Project

Energy Efficiency in the residential buildings of Dushanbe

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OVERVIEW OF HEATING AND RESIDENTIAL SECTOR IN DUSHANBE

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Content

This report is prepared with accordance to the activity #1 "Overview of system, performance and major stakeholders in residential heating of Dushanbe" of the project "Energy Efficiency in Buildings in Tajikistan", under the cooperative agreement AID-176-A-10-00003. It gives and overview of situation in the heating in the multistory residential sector of Dushanbe.

Section 1 provides background overview of the heating systems in the multistory residential sector of Dushanbe on the residential sector of Dushanbe and district heating system. The more detailed information on the latter is given in Section 2. The following section views institutional and regulatory framework with respect to overall energy and urban housing system, and highlights major stakeholders in the sectors. Some peculiarities of energy consumption in the residential sector and respective energy efficiency issues are discussed in Section 4.

Views contained in this report do not necessarily reflect the position of CAREC and USAID.

1. Background on the residential sector and urban heating system in Dushanbe.

Dushanbe, the capital of Tajikistan, located in the Gissar valley and occupying 122 sq. km, is currently home to about 720 thousand people. Prior to 1922 the place was a large-size village called Dushanbe and from the mid 1920s it began to be transformed to urban statement. The adoption of the major city construction plan of 1956 gave an impetus to the city development, a process that rapidly continued till the late 1980s before the dissolution of the Soviet Union. Currently there are 3384 multi-storey apartment buildings and 35167 houses, distributed among the six districts and the suburbs of the city (REF).

Most of the apartment buildings were constructed during 1960s–1980s and involved the construction of a vast number of similar multi-storey apartment buildings according to a General Plan. The first phase of the construction plan included the construction of 5-6 storey buildings most of which were built from bricks and have typically small area and high ceilings, and were relatively better insulated compared to the vast number of monolith, panel buildings that were massively built during the 1970-80s (see Table 1 on p. 3 for comparative data). Housing built during this period had considerable low levels of thermal efficiency, yet construction of such housing continued with only minor improvements till the 1990s.

The buildings raised during a specific time were almost of the same design and were built in over short periods of time as the aim was to provide as many apartments as needed according to the plan, without due attention to the quality. This lack of consideration and awareness at the design and construction stage can led to a building, which is predisposed to high energy consumption, regardless of other contributing factors such as its location, its management or the behavior of its occupants. In fact, energy efficiency was not regarded as something important since energy was cheap an in abundant supply. The warm climate of the city also played a role in that the population remained largely unaware of the highly inefficient use of energy for heating in residential buildings. Insulation was not used, so was the use of the sunny side to face the windows to, walls were built as thin as 20 sm, and the temperature in the room could not be controlled as there was no controlling device installed on the heating batteries.

A positive element of central planning was that heating and hot water were centrally administered with 50–70 % of urban households typically connected to district heating. However, heating, along with water and electricity prices for the residential sector were heavily

subsidized by the State with payment not being related to use. This gave no economic incentive to an occupant to save energy in the first place.

Although most buildings are connected to the heating grid and the apartments have batteries installed, it is only the ones in the central part of the city that have been heated from the grid. Farther from the centre, entire districts of the city, such as the 102 district and the Zarafshon in the Eastern end of the city, have never seen the central heating delivering heat. In these buildings electrical heaters have always been used to warm the dwellings. As the city grew the central heating system largely fall behind in terms of expansion and as time passed the equipment in the system become obsolete, with more and more apartments shifting to use electric heaters. In the non-apartment houses electricity became the major type of energy to use for heating as the decade following the break-up of the Soviet Union saw the gradual collapse of the energy and fossil fuel supply.

The country has never achieved that level of natural gas, oil, coal and diesel fuel supply that it had in decades and the centralized heating system, designed to use these for its continuous operation, faced a crisis that continues to this day. So gradually people shifted to using electricity for heating the highly energy inefficient buildings where they live, continuously increasing the pressure on electricity supply system, which is currently not capable to meet the rising demand of the city for energy.

Further construction of residential buildings in the city will develop according to The General Urban Plan, which among other objectives, aims to increase living space per person from the current 7m2 to 16 m2 by 2030. This will require more than a doubling of the housing area and therefore increase in energy consumption for heating. Most of the planned new development will be 4–5 storey buildings (4.5 million m2), with 6–9 storey ones in the central area (0.8 million m2) and a small number of 2–3 storey apartments (0.4 million m2) in the suburbs.

Some of the general characteristics of residential buildings and the conditions of the existing heating system are summarized below[1].

- Over 95% of buildings in Dushanbe do not conform to the modern insulation standards;

[1] Abdurahmanov A. (2009)"Energy sufficiency and efficiency in Dushanbe". Proceedings of the conference "Environmental safety and energy efficiency in municipal buildings in Dushanbe". 15-16 December 2009.

- In the fall and winter periods the electricity supply system is severely overloaded and some estimates suggest that power consumption in winters raises up to three times;
- The city consumes 1121 Gcal/h of heat energy, including 820 Gcal. in residential and public sectors combined;
- Theoretically about 67% of the city buildings are connected to the central heating grid, yet the real number is only 52%, of which according to the most optimistic estimation only 15-25% are heated from the grid.

Table 1. General characteristics of multi-story buildings in Dushanbe.

Buildings/Series	Year built	Walls material	Wall thickness, mm	R_0 M^{20} C/BT	R_0^m M^{20} C/BT	$R_0 - R^2_m$	Insulation needed
2-3 story buildings	1930 - 40	brick	510	0.80	1.2	-0.40	yes
4 story, series ТЖ 1-401	1960-70	brick	380	0.65	1.2	-0.55	yes
4-5 stories panel, ТЖ 1-464АС	1970-80	concrete	300	0.52	1.2	-0.68	yes
9 stories panel, series 165	1980-90	concrete	300	0.52	1.2	-0.68	yes
9 stories monolith	1970-90	light concrete	300	0.63	1.2	-0.57	yes
9 stories, carcass-monolith	2005-09	concrete blocks	200	0.90	1.2	-0.30	yes
9-12 stories monolith	2007-09	double layer concrete	400	1.63	1.2	+0.43	no
		insulation	40				

Table 2. Distribution of residential dwellings according to type.

All buildings	100%	38 581
- private houses	91%	35167
- multi-storey apartments	9%	3384
of which:		
2 – 3 story	33%	1038
4 – 5 story	62%	1870
6 – 9 story	3,4%	110
12 – 16 story	2,6%	56
Total length of heating system pipes	km	553,2
Total length of gas delivery pipes	km	623,8

Table 3. Dushanbe climate.

[2] R-value refers to resistance of a material/object to transferring/loosing heat (the higher the value, the better the material's insulation properties). Here, $\mathbf{R_0}$ is an actual R-value of the building's elements whereas $\mathbf{R_0^m}$ is the required level. Estimates made by the Alumni Association of the Tajik Technical University.

Average January temperature	-10C … +2 C
Average July temperature	+28 C
Minimum January temperature	- 27 C
Maximum June temperature	+44 C
Annual average temperature	+14,6 C
Heating season	110 days
Climate	Warm summers and mild winters

Data source: Yakubov N. (2009) "*Architectural and building principles for improved in residential buildings in Dushanbe*". Proceedings of the conference "Environmental efficiency in municipal buildings in Dushanbe". 15-16 December 2009.

energy efficiency
safety and energy

2. Existing heating infrastructure in Dushanbe

The existing district heat supply infrastructure in the city is comprised by several thermal station and boilers located in different parts of the city. With respect to size and coverage area, existing district heat generation facilities can be represented as the following groups:

- Large thermal station and boilers, operating on liquid fuel and gas:
  - Dushanbe Thermal Station – installed capacity 380 Gcal/h;
  - West boiler house: - installed capacity 660 Gcal/h, with two boilers (180 Gcal/h each) out of order;
  - Eastern boiler house - installed capacity 70 Gcal/h, average load capacity is 30-40%
- 6 coal based boiler houses built in 2008 with total installed capacity of 28,54 Gcal/h.
- Small boiler houses operating on liquid fuel and gas with total installed capacity 21,5 Gcal/h.
- A newly built boiler house operating on composite fuel with installed capacity 70 Gcal/h

The heat transmission system consists of:

- 125km of main heat supply grid;
- 414km of smaller heat distribution networks.

Literature review[3] suggests that overall efficiency of large heat supply facilities is ranging between 50-70%. Due to lack of investment and proper maintenance, existing heat generation facilities are hugely depreciated which results in their low efficiencies and low level of heat output (temperature of heat carrier should be 120-70 C while in reality actual temperature of water at the bar-point does not exceed 80 degrees)[4]. Due to high costs of natural gas and liquid fuels, large heat station and boiler houses` load work does not prevail 30% of their installed capacities, which also decreases overall energy use efficiency of the system. It should be noted that the west boiler house, supplying heat to northern and western parts of the city, is rarely put into operation due to higher operation costs. It is also reported that more than 50% of heat transmission and distribution system needs repair.

[3] Abdurahmanov A. (2009) "Energy sufficiency and efficiency in Dushanbe". Proceedings of the conference "Environmental safety and energy efficiency in municipal buildings in Dushanbe". 15-16 December 2009;
"The concept for development of the energy system of Dushanbe till 2015".

[4] "The concept for development of the energy system of Dushanbe till 2015"

Lack of maintenance and obsolete equipment determine high heat losses in the heat generation and transmission systems, and it is estimated that:

- 15-30% is lost during heat generation;
- up to 12% is lost in heat delivering grid;
- 15-20% is lost in distribution points and building-level heating systems;

Given that total need of the city in heat supply constitutes around 1 121 Gcal/h/ч (820 Gcal/h for housing sector and 820 Gcal/h for municipal buildings), it is estimated (Abdurahmanov 2009) that the actual heat output by the district heating meet only 15% of Dushanbe`s total demand in heat or 28% of those buildings that has access to district heating. Some sources suggest that only 650 multistory buildings in Dushanbe have central heating, of which 450 buildings are classified as residential housing. According to recent media releases[5], it was planned to supply with heat 715 buildings in the city in the 2011 winter season, however in fact, only 264 of these buildings have functioning centralized heating at the moment.

Long absence of centralized heating in the city and maintenance of the respective facilities has also resulted in demolition of respective infrastructure on building level. It is reported that dwellers in many buildings have removed "useless" radiators in their apartments, and since building level heating infrastructure envisages sequential supply of heat[6], whole blocks or even buildings became isolated from centralized heat supply. This problem may to some extent explain why actual number of buildings connected to district heating falls below planned target.[7] While there is no working centralized heating at all in the most parts of the city, this fact may also impose serious barrier if the state would intend to reintroduce the central heating back to these districts.

[5] "*Dushanbe`s municipality reinforces accounting for electricity consumption in the city*", CA NEWS release dated 17/01/2011, available ate http://www1.ca-news.org/news/581341

[6] Single hot water tubes run vertically throughout the whole building blocks, consequently when any element of the heat supply system is cut off, circulation of heat carrier in the tubes stops.

[7] "Energy saving means responsibility" by Edgorov N., article in "TRUBUN.tj" dated October 20, 2010. Available at http://www.tribun.tj/news.php?n=8182&a=1

3. Institutional and regulatory framework

3.1 Energy sector

The Ministry of Energy and Industry of the Republic of Tajikistan is the state body responsible for development and carrying out state policies and legal regulation in the sphere of fuel and energy sector. The state holding company "Barki Tojik", nominally subordinated to the ministry, regulates generation, transmission and distribution of electricity. It is also responsible for generation, transmission and distribution of heat energy, and thus, operates all thermal stations and large boiler houses in the country.

"Barki Tojik" has several respective subdivisions and affiliate companies that govern the sector and implement different functions. Delivery and distribution of electricity on the city level is carried out by state stock company "Dushanbe Electric Grids". "Energosbit" is responsible for sale of electricity to population and business at established tariffs, and overall accounting of power consumption on city and district scales.

As the main body regulating power production and consumption on operational level, "Barki Tojik" is responsible for development of tariff policy in the country. In January 2010 the electricity tariffs were raised by 25%, reflecting government's commitment to steadily increase energy prices to a level that allows self-sufficient functioning of energy sector[8]. Table 4 represents current tariff for electricity for various categories of consumers. The government has already announced that tariffs will see another 25% increase in 2011, which sparkled some discontent in the society since bills for electricity consumption impose sensible burden for population. It should be noted that the World Bank estimated that in order to allow smooth rehabilitation and modernization of the hydropower sector (the main producer of electricity in the country), the tariffs should be increased to 20 dirams (4.65 $US cents) per kW/h.

Table 4. Electricity tariffs in Dushanbe, as of December 2010

User categories	**dirams per kW/h**	**$US cents per kW/h***
Industry and business	21.3	5.0
Tajik Aluminum Plant (Talco)	8.2	2.0
Irrigation and transport	5.7	1.3
State organizations and communal services	8.5	2.0
Residents (VAT inclusive)	9.0	2.1

* Exchange rate: 1 US cent =4.3 dirams (0.043 somoni).

Source: *Ministry of Economic Development and Trade of Tajikistan.*

[8] Increase of energy tariffs is also one of the conditions of the international financial and donor organizations for further investment into development of energy sector in Tajikistan.

In 2002 the government of Tajikistan has adopted The Law on "Energy saving", which recognizes energy efficiency as a national interest. However, implementation of the law up to date was hindered by absence of specific national and state scale programs that should envisage particular targets and measures with regard to energy efficiency improvement in the country. The presidential decree "On additional measures for rational use of energy and energy saving" adopted in 2009, was expected to lay a foundation for elaboration of more concrete action plan[9] for addressing energy efficiency issues, including development of the State program for energy saving 2010-2015. As of December 2010, however, the program does not exist yet. The Tajik Government has also adopted a program supporting the development of renewable energy in Tajikistan for the years 2007 – 2015. However, this program also largely remains a declaration rather than a serious intention.

In 2009, the city hukumat has presented "The concept for development of the energy system of Dushanbe till 2015", which was elaborated in collaboration with the Ministry for Energy, "Barki Tojik", "Tajiktransgas", Academy of Science and Tajik Technical University. The concept, which is discussed more in detail in the subsequent sections of this report, addresses the main issues of the energy system of the city and determines measures with regard to rehabilitation of the infrastructure, increasing energy supply and improving respective municipal services. It was expected to develop and adopt an official state program for development of Dushanbe`s energy system based on this concept in 2010, however up to now no respective developments took place.

It should be noted, that UNDP office in Tajikistan is currently assisting the government in preparing Energy Efficiency Master Plan for Tajikistan. The perspective plan is aimed at setting national and sector-specific targets for energy efficiency improvements and outline the policy instruments, as well as respective measures and actions to be undertaken in the period until 2020.

3.2 Housing and municipal services.

The main body that governs residential sector in the city is municipality*, or hukumat,* of Dushanbe, which has several departments on city and district levels responsible for provision of municipal services.

Like in other soviet countries, all residential buildings in Tajikistan during the soviet time were state (or municipally) owned. Maintenance of buildings during that time was a responsibility of so called Housing Maintenance Departments operating under local governments. With adoption of the

[9] It should be thought mentioned that the decree already sets more-or-less detailed targets and action plan for dissemination of energy saving bulbs, which was paid high attention from the government in recent years.

Law "On privatization of the housing stock" in 1995, almost all residential apartments were privatized by their dwellers. The law also delegated servicing of building-level facilities beyond apartments[10] to the tenants, however up to now common-shared facilities were regarded by population by inertia as municipal owned. As a result common shared facilities in buildings have been out of maintenance for a long period. The lack of maintenance, which was also reasoned by the hardship of transition period and the civil war in 90s, led to significant depreciation of common shared facilities and buildings in general. Some experts have also highlighted insufficient regulatory base provided by the law as one of the main reasons that caused vagueness with regard to sharing of responsibilities between tenants and municipal bodies.

To eliminate the latter issue, the government adopted "On maintenance of multi-apartment buildings and Tenants Associations in Tajikistan" in 2009. Stating more firmly this time that maintenance of buildings and common shared facilities is a responsibility of apartments owners, the law also provided necessary legal base for establishing appropriate ways for building management. Accordingly, building maintenance can now be implemented either by:

- tenants themselves, without establishing any form of legal entity;
- establishing building-level tenants association, joined by at lest two-third of apartments owners;
- delegating respective functions to specialized organizations that operate on costs-covering basis.

Although the law came into force in 2009, only a small fraction of apartment owners have made their decision up to now with regard to choosing suitable way for establishing building maintenance. According to Consumers Union of Tajikistan, only 50 buildings out of hundreds multistory houses in Dushanbe have formed tenants associations, which considered to be the most appropriate form of building management. The union outlines low awareness of population about the respective reform as the main reason determining low participation of tenants.

[10] All common shared facilities including building level power transmission and heating infrastructure, attics, roofs, etc

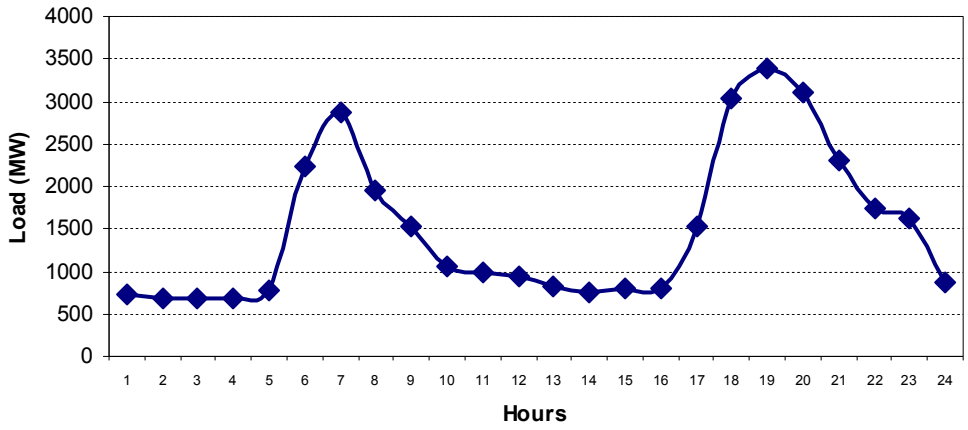
4. Energy use for heating in the residential sector and measures to increase energy use efficiency.

4.1 Reliance on electricity for heating

According to the estimates made by the Alumni Association of the Tajik Technical University, the main source of heat t is electricity, which is usually in deficit in winters. The present energy use in buildings is characterized by extremely low efficiency, the use of outdated technologies and equipment, dependence on imported fossil fuels, as well as negative impacts on the environment. Since about 2/3rd of the centralized heating system is out of order, electricity consumption continues to grow. Some estimates suggest that energy consumption of houses represents more than 53% of the total consumption of the city[11]. It should be noted that though electricity is the main source for heat some dwellers use other sources of heat and energy such as coal, wood, etc.

High reliance on electricity for heating determines high fluctuations of power consumption in the country throughout a year. According to official data[12], electricity generation in Tajikistan in 2009 equaled 1.6 billion kWh, around 4.2 billion of electricity was exported in the summer whereas import in the winter constituted 4.3 billion kWh, which reflects high seasonal difference in power demand. Use of electric heaters also leads to high variability of power consumption throughout a single winter day. The diagram below depicting electricity consumption registered during selected day in December 2005, shows that power demand in mornings and evenings (i.e. when most people are in their homes) exceeds respective values during remaining part of the day 4-5 times. Though extrapolation of this pattern to a city level might be subjected to various factors, it may be strongly assumed that winter electricity consumption peak loads in Dushanbe follow the same pecularity.

Diagram 1. Electricity consumption load as of 21st dec 2005



Source: INOGATE (2006)

[11] "The concept for development of the energy system of Dushanbe till 2015"
[12] Tajik Agency for Statistics http://www.stat.tj/en/macroeconomic-indicators/

4.2 Measures to improve heating in the urban residential sector

In the past, fossil fuels were used for heating in the residential sector. After gaining independence and the following economic and political stagnation, imports of fossil fuels felt by 10, since the most of population could not afford paying for fuels at market prices. At the same time, absence of any other options for heating and considerably low price for electricity led to significant increase of power consumption in the country. As a result, the hydropower sector fails to meet the high demand for power in the winter period any more and severe power rationing was imposed in the country, covering mainly the residential sector. The issue of winter electricity shortages adversely affects population living standards as well as substantially hinders entrepreneurial activity in the country.

Faced with energy crisis the, Government and other stakeholders began to look for ways to mitigate the situation and one of the solutions believed to be increasing the efficiency of energy use in the residential sector. Since energy use for heating purposes comprises the major part in its overall use, energy use efficiency in residential buildings is of major concerns. In general, technology-wise measures to improve energy efficiency in buildings can be grouped into three categories:

1. **active-technology measures** refer to introduction of more advanced heating (heat generation) system or renovation of the existing ones, which allow to increase energy/fuel use efficiency and avoid heat losses during generation and transmission;
2. **passive-technology measures** include insulation and retrofitting of buildings, which allow to reduce energy required to maintain needed levels of comfort/temperature;
3. **behavior-related measures** envisage optimizing energy use behaviors of the dwellers through introduction of economic incentives and technical tools.

Several studies (Marinot 1997, Legro et al 2005, UNEP/EEA 2007) claim that post-soviet countries can dramatically reduce energy consumption in buildings through the sets of both passive-technology and behavior-related measures (such as introduction and enforcement of stricter codes for new buildings; retrofit of the huge stock of inefficient multi-apartment blocks; modernization of energy distribution networks; installation of metering and controls in apartments[13]; and reform of tariffs to create economic incentives for saving). The generalizations in

[13] There is no metering of heating in Dushanbe even in buildings connected to centralized heating system.

these studies however do not allow deriving - what authors suggest the best options for Tajikistan, which certainly posses different technical and, what is more important economic, conditions.

states that *"a number of studies conducted by both national research institutions and international organizations have concluded that by taking simple measures, energy use efficiency in residential buildings of Dushanbe can be improved by as much as 50%"*. Referring to these studies ____ suggest that there are ways to improve their insulation, install more efficient heating systems (both central and autonomous), raise awareness of the population of the energy waste issue and others to name a few.

Though no detailed estimates exist on the scope of energy efficiency measures with respect to their costs, some sources[14] suggest that perspective building level measures in Tajikistan can be grouped into the following categories:

1. **low-cost measures** – window and door insulation using cheap and accessible materials, installation of reflective films on windows, etc;
2. **medium-cost measures** - installation of heat metering and control devices, retrofitting of building level heating infrastructure, installation of modern ("plastic") windows, partial wall insulation;
3. **high–cost measures** whole building insulation, installation of autonomous heating system, installation of automatic heat registering and control systems.

4.3 Energy source options for urban heating in Tajikistan

Determination of optimal energy efficient heating for urban residential sector of Tajikistan is dependant on multiple technical and economic factors. But one of first and most fundamental tasks in choosing right heating option is to determine - on what energy sources should the prospective heating system be based on. In this connection some discussion on available energy sources for residential heating, both in the short- and long term, might be very useful.

As it was mentioned before, electricity constitutes the biggest share in Tajikistan's total energy consumption, and more than 95% of it comes from the country's **hydropower** facilities. At the same time the country employs less than 5% of total technical potential for hydropower and looks forward to increase the hydropower generation through implementation of several large and small-hydro projects.

[14] "The concept for development of the energy system of Dushanbe till 2015" and Lampietti J. and Meyer A. (2003)

In contrast, endowment of the country with confirmed reserves of fossil fuels in the country is less significant. **Oil&gas** reserves, for example, represent only 3% of total energy resources of the country (Kabutov et al 2005) and their extraction is restrained by considerably location of the reserves (6000m depth). The volume of technically extractable **coal** reserves is estimated as 1 billion ton, but complete exploitation of these reserves and increasing output of coal mining in the country is restrained by absence of necessary infrastructure and by the fact that they are located in distant and had-to-reach parts of the country (Buzurukov 2004).

Ability of the country to completely meet energy needs for heating in the medium term through import of fossil fuels is also questionable due to economic reasons and geo-political issues, not discussed within this report. Considerably high prices of imported natural gas and absence of needed infrastructure for coal transportation and storage make these fuels relatively uncompetitive for use in urban heating be it district or autonomous system. It is worth to mention that consumption of natural gas, which is considered as the most convenient fuel option for district heating[15], has fell by ten times since 1991.

Table 5. Fuel consumption dynamics in Tajikistan during 1991-2009 (in % to base year 1991)

Year	1991	1995	2000	2005	2009
Petrol	100	5	2	2	2
Kerosene	100	9	6	15	2
Diesel	100	31	21	20	16
Natural	100	33	19	16	5
Liquefied gas	100	2	2	0,3	0,7
Coal	100	2	0,1	1	6

Source: Tajik Agency for Statistics (http://www.stat.tj/ru/library/table_12.xls)

In these circumstances, any further development in the energy supply sector in the future will likely largely focus on increasing electricity generation. Some authors (Buzurukov 2004, UNDP 2007) actually conclude that hydropower is the only feasible alternative for reducing energy deficit and development of the energy sector in the country. Taking all this into account, it can be consequently assumed that electricity is the only available energy source for heating in urban areas of Tajikistan today, because of absence of any other alternatives. It seems that electricity will remain as the most perspective options in the long term as well, since gradual development of hydropower is one of the highest priorities in the government's agenda.

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4.4 District vs. decentralized heating

One of the open questions in elaboration of optimal "active-technology" measures is whether the prospective heating should be autonomous or be based on renovation of existing district heating system. To larger extent this is subjected to financial and technical feasibilities of each option. Considering various heating options in "the poorer countries of Eastern Europe and Central Asia" Lampietti J. and Meyer A. (2003) concluded that running centralized heating system is too expensive to enable district heating facilities to reach cost recovery. While highlighting high operation and maintenance costs linked to running centralized heating in the city, "The concept for development of the energy system of Dushanbe till 2015" envisages to keep district heating and to introduce autonomous heating in areas where centralized heating does not exist.

As it was discussed earlier electricity seems to be the only feasible option today for heating in urban areas. Any proposals on advancement of electricity based heating will definitely exclude introduction of any types of district heating systems and will likely involve only apartment-level improvements.

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