+ Improved efficiency and emissions profile compared with existing coal stoves + Reduce indoor air pollution + Reduce coal consumption compared to current models	- Negative environmental and health impacts associated with the continued use of coal - "Locks in" customers to a coal-fired technology and slows the transition to low-emissions heating sources - Need for adequate implementation and financing mechanisms to enable and incentivize customers to switch to more efficient stoves
	M18 - Installation of efficient coal boilers	+ Improved efficiency and emissions profile compared with existing boilers + Reduce coal consumption compared to current models	

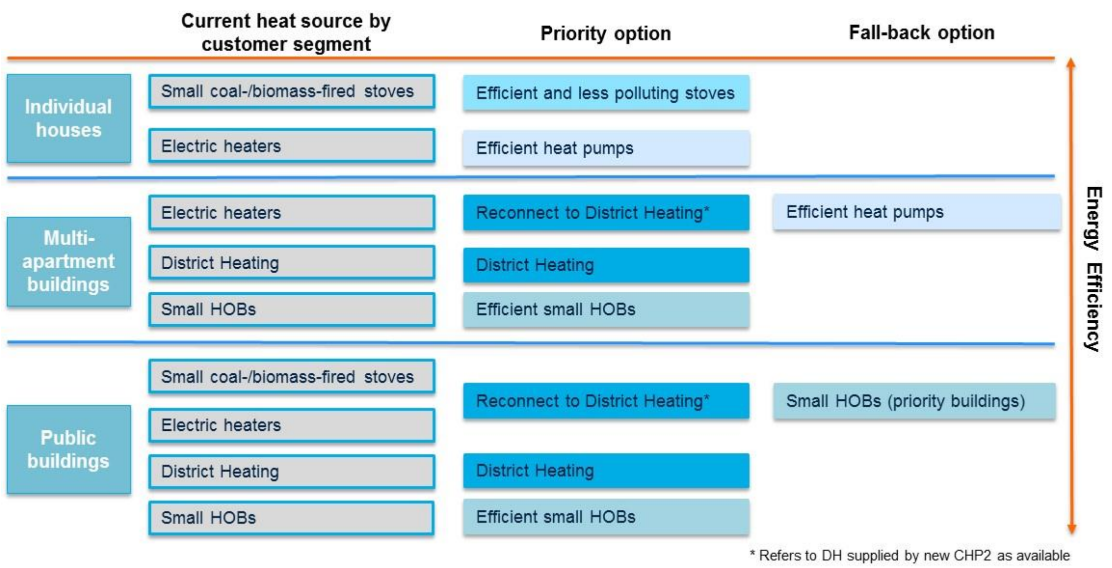
Notes: *These three measures are only effective if they are implemented together, so for the purposes of this analysis they are evaluated together.

5.4 Summary of the Analysis of the Heating Options and Short List Measures

Based on the results of the economic assessment and the evaluation of other advantages and disadvantages, the applicable investment measures for each customer segment were prioritized to help inform the recommendations. The prioritization was done taking into account first the economic viability of the main heating options, second the results of the cost efficiency analysis for the specific investment measures, and third the other advantages and disadvantages associated with each measure. The weighting of the latter is a policy choice; for the purpose of this report, advantages/disadvantages related to the impact on winter power shortages and comfort levels were weighted the most. The multi-criteria approach was used to determine priority heating options as well as fallback heating options for each customer segment.

Figure 5.5 presents an overview of the priority and fallback heating options for each customer segment in Dushanbe and Khujand, based on the multi-criteria assessment of economic and non-economic benefits of each heating option. A more detailed description is provided in Section 6.

Figure 5.5: Priority and Fall-back Heating Options by Customer Segment



6 Recommendation of Measures to Improve the Heating Sectors of Dushanbe and Khujand

The investment needs of the heating sector are sizable, estimated to amount to about US$200 million in the short and close to US$700 million in the long-term. The implementation of the investment measures will therefore need to be adequately phased and prioritized. This could be achieved by preparing detailed investment and implementation plans for the heating sector based on the viable investment measures recommended in this study. Heating companies could also use the investment plans to ensure well-planned and coordinated fund raising from bilateral and multi-lateral development partners and the private sector. Also, deployment of efficient autonomous and individual heating solutions, such as switching to small HOBs or replacing inefficient coal stoves and heaters with more efficient models, will require demand-driven programs supported by public consultation and outreach campaigns in addition to appropriate implementation, financing and incentive mechanisms.

This section summarizes the recommended investment measures and related policy actions needed to improve the reliability and efficiency of heat supply in Dushanbe and Khujand. For each recommendation, the investment measures and the scope of their implementation are described. Some of the most important implementation issues are also highlighted, and immediate next steps are outlined.

6.1 Recommendation 1: Implementation of a Scalable Program for the Replacement of Inefficient Individual Heating Sources

Inefficient, individual heating systems are a key challenge for Tajikistan's urban heating sector. The use of inefficient coal- and biomass-fired stoves and boilers results in high indoor pollution and low comfort levels, while the high reliance on electric heaters is an inefficient use of valuable electricity resources. The proliferation of inefficient, individual electric heating systems has also destabilized the power grid and increased the frequency of blackouts and power shortages.

6.1.1 Recommended measures

A scalable program for more efficient small heating technologies is recommended, including more efficient individual stoves, boilers and heat pumps. International experience shows that such programs can bring substantial benefits to residential consumers by reducing coal consumption and costs (by up to 35 percent), decreasing electricity consumption and related costs for heating (by up to 70 percent), lowering indoor air pollution and increasing comfort levels. The program would also have a high replication potential in both urban and rural areas given the large share of households currently relying on inefficient individual heating solutions.

6.1.2 Scope of implementation

The target group for such a program would be residential and public consumers currently relying on inefficient individual heating solutions as their primary heat source and for which small HOBs are not an option. This includes residential and public consumers using traditional coal- and biomass-fired heating stoves or boilers as well as those using inefficient electric oil radiators.

- **Replacement of inefficient coal-/biomass-fired stoves or boilers with more efficient models.** Switching to more efficient and less polluting solid fuel-fired stoves and boilers should be incentivized for households and public institutions that are currently using traditional solid fuel-fired models for heating.
- **Replacement of inefficient electric oil radiators with heat pumps**. Individual heat pumps could be promoted for residential and public buildings that currently rely on electric heating options. However, in Dushanbe, the detailed scope of priority buildings for individual heat pumps needs to take into account the planned coverage area to be served by the CHP 2.

6.1.3 Implementation issues

Ensuring adequate equipment supply and efficient distribution channels: In order to ensure that the individual heating technologies promoted as part of the program (i.e., coal stoves and boilers, heat pumps) result in significant efficiency gains and comply with safety and emission requirements, the supply chain for such equipment must be strengthened. To this end, potential design elements for the program should take into account: (i) adoption of technical, environmental and safety performance standards for products; (ii) eligibility criteria for products and suppliers, including supply capacity of producers; (iii) quality verification and enforcement mechanisms to ensure adequate performance of products; (iv) regulating supply chains and distribution channels to avoid non-compliant copy-cat models, e.g., through dedicated distribution centers; (v) eligibility criteria for households to ensure targeted replacements and incentive schemes; (vi) organizing efficient return and disposal systems for old equipment; and (vii) capacity building and technical assistance for local producers, as needed.

Enhancing demand through dedicated financing and incentive mechanisms and public outreach campaigns: Financing and perception are the principle challenges to developing and implementing a program to promote efficient individual heating technologies. The experience in Tajikistan and other countries suggests that households are reluctant or unable to fund the higher upfront investment for new, individual heating solutions unless payback periods can be shortened. Given the relatively high unit price of more efficient models compared to traditional options (stoves, boilers and electric heaters), the market penetration of efficient technologies at scale would require a dedicated financing mechanism and a well-targeted incentive program from the Government. Experience from ongoing pilot projects in Tajikistan as well as countries with similar programs could offer useful lessons learned and design options for implementation and financing schemes. International models used include the development of dedicated (micro-) credit-lines for eligible households, results-based financing schemes or demand-side management programs combined with targeted subsidy schemes (e.g., disbursement after verified installation). The subsidy schemes could be designed to reflect the affordability of target households, reward the use of models with higher performance and/or promote rapid penetration of new equipment. Box 6.1 and include examples of programs in Mongolia and Armenia. In addition to such programs, extensive public outreach activities and information campaigns will be required to increase awareness and enhance demand. The design of a program for the deployment of efficient heating solutions at household-level should also build on the implementation experience and lessons learned from ongoing pilot programs in Tajikistan, which aim to address the winter energy crisis through the deployment of energy efficient stoves and improving the insulation of individual houses. This includes initiatives supported by the German development agency for international cooperation (GIZ), the Asian Development Bank, Non-Governmental Organizations (e.g. Habitat for Humanity, l'Agence d'Aide à la Coopération Technique et au Développement) and some microfinance institutions. While the scale and impact of the initiatives vary, a few key points can be distilled at this stage: (i) a range of technologies are on the market but adequate performance, safety and quality standards are not ensured; (ii) demand has been less than expected and has declined in recent months due to the impact of the Russian economic crisis on Tajikistan; (iii) public awareness is a critical component of stimulating demand, however more needs to be done; (iv) existing initiatives do not target the very poor; and (v) public buildings (schools and clinics) continue to face challenges in improving their comfort levels.

Box 6.1: Clean Stove Initiative in Mongolia

The Clean Stove Initiative for Mongolia (Mongolia-CSI) sold nearly 98,000 subsidized, low-emission stoves in five districts in Ulaanbaatar between June 2011 and November 2012, reaching 55 percent of all households in the target area. The program was funded by the Millennium Challenge Corporation and the Mongolian Clean Air Fund, and followed a number of smaller pilot programs that were financed by the Asian Development Bank, Gesellschaft for Internationale Zusammernarbeit, Millennium Challenge Corporation, the World Bank and World Vision.

In order to identify models of stoves to subsidize, the Mongolian University of Science and Technology tested the emissions performance of 14 models of energy efficient solid fuel-based stoves, and four were selected for the program. Two of the models were manufactured in Turkey, and two were from China. Stoves were sold in “Product Centers” in each administrative subdivision, and each household was eligible to purchase one subsidized stove. Many of the product centers were operated by XacBank, a commercial bank that supplied sales and support staff and offered micro-loans to households who could not afford even the subsidized prices. Depending on the model of stove, subsidies ranged from US$195 to US$319 per stove. After subsidies, the stove price to the consumer was 60 to 75 percent below the market prices for the same stove. To receive the subsidy, households were required to turn in their old stove. This ensured that polluting stoves were no longer in use. New stoves were delivered to the household. Customers completed a training program learn proper use of the stove.

Mongolia’s program contains several key lessons and best practices that should be applied to stove and heat pump subsidy programs in the Tajikistan. These are as follows:

- Subsidy programs should allow consumers to choose among several models, and subsidy payments should only be made after installation is confirmed.
- Final prices after subsidy should not be so low as to allow purchases by consumers who will not use and maintain the equipment properly.
- Equipment should be distributed through local product centers to ensure quality of the product and eligibility for the subsidies.
- Confirming installation of the equipment and training consumers ensures that equipment is used properly, and prevents re-selling of subsidized products.
- Removing old equipment from use ensures large and sustainable improvements in efficiency.
- Programs should be implemented in partnership with the private sector in order to provide good customer service and respond to market demands.

Source: World Bank Group, “Stocktaking Report of the Mongolia Clean Stoves Initiative,” 2013.

Box 6.2: Efficient Gas Stove Subsidies in Armenia

As its gas distribution network gradually expanded, Armenia launched a program to distribute efficient gas stoves to poor urban households with limited access to heating. The Global Partnership on Output-Based Aid, the World Bank's Urban Heating Project and the Government of Armenia funded the program.

Families were eligible for participating in the subsidy program if they were enrolled in the Poverty Family Benefit Program, a social protection program for Armenia's low-income households. In addition, families had to live in an urban multi-apartment building that was connected to a functioning gas network. Finally, the family had to contribute US$25-50.

Armenia's Renewable Resources and Energy Efficiency Fund (R2E2) administered the program. The R2E2 Fund publicized the program and encouraged poor urban families to apply. After determining eligibility, the R2E2 Fund collected the family cash contribution and worked with the gas company to organize installation and connection of new stoves. The R2E2 Fund then independently verified the installation of the stoves and delivery of gas service. It refunded the payments made by the gas company to the contractors who installed the stoves.

Armenia's experience in subsidizing gas stove installations provides several key lessons that are worth noting if a coal stove program is implemented in Tajikistan:

- Early preparation for implementation is crucial to adjust reporting and monitoring mechanisms to the program's requirements.
- Households should be made to apply for the program and provide cash payment, as these activities foster a sense of ownership and commitment to the program.
- Procurement needs adequate planning, including the ability to allow contract extensions with the providers who win the bidding for the project.

Source: "Output-Based Aid in Armenia: Connecting Poor Urban Households to Gas Service," *OBA approaches* Note Number 23, 2009.

6.1.4 Next steps

The next steps for developing and implementing a program promoting efficient individual stoves, boilers and heat pumps are described below.

Conduct a detailed market assessment. The scope of the market assessment should include a review of: (i) the current use of inefficient coal- and biomass-fired stoves/boilers and electric heaters, including the types of devices, average lifetime in use, market prices, equipment suppliers and available products; (ii) the efficiency, environmental and safeguard performance of internationally available efficient models; (iii) the supply chain and local market for more efficient technologies; (iv) the energy savings potential and pollution reduction benefits that are possible from the deployment of more efficient models; and (v) for heat pumps, the evaluation of grid stability and frequency fluctuations and their potential for damaging heat pump equipment and measures to mitigate this risk.[25]

[25] For instance, one potential mitigation option could be the installation of adequate protection devices such as surge protectors, power conditioners or Uninterruptible Power Supply (UPS)

Develop and design targeted implementation and financing schemes, including the mobilization of grant resources. As indicated above, international experience from countries with similar program could offer useful lessons learned and design options for implementation and financing schemes.

Implement pilot projects. A pilot project is recommended to: (i) demonstrate the benefits of more efficient individual heating models in terms of energy (cost) savings, indoor air pollution, and comfort levels; (ii) test the adequacy of the selected implementation and financing schemes; and (iii) investigate the willingness of consumers to switch to new stoves and boilers under the chosen implementation and financing schemes.

Conduct early public outreach campaigns. International experience confirms that extensive awareness and promotion campaigns are important to educate the public about benefits related to more efficient individual heating options and inform people about the dedicated financing and implementation mechanisms.

6.2 Recommendation 2: Implementation of a Targeted Rehabilitation and Construction Program for Small HOBs

Around 90 percent of the multi-apartment buildings and 73 percent of the public buildings rely on individual systems for heating. Many of these buildings were previously served by either DH systems or small HOBs that are no longer in operation. The large majority of the few small HOBs still in operation are in poor condition with low efficiency and high pollution levels due to the absence of modern flue gas cleaning systems.

6.2.1 Recommended measures

In selected residential and public buildings with large heating loads and without access to DH, it is recommended to: (i) replace dilapidated or non-operational small HOBs[26] with efficient small HOBs that are equipped with modern flue gas cleaning systems; and (ii) substitute electricity- or solid fuel-based individual heating sources in selected buildings with efficient small HOBs (with flue gas cleaning systems).

The recent World Bank report on Tajikistan's Winter Energy Crisis showed that switching from electricity to coal-based heating options is needed to help reduce the winter energy deficit and meet future demand. Compared to current small HOBs in use, modern HOBs can save between 20 and 50 percent of the coal consumption and help reduce pollution due to modern flue gas cleaning systems. Compared to individual coal-based stoves or boilers, the efficiency and pollution reduction gains are likely to be even higher. Substituting electricity-based heating with small HOBs would also help to reduce power shortages, while meeting heating demand in a cost-efficient way.

[26] There are 15 small HOBs owned by Dushanbe Teploset, three small HOBs owned by KMK Khujand, and a number of small HOBs owned by individual public and residential building owners.

6.2.2 Scope of implementation

For residential and public buildings without access to DH in the medium-term, the construction and rehabilitation of small HOBs should be considered for the following priority building types:

- As a first priority: (i) public buildings relying on unreliable and inefficient individual heating solutions or old HOBs with large heating loads, such as hospitals; and (ii) new public and multi-apartment buildings under construction.
- As a second priority: (i) construction of small HOBs for multi-apartment buildings with large heating loads and an existing internal heating network (including those in need of substantial rehabilitation), which are currently relying on individual heating systems; and (ii) new multi-apartment buildings which will be built in the future .
- As a third priority, the construction of efficient small HOBs and related networks could also be considered for multi-apartment buildings with large heating loads and currently relying on electricity-based heating and without an internal heating network. Construction of small HOBs in these residential buildings should be demand-driven, with the apartment owners opting to switch to a central heating system.

To ensure the sustainability of investments, it is also recommended that the internal building heating systems are rehabilitated, as necessary. Whenever the internal heating network is rehabilitated or newly constructed, the investments should also include building level metering, allow apartments to regulate their heat consumption, enable the introduction of consumption based-billing and disconnection of individual apartments (in case of newly built internal heating infrastructure).

6.2.3 Implementation issues

Environmental impact: In order to minimize the environmental impact of coal combustion, new small coal-fired HOBs should have an efficiency of 80 percent and modern flue gas cleaning systems. As indicated earlier, replacing old coal-fired small HOBs with more efficient and cleaner models can save 20 to 50 percent of the coal used and will therefore have a positive environmental impact. Similarly, replacing individual coal-fired stoves (e.g., in public buildings) with efficient small HOBs is expected to result in significant efficiency gains and reduce indoor air pollution. However, substituting electricity-based heating in selected buildings with coal-fired HOBs will increase pollution and would need to be carefully considered and prioritized for selected buildings only. A prioritized investment and implementation plan should be prepared and detailed feasibility and environmental and social impact assessments conducted before implementing a program targeting the replacement or construction of small HOBs. In addition, to reduce heat losses in buildings (and therefore consumption), the upgrades of the heating system should be accompanied by energy efficiency measures in the selected buildings.

Building-internal heating infrastructure: The recommended priority buildings either have an internal building heating infrastructure or are under construction. The replacement of small HOBs should be accompanied by the rehabilitation of internal heating networks to ensure reliable and efficient supply. Where possible, thermostatic valves and heat cost allocators should be installed. For greenfield installations of small HOBs for new buildings, it is advisable to opt for horizontal designs of internal heating networks to allow for individual apartment metering and disconnection (for non-payment). However, implementation experience from other countries shows that resuming centralized heat supply in buildings where the building-internal heating infrastructure has been dismantled is institutionally challenging. This challenge is particularly pronounced in multi-apartment buildings where collective decision-making is required, and given that low electricity tariffs provide no incentives to switch to alternative sources for heating. Options to help promote collective solutions include: focusing first on public buildings; developing a demand-driven program for multi-apartment buildings accompanied by adequate financing and incentive arrangements; and conducting extensive public outreach and information campaigns to inform customers about expected benefits and investment requirements.

Financing: As described in Section 2, heating companies are in poor financial condition. They lack the funding to pay for the up-front capital cost of new small HOBs. Because the companies operate at a loss, their borrowing capacity is seriously constrained. Securing concessional financing for rehabilitation may also be challenging, in particular for coal-fired HOBs. However, greenfield installations in newly constructed multi-apartment buildings, or replacement of boilers owned by public institutions may offer new business opportunities for engaging private sector participation (for example, private heat suppliers or private maintenance companies), in particular if the tariffs for small HOBs are deregulated.

6.2.4 Next steps

The next steps for the implementation of small HOBs are as follows:

- **Select target buildings** for constructing or replacing small HOBs. Depending on the availability of funds and the planned coverage area of the CHP 2, the selection of priority buildings could focus first on public buildings with large heat demand, followed by large residential buildings with existing building-internal heating systems (if the majority of residents are willing to switch collectively to centralized heat supply).
- **Conduct a feasibility study** to confirm the costs and scope of the recommended investment, and to assess the technical condition of selected buildings and/or boilers; heat demand; availability of internal building heating systems and the need for rehabilitation; the suitability of these systems for supply with small HOB (required space for small HOBs, flue gas cleaning and coal storage, options for the transport of coal, etc.); and potential environmental impacts. In case of the installation of a small HOB in public buildings, ownership issues must also be clarified. Currently, some of the small HOBs are owned and operated by the utility while others belong to the building owner.
- **Develop targeted financing and implementation schemes and public outreach campaigns.** Given the challenge noted above of incentivizing building owners to switch to collective heating solutions, and taking into account the low affordability level, targeted financing and subsidy schemes accompanied by extensive public outreach campaigns are needed to construct or rehabilitate small HOBs and the related building-internal heating infrastructure. Potential options include: partial

subsidies, recovery through temporarily adjusted heating bills, micro-credits for building-internal rehabilitation, etc.

- **Combine with energy efficiency measures.** Experience from other countries demonstrates the importance of reducing building structure-related heat losses when improving the heating system in order to help achieve better results in terms of efficiency and financial viability.

6.3 Recommendation 3: Improving the Reliability and Efficiency of the DH network in Dushanbe

Measures targeting reliability and efficiency improvements of the DH network in Dushanbe have been identified among the most viable investment opportunities given that the construction of the new CHP is already funded and ongoing. Furthermore, early investments in rehabilitating the DH network are needed to ensure that the network can absorb the additional heat supplied, avoid excessive losses and provide heat to parts of the city that are no longer served by it.

6.3.1 Recommended measures

It is recommended to implement a priority package of investment measures that improve the reliability and efficiency of the DH network supplied by the new CHP in Dushanbe. These include:

- **Install building-level substations.** Modern substations with heat exchangers will allow supply to be matched with demand through better temperature control at the building level, and should be installed in all multi-apartment and public buildings. Transitioning to a 'closed' DH system (via heat exchangers at substations) will further enable an increase of the heat delivery to end-consumers, improved water quality, safer operation and less corrosion of network pipelines.

- **Implement metering, temperature regulation and consumption-based billing.** These measures will allow heat service companies to bill customers based on the amount of energy consumed, rather than simply on the area heated. The transition to consumption-based billing also enables households to control their heat consumption and bills and provide them with an incentive for more economic use of thermal energy. Given the limited resources, it is recommended to focus in a first step on the installation of building-level heat meters and apartment-level hot water meters. The second phase could then involve the installation of temperature regulation and heat cost allocators at apartment level.

- **Replace priority transmission and distribution pipelines and re-insulate overground distribution pipelines.** Replacing worn-out pipelines with pre-insulated and accurately dimensioned pipes and re-insulating overground pipelines would improve supply reliability and service quality, decrease heat losses and reduce service interruptions.

- **Install variable speed drives in DH substation pumps**. Variable speed drives allow the system to adjust the output of DH substation pumps to match the required fluid throughput, rather than running at a single, high throughput level all of the time. Estimates indicate that this would reduce electricity consumption in pumping stations by more than one third.

While in principle the measures listed above could be implemented separately, it is recommended that building-level substations (M6) be implemented together with metering (M2), temperature regulation (M3) and consumption-based billing (M4). Implementing these measures together with the re-insulation of above ground distribution lines (M9); the installation of variable speed drives in DH substation pumps (M10); and the rehabilitation of internal building heating systems (M11) would help to ensure maximum efficiency gains and technical sustainability of investments at the network level.

6.3.2 Scope of implementation

The reliability and efficiency investment package should only be implemented in public and multi-apartment buildings that are supplied by a reliable generation facility. Accordingly, it is recommended to consider first the implementation of these measures only for the network and buildings supplied by the CHP 2. As feasibility studies for the modernization of other DH generation assets (e.g., East and West boiler houses) are conducted, and once financing is mobilized (depending on the outcome of the feasibility study), implementation of the efficiency and reliability investment package could also be considered for the network and buildings served by these generation facilities.

6.3.3 Implementation issues

Tariff reform: Heat tariffs in Tajikistan are well below cost-recovery levels and gradually would need to be adjusted towards cost-recovery levels to improve the financial and operational performance of the heating sector and ensure the sustainability of any investments in the DH system. Without tariff increases, companies will not be able to make investments to improve the reliability of heat supply. To track improvements in reliability and service quality as tariffs increase, it is recommended to develop and adopt a transparent performance monitoring and reporting framework, including key performance indicators, for heating companies. It is important to note, however, that heating tariff increases should be implemented in parallel with increases to electricity tariffs. Increasing heating tariffs alone may accelerate fuel switching from DH to electricity, putting further strain on the power grid during peak winter months.

To ensure that a basic level of consumption remains affordable to the poor, tariff reforms need to be accompanied by improved targeting and coverage of the social protection program. Additional measures the Government may want to consider to help mitigate the impact of tariff increases include, for instance, an energy efficiency program for buildings (see Section 6.4) that can help to reduce energy consumption and expenditures; the gradual transition to consumption-based billing would also help to ensure that consumers can control their consumption and match it with what they can afford. Consumption-based billing will also increase pressure on heating companies to show value-for-money by improving service quality and reducing network losses. Experience from other countries in the ECA region indicates that heat metering and consumption-based billing can generate substantial energy savings (around 25 to 30 percent of the heat consumed), and reduce energy costs for consumers compared to norm-based billing practices. However, implementation of consumption-based billing is politically and institutionally challenging. It will require careful planning and phasing and should be accompanied with extensive public outreach campaigns.

Efficiency improvements at the apartment level: The installation of thermostatic valves and heat cost allocators in individual apartments can be challenging (e.g., access to apartments, financing arrangements, etc.) despite the benefits for consumers. This will require careful planning, extensive information and public outreach campaigns to inform customers about the benefits of these improvements, and adequate financing/implementation arrangements (e.g., direct-to-consumer subsidy and distribution programs, through the heating utilities). Therefore, as a first step, it is recommended to prioritize the installation of building-level heat and apartment-level hot water meters before moving to the institutionally more complex implementation of thermostatic valves and heat cost allocators in individual apartments.

Ensuring technical sustainability of investments: The technical sustainability of efficiency measures targeting the distribution network should be evaluated for the total network (over- and underground transmission and distribution network) in order to identify and address urgent rehabilitation needs. This also includes internal heating network within buildings. Issues and challenges related to the poor condition of the building-internal heating infrastructure are highlighted as part of Section 6.2, and are equally applicable for DH systems.

Financing: The current financial condition of the DH companies, coupled with the low end-user tariffs means that the DH companies will struggle to attract commercial financing for the investments recommended above. The DH companies and the Government may want to consider mobilizing different sources of concessional financing. As highlighted above, the rehabilitation of the building- and apartment-level heating infrastructure (usually not owned by the DH company) is expected to require special financing and implementation schemes, as well as some regulatory changes.

Box **6.3** describes how similar actions were implemented in Poland.

Box 6.3: World Bank Program Supporting DH Reforms in Poland

During the mid-1990s, Poland experienced many of the problems facing Tajikistan today. In the early 1990s, the Government of Poland transferred ownership and responsibility for DH companies to the municipalities. The decentralization of ownership and a phasing out of investment subsidies meant DH companies lacked funds to effectively operate, maintain, and rehabilitate their infrastructure. This, in turn, led to high heat and hot water losses, which further deteriorated the financial sustainability of DH companies.

The World Bank supported the Government in tackling some of the key issues in the DH sector. From 1991 to 2000, the World Bank provided US$340 million for the Heat Supply Restructuring and Conservation Project in Poland. The project included support for: (i) energy restructuring, commercialization of restructured enterprises, introduction of a transparent regulatory framework, and pricing policy reform; (ii) rehabilitation and modernization to extend DH infrastructure asset life; and (iii) energy conservation and pollution reduction through investments in energy efficiency improvements.

The Government's support for energy efficiency and conservation investments and pricing policies led to gradual increases in residential tariffs. The Government also reduced budget layouts for energy subsidies. These two efforts were key to the project's success. Energy efficiency measures carried out by DH companies achieved a 50 percent reduction in heat transmission and distribution losses, which led to 22 percent energy savings, equivalent to roughly US$55 million per year.

Building-level heat metering was a crucial component of these energy efficiency improvements. Metering in the buildings covered by the five DH companies targeted in the project increased from 21 percent at the start of the project to 100 percent by project completion. Further evaluation of the project underlined the significance of metering: without accurate measurement of the heat supply, DH companies often vastly underestimated the level of heat transmission losses in the network. Heat transmission losses can reach 20 percent of heat purchased and represent up to 17 percent of variable operating costs. As a result, the companies failed to properly prioritize heat loss mitigation and lost major opportunities for cost savings. Evaluation of the project concluded that: "Future Bank projects with DH companies should assign top priority to metering of total purchases and sales of heat as early as possible during project implementation."

Source: World Bank. Implementation Completion Report: Heat Supply Restructuring and Conservation Project in Poland. 5 June 2000.

6.3.4 Next steps

Prepare a detailed investment and implementation plan for the DH reliability and efficiency improvement measures. This should include: a detailed list of investment measures and implementation steps; cost of each investment measure based on local market prices (including imports); estimated energy (cost) savings or other benefits associated with each measure; and sequencing of implementation steps with related timetables. The investment plan should prioritize/rank the investment measures based on heat supply reliability and efficiency criteria and the results of an economic-financial analysis. As part of the detailed assessment, the following aspects are recommended to be included:

- Assess which buildings should be prioritized for the installation of modern substations; consider switching from open to closed system through the use of heat exchangers; include an analysis of associated substation reconstruction needs, and detailed cost estimates; conduct an economic-financial analysis of different options to help prioritize investments.

- Assess costs and benefits for building-level and apartment-level heat metering (including the installation of thermostatic valves, bypasses, balancing valves and heat cost allocators); conduct an economic-financial analysis for each option; prepare implementation plan with detailed sequencing.
- Assess the needs and related cost estimates for the rehabilitation of building-internal heating systems to ensure the technical sustainability and optimal efficiency gains associated with the other building- and apartment-level heating upgrades; include a company-level evaluation of relevant Management Information Systems (MIS) to facilitate the transition to consumption-based billing, and strengthen the consumer focus (e.g., through Customer Management Systems).
- Identify required replacements and re-insulation of the transmission and distribution network in order to ensure reliable operations of the DH system; include detailed cost estimates, an economic-financial analysis and safeguard issues (e.g., asbestos).
- Analyze the installation of variable speed pumps/drives at pumping stations and DH network pumps; include detailed cost estimates and an economic-financial analysis.
- Prepare a detailed implementation plan outlining the sequencing of works for each measure; prepare technical specifications; design possible implementation and financing mechanisms, in particular for the installation of building- and apartment-level devices; and conduct extensive public information campaigns for customers.
- Develop a time-bound transition path towards consumption-based billing, taking into account implementation of required investments at building- and apartment-level; adopt a tariff structure to enable consumption-based billing; introduce changes in the billing/collection practices of the DH companies; introduce required legal, regulatory and institutional changes for tariff and social protection reforms.

6.4 Recommendation 4: Implementation of an Energy Efficiency Program in Buildings

Improving the efficient use of energy in buildings is one of the most cost-effective and environmentally friendly ways to help meet heat demand in Tajikistan. It is estimated that energy efficiency improvements could reduce energy consumption by 30 to 40 percent, and generate savings of up to nearly 270,000 MWh per year in Dushanbe and Khujand. Given the poor energy performance of the majority of buildings in Tajikistan, this would also have a number of other co-benefits, including improved comfort levels in buildings, reduced air pollution and reduced energy expenditures for households and public institutions.

6.4.1 Recommended investment measures

Energy efficiency retrofits in public and multi-apartment residential buildings are recommended in both Dushanbe and Khujand (M1). Depending on the conditions of the buildings, recommended retrofitting measures include the insulation of walls, basements and/or attics; repair/replacement of external doors and windows; window optimization (partial replacement of existing windows with walls while complying with day-light requirements); and improved operations and maintenance practices.

6.4.2 Scope of implementation

The LCHS indicates that energy efficiency, in conjunction with individual stoves and DH supplied by the CHP, is the most viable option to meet demand in public and residential buildings.

As a priority, energy efficiency measures in Dushanbe and Khujand should be implemented in all public and residential buildings where the heating systems will be upgraded. Experience in other ECA countries demonstrates that linking improvements of heating systems with building energy efficiency measures generates significant operational and financial synergies.

It is also recommended that the Government consider developing a broader energy efficiency program for public and/or residential buildings nationwide. To streamline limited resources, the Government should consider focusing initially on an energy efficiency program for public buildings. This would help to demonstrate the benefits of energy efficiency, benefit a large share of the population, and improve provision of key public services by increasing comfort levels in schools, hospitals, kindergartens and other social facilities during winter. Starting with the public sector can also help to catalyze the energy efficiency market before moving to the institutionally more complex residential sector. Multi-apartment buildings in Tajikistan often lack well-functioning collective decision-making structures, sufficient financial incentives for private investments and access to affordable financing.

6.4.3 Implementation issues

Energy efficiency building programs supported by the World Bank and other development partners in ECA have demonstrated that substantial energy savings (between 20 and 50 percent) and co-benefits (e.g., increased comfort levels) can be achieved. However, effective implementation requires a strong enabling environment and targeted financing and implementation mechanisms. Decisive government actions and long-term commitment is required to enact and enforce legislation, adopt policy and regulatory enhancements, improve market conditions, build local capacity and provide access to affordable financing. Some of the priority actions and implementation issues are highlighted below.

Tariff reform: The transition to cost-reflective energy prices for both heat and electricity is key to improving the financial viability of the energy efficiency investments (see Section 6.3.3). In addition, the introduction of consumption-based billing practices for customers connected to the DH system is a pre-requisite for the generation of energy cost savings for households and public institutions investing in energy efficiency.

Developing targeted financing and implementation mechanisms: The Government should consider developing and designing effective financing mechanisms to support implementation of an energy efficiency program targeted either for public or residential buildings.

Financing mechanisms for public buildings: International experience indicates that there are a number of different financing options ranging from public financing (e.g., grant-financed pilot programs) to commercial financing (e.g., credit lines, partial credit guarantees, energy service company (ESCO) financing, etc.). Based on the local market capacity and the maturity of the financial and credit markets in Tajikistan, the following two mechanisms may be the most suitable short-term financing options to support energy efficiency investments in public buildings:

- **Budget financing with piloting of more sustainable models:** To build capacity, demonstrate energy efficiency benefits, reduce public energy cost spending and improve comfort levels in schools, hospitals, kindergartens and other public facilities, the Government should consider the implementation of a budget/grant-financed energy efficiency program for public buildings. Under such a program, the Government provides funding (e.g., as part of a project financed by international financial institutions and/or other development partners) to public facilities/municipalities to cover the up-front costs of energy efficiency investments. Gradually, the program could include more sustainable financing features, such as 'budget capture models'. In this case, future energy budgetary provisions for the benefit of public institutions are reduced until the loan has been (partially or fully) repaid. The Government can then use some of the cash saved through the budget capture system to finance additional projects. Another option would be the phasing-in of co-financing arrangements with the beneficiaries. Budget/grant-financed energy efficiency programs are typically implemented through a project implementation unit (PIU), which provides support for selecting buildings, conducts technical preparatory activities and related procurements (e.g., energy audits, designs) and supervises and implements the energy efficiency measures and monitoring of results.
- **Revolving Fund for energy efficiency:** Some developing countries (e.g., Armenia, Bulgaria, India, Romania, Kazakhstan, Macedonia, Bosnia and Herzegovina) have or are planning to create revolving funds to finance energy efficiency measures in public buildings. In this case, a Fund (typically an independent entity established by the government) provides the up-front investments and technical assistance for preparing and implementing energy efficiency measures. The benefitting public institution repays the investment costs based on the estimated or verified energy cost savings achieved. This allows the funds to revolve (by re-investing the repaid funds) while the benefitting public institution can maintain a positive cash flow. Such a Fund may offer different financial products and technical assistance services to cover the needs and capacity of different public institutions (e.g., loans, grants, guarantees for commercial bank loans, technical assistance for energy auditing, procurement, supervision, etc.). Key issues in Tajikistan that could hamper implementation of a revolving fund scheme include: (i) the low energy tariffs (which keep savings from reduced energy consumption low); (ii) unmet demand in public buildings (which means that when building energy efficiency is improved, energy consumption does not drop); and (iii) the limited technical and financial market

capacity. Box 6.4 provides an example of experience with a revolving energy efficiency fund in Armenia.

Box 6.4: Energy Efficiency Revolving Fund in Armenia

The R2E2 Fund was established in 2005 initially as a PIU for a World Bank-supported energy efficiency/renewable energy 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. A government-appointed executive director, supported by technical and financial staff, manages day-to-day activities. The Fund is currently implementing a World Bank/GEF-supported energy efficiency program in public sector facilities (e.g., schools, hospitals, and administration buildings, street lighting) using a revolving fund scheme. The Fund offers two financing products to eligible public entities:

Energy Service Agreements (ESA) are used for schools and other public entities that are not legally or budget independent. Under the ESA, a public entity pays the Fund its baseline energy costs (with adjustments for energy prices, usage, and other factors) over the 7-to-10-year contract period. The Fund designs the project, hires subcontractors, oversees construction and commissioning and monitors the subproject. In this case, the client entity incurs no debt. Rather, the Fund directly pays the energy bills to the utility on the client's behalf. The Fund retains the balance to cover its investment cost and service fee. The ESA is designed so that the duration can be adjusted if the Fund recovers its full investment earlier (or later).

For municipalities and public entities with revenue streams independent of the state budget, loans are provided. These loans count as municipal debt, with fixed repayment obligations to be made within their budget provisions in future years. The repayment amounts are designed to allow clients to repay the investment costs and service fees from the estimated energy cost savings. The client can pay additional fees for the Fund to implement the project on its behalf.

R2E2 uses simplified performance contracts to shift some performance risks to private construction firms/contractors. Under these contracts, firms are selected based on the net present value of the projects they propose. A portion of their final payment (around 30 percent) is based on a commissioning test.

The R2E2 Fund is expected to finance an estimated 85 projects worth about US$6 million between 2012 and 2015 and to demonstrate a sustainable financing and implementation model for the public sector. As of January 2014, the Fund signed 20 loans and ESAs valued at US$3.05 million since 2011.

Source: World Bank, Project Appraisal Document for an Energy Efficiency Project in Armenia, March 2012.

Financing mechanisms for residential buildings: International experience indicates that there are four major financing options for a residential energy efficiency program: energy efficiency funds, commercial bank financing, partial credit guarantees and utility energy efficiency programs. Energy efficiency funds (similar to the public sector), commercial bank financing (e.g., micro-credit loans to residential consumers), and utility energy efficiency programs, combined with grant-based incentive schemes, are the most suitable financing options for kick-starting energy efficiency in residential buildings in Tajikistan. Regarding energy efficiency programs implemented through a utility demand-side management program, international experience shows that utilities can be well placed to deliver energy efficiency programs because of their established relationships with customers and knowledge of local energy use patterns. They also have billing systems in place that can be used to recover costs from customers. Because electricity and heating companies in Tajikistan currently lose money on each unit of heat supplied and have insufficient supply capacity, they also have incentives to implement programs that will reduce demand.

Strengthening HOAs: Split incentives in multi-apartment buildings and weak HOAs are key challenges to both energy efficiency investments and upgrades of collective heating solutions (i.e., small HOBs or DH). Without decision-making structures for investments and mechanisms for financing more capital-intensive upgrades, it will be very difficult in multi-apartment buildings to reach consensus on upgrading/switching to collective heating solutions or implementing building-level energy efficiency measures. Experience in the ECA region has shown that governments can support the development of HOAs by drafting better legislation for decision-making in multi-apartment buildings; by setting and enforcing standards for apartment-building maintenance; and by providing training and public outreach on collective decision-making, building management and maintenance.

However, experience in the region has also shown that many efforts to strengthen HOAs meet obstacles that prove difficult to overcome. Such obstacles include: [27]

- **The mix of residents from different economic levels living in the same building.** This accentuates the challenge of collective decision-making as poorer residents may refuse or not be able to make contributions toward the cost of implementing energy efficiency measures.
- **The technical capacity of HOAs.** It is difficult for apartment owners to establish and operate HOAs on their own, especially for low-income households, whose buildings are typically in the most need of repair. HOAs typically hire professional managers, but it is important for apartment owners to understand their rights and responsibilities as members of the HOA.
- **The poor condition of the buildings.** Residents may fear that they will not have enough money to address the magnitude of the problems.
- **The absence of incentives.** Low tariffs have kept services affordable, but have also led to poor service quality and reliability. Meanwhile, the use of norm-based billing practices and the related lack of metering and controls gives residents no reason to cut their consumption.
- **Limited access to financing.** HOAs have difficulty borrowing because banks do not view them as creditworthy and are typically unwilling to lend on a project finance basis.

[27] International Housing Coalition, Homeowners Associations in the Former Soviet Union: Stalled on the Road to Reform, prepared by Lipman, Barbara J., 2012.

Given the difficulty of working through HOAs, Tajikistan may want to consider other approaches. Lithuania offers an example of an alternative approach in which a municipality initiated and managed energy efficiency improvements in buildings. The program retrofitted more than 2,400 residential buildings between 1996 and 2013—saving about 82.3 GWh per year—despite the fact that homeowners and HOAs lacked borrowing and technical capacity. Box 6.5 provides insight from experience improving HOAs in Lithuania.

Box 6.5: Approach to Address the Lack of Borrowing Capacity by Homeowners and HOAs in Lithuania

The residential energy efficiency program in Lithuania, initiated in 1996, provided loans and subsidies, combined with technical assistance, to support energy efficiency investments in residential buildings. To address the limited technical and borrowing capacity, the lack of awareness and split incentives of homeowners and HOAs, the program[1] allowed building renovations to be initiated by the municipality. The municipality appointed a project administrator for multi-apartment buildings with weak or inexistent HOAs. The appointed building administration company (mostly municipally owned) took loans on behalf of the homeowners to finance the energy efficiency investment costs. The company recovered the investment costs through a monthly building-management fee paid by homeowners based on the estimated energy cost savings achieved. Homeowners were not obliged to borrow. The municipal project administrator assumed the loan repayment risk. While the consent of homeowners was required to implement the energy efficient retrofits in their buildings, the program also provided additional incentives to facilitate consent from low-income households. After completion of the renovations, all low-income households received a subsidy covering 100 percent of the preparation and renovation costs. The state reduced the heating subsidy by 50 to 100 percent over three years for low-income households that opposed the implementation of energy savings measures.

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

Ensuring enforcement of building codes for new buildings: The legislative framework for efficient energy performance standards is relatively well advanced in Tajikistan. However, in reality, few of the newly constructed buildings comply with these buildings codes. In order to establish an enforcement system, the following components are typically needed: dedicated unit/department with sufficient budget and staffing to administer and implement building codes; clear compliance process with administrative procedures, compliance forms, checklists and procedures, user manuals or guidebooks, compliance tools, etc.; awareness raising, training and capacity building among officials, designers, architects, engineers, manufacturers and other key stakeholders; and evaluation and monitoring arrangements[28].

6.4.4 Next steps

The next steps required for implementation of an energy efficiency program are as follows:

[28] ESMAP, Improving Energy Efficiency in Buildings, 2014.

- **Set up priority/target buildings for an energy efficiency investment program.** For reasons indicated above, the Government may want to consider starting initially with an energy efficiency program focusing on the public sector before moving to the more complex residential sector.
- **Conduct a comprehensive market assessment for the targeted sector**. This will help to: (i) analyze the technical, economic and financial energy efficiency potential for various building types; (ii) evaluate the energy efficiency supply market (e.g., energy auditors, equipment suppliers, design and construction companies, etc.) to provide an overview of the market capacity and quality of services/products; (iii) assess key policy, regulatory, financial and institutional barriers to realize the energy efficiency potential and identify specific ways that these barriers can be addressed; and (iv) inform the selection and design of an adequate implementation and financing scheme.
- **Select and develop targeted implementation and financing mechanisms for the energy efficiency program**. To incentivize energy efficiency investments, careful design of effective implementation and financing schemes is needed. In addition, broad stakeholder consultations are recommended to ensure that the selected mechanisms and design features reflect the needs of the target market segment and other stakeholders. In parallel, the Government may want to explore different financial resources, including grant funding for technical assistance and investment incentives. During preparation and throughout implementation of an energy efficiency program, extensive public outreach, awareness raising and capacity building activities will be critical for the success of the program.

6.5 Recommendation 5: Feasibility Studies for the Rehabilitation and Modernization of Large HOBs in Dushanbe

The DH system supplied by Boiler House East currently serves approximately two percent of the multi-apartment buildings and two percent of the public buildings in Dushanbe. Poor gas supply and the deterioration of assets have led to decreased use of the DH system supplied by large HOBs (boiler houses East and West) in the past decade.

The LCHS assessment showed that DH in Dushanbe supplied by large HOBs is economically more viable than current electricity-based heating options. Increasing the output and supply reliability of the two large HOBs could help to address power shortages in winter by reducing reliance on electric-based heating options. However, the LCHS assessment also indicated that small HOBs may be an economically more viable solution compared to the rehabilitation of large HOBs. Accordingly, an in-depth study to determine the viability of rehabilitating or replacing the large HOBs is recommended.

6.5.1 Implementation issues

The implementation issues specific to the rehabilitation of large HOBs should be identified and studied in greater depth in the recommended feasibility study. The rehabilitation of the large HOBs will likely face similar implementation issues as the improvements to the rest of the DH system in Dushanbe, and the rehabilitation of small HOBs. These implementation issues are described above in Section 6.3.3.

6.5.2 Next steps

In order to determine the exact scope and investment requirements for this task, a detailed feasibility study should be conducted with the goal of accomplishing the following:

- **Determine whether HOBs require rehabilitation or complete replacement**. As part of the assessments, also investigate whether their replacement by small HOBs may be a more viable option.
- **Conduct a detailed cost assessment and comparison** of the technical and economic feasibility of heat supply with large HOBs and other heat supply options. Include a detailed analysis of the cost of rehabilitating building-internal heating systems for the buildings that would be supplied by the large HOBs.
- **Evaluate the environmental and health-related impacts of rehabilitating and modernizing the large HOBs.** Compare with alternative heating options for consumers currently connected to the large HOBs.
- **Develop a prioritized investment and implementation plan.** This will ensure optimal benefits in terms of cost-efficiency and supply reliability.
- **Forecast the likely reliability of fuel supply for large HOBs in the years to come.**

6.6 Action Plan for Dushanbe and Khujand

As the recommendation sections highlighted, a comprehensive package of policy reforms and investment measures is needed to improve the operational and financial performance of the heating sector, and adequately meet residential and public heat demand. Table 6.1 recommends a roadmap with a timeframe in which actions should be implemented, and demonstrates which challenge these actions will help address.

Table 6.1: Investment Action Plan for Dushanbe and Khujand

Recommendation	Short-term (next 24 month)	Medium-term (next 2-5 years)
Enhance the performance of the heating infrastructure through:		
Replacement of inefficient individual heating sources	▪ Conduct a detailed (qualitative and quantitative) market assessment on the replacement of inefficient individual heating sources (coal- or biomass-fired stoves and electric heat radiators) by efficient stoves/ boilers or electric heat pumps ▪ Determine the eligibility criteria for households, products and supplier to be included in the program based on the results of the market assessment and the objectives of the program ▪ Design the financing, subsidy and implementation schemes of the program (e.g., credit-lines or demand-side management program; level and beneficiary of subsidies; distribution channels through local product centers, utilities or housing management companies; etc.) ▪ Mobilize funding for implementation of an efficient heating program (including pilot phase and implementation of full-scale program) ▪ Pilot the designed program for more efficient small heating technologies, including measurement of results and adjustment of the design of the program ▪ Conduct public outreach campaigns to raise awareness about the benefits of more efficient small heating technologies	▪ Deploy full-scale program for small efficient heating technologies based on the results of the pilot phase

Construction or replacement of small HOBs	▪ Define priorities for replacing existing small HOBs (e.g., among those which are no longer in operation) or inefficient individual heating solutions by efficient HOBs (e.g., construction of new small HOBs for education and health facilities with large heating loads) ▪ Conduct a detailed feasibility study for the selected target buildings/small HOBs ▪ Mobilize funding for and start construction or replacement of small HOBs based on the results of the feasibility study and the identified priorities	▪ Complete construction or replacement of small HOBs according to identified priorities
Improvement of the reliability and efficiency of the DH network	▪ Complete construction of CHP2 and connect it to the existing DH network in Dushanbe ▪ Conduct hydraulic analysis of the transmission and distribution network to configure the network and dimension of pipes and the capacity of pumping stations	▪ Develop and adopt a detailed investment and implementation plan with prioritized reliability and efficiency measures (e.g., replacement/re-insulation of transmission and distribution pipes, upgrading of pumping stations, installation of building-level substations and metering, and taking into account the supply capacity of the CHP2 plant ▪ Mobilize funding to support implementation of the investment plan ▪ Start implementing priority investment measures to improve reliability and efficiency of the DH system based on the results of the investment plan
Rehabilitation or replacement of large HOBs (boiler house East and West in Dushanbe)		▪ Conduct a detailed feasibility study to determine whether large HOBs should continue their operation, or if part or all of their service area should be served by small HOBs or the CHP2 (through the expansion of the DH network) in the future ▪ Develop and adopt a prioritized investment and implementation plan based on the feasibility study and mobilize funding for implementation

			▪ Start decommissioning or rehabilitating large HOBs based on the identified priorities
2	**Improve the energy performance of buildings**	▪ Select target segment (i.e., either public or residential) of the energy efficiency program and define its objective ▪ Conduct a detailed market assessment to define the energy efficiency potential and inform the design of the program ▪ Design the implementation and financing scheme of the program ▪ Mobilize funding and implement the energy efficiency program for the selected target segment starting with simple financing models (e.g., budget financing for public buildings) and gradually transitioning towards more sustainable schemes (e.g., revolving funds) ▪ Develop policy/program enhancements to support energy efficiency (e.g., strengthening of homeowner associations/ professional management companies, adopt and enforce standards for appliances/ construction materials, provide training for energy auditors, etc.)	▪ Implement a full-scale energy efficiency program
	Improve financial viability through:		
3	**Tariff and social protection reforms**	▪ Adopt a tariff methodology for heating and electricity based on sector revenue requirements (including a capital repair and maintenance reserve account) and define formal tariff-setting procedures (including public hearings)	▪ Implement tariff policy reforms according to the transition path and implement the restructuring plan for the social assistance programs ▪ Implement the performance reporting and monitoring framework for heating and electricity ▪

	▪ Develop and adopt a transition path to move towards cost-recovery levels for heating and electricity while ensuring protection of poor customers ▪ Adopt an effective performance reporting and monitoring framework for the heating and electricity sector, including key performance indicators and clear monitoring and verification procedures and templates ▪ Adopt a plan for transitioning to consumption-based billing for existing and new buildings (for existing buildings, in the short-term, the focus could be on building-level metering and in the medium-term on consumption-based billing at apartment level)	

6.7 Investment Cost Estimates

The investments to implement the recommended measures are sizeable and will need careful planning, prioritization and funding from both public and private sources. Table 6.2 and Table 6.3 provide a rough estimate of the investment costs for Dushanbe and Khujand, respectively, based on the recommendations and the action plan.

Table 6.2: Heating Sector Recommended Measures and Investment Costs (Dushanbe)

Recommended Measures	Investment cost estimates (US$ million)	
	Short-term	**Medium-/long-term**
DH reliability and efficiency measures		
Building-level substations	2	7
Metering, temperature regulation, consumption-based billing	1	6
Replacement and reinsulation of network pipelines	5	4
Variable speed drive pumps	1	
Program for efficient individual heating systems		
Efficient small coal stoves and boilers	2	9
Efficient heat pumps	74	297
Replacement and construction of small HOBs	19	49
Rehabilitation and modernization of large HOBs*		
Energy Efficiency Program for Buildings		
Public buildings	52	
Residential buildings		169
TOTAL	**156**	**541**

Note: * The economic and financial viability of the continued operation of large HOBs needs to be determined based on detailed feasibility studies for each case

Table 6.3: Heating Sector Recommended Measures and Investment Costs (Khujand)

Recommended Measures	Investment cost estimates (US$ million)	
	Short-term	**Medium-/long-term**
Program for efficient individual heating systems		
Efficient small coal stoves and boilers	4	16
Efficient heat pumps	13	52
Replacement and construction of small HOBs	6	19
Energy Efficiency Program for Buildings		
Public buildings	19	
Residential buildings		47
TOTAL	**42**	**134**

Appendix A: Description of Different Applications of Each Short List Measure

Many of the short list measure can be applied to multiple customer segments or building types. Appendix Table A.1 shows the specific application of each short list measure and the number letter combination that indicates that particular application.

Appendix Table A.1: Specific Application of Each Short List Measure

No.	Measure	#	Application
M1	Insulation of buildings	M1a	Average public building
		M1b	Average panel building (Type 3)
		M1c	Average brick building (Type 2)
M2	Metering at consumer side: Installation of heat and DHW meters at consumer side - building level	M2a	Average panel building (Type 3)
		M2b	Average brick building (Type 2)
M3	Installation of thermostatic valves - temperature regulation at dwelling level	M3a	Average panel building (Type 3)
		M3b	Average brick building (Type 2)
M4	Implementation of consumption based billing	M4a	Average panel building (Type 3)
		M4b	Average brick building (Type 2)
M2+3+4	Combination of metering (M2), temperature regulation (M3) and consumption based billing (M4)	M2+3+4a	Average panel building (Type 3)
		M2+3+4b	Average brick building (Type 2)
M6	Installation of automatic, individual DH substation	M6a	Average public building
		M6b	Average panel building (Type 3)
		M6c	Average brick building (Type 2)
M7	Temperature and hydraulic regulation of house service connections	M7a	Average public building
		M7b	Average panel building (Type 3)
		M7c	Average brick building (Type 2)
M8	Replacement of distribution pipelines	M8a	Over- and underground distribution pipelines
M9	Re-insulation of over-ground distribution pipelines	M9a	Over-ground DH distribution network

M10	Variable speed drive pumps	M10a	Replacement of DH water pumps by pumps with variable speed drive at pumping stations
		M10b	Installation of variable speed drives at DH network pumps
M11	Rehabilitation of internal heating system	M11a	Average panel building (Type 3)
		M11b	Average brick building (Type 2)
M12	Construction of new efficient autonomous small HOB	M12a	Small HOB (coal)
		M12b	Small HOB (coal) with rehabilitation of building-internal heating system
		M12c	Small HOB (coal) with new building-internal heating system
M13	Solar heat production for DH	M13a	Simple solar flat plate collector system
M15	Installation of heat pump systems	M15a	Average public building
		M15b	Average individual family home
		M15c	Average multi-apartment building
M16	Extension of CHP 2	M16a	Remaining part of the DH network (in operation today)
M17	Individual house stoves (coal)	M17a	Average individual family home
M18	Individual house boilers (coal)	M18a	Average individual family home

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