Final Draft

ALLIANCE TO SAVE ENERGY

Municipal Network for Energy Efficiency

Armenian Urban Heating Policy Assessment

By Arusyak Ghukasyan and Astghine Pasoyan

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List of Abbreviations

AMD	Armenian Dram - *for reference, the official exchange rate on September 2006: 396 AMD for 1USD*
ASE	Alliance to Save Energy
CH	centralized heating
CHP	combined heat and power (also referred to as cogeneration)
CHS	central heat substation
CJSC	closed joint-stock company
DH	district heating
DBP	district boiler plant
DRH	decentralizing residential heating
ESCO	energy service company
GDP	gross domestic product
GoA	Government of Armenia
HDD	heating degree-day
HHWB	heat and hot water boiler
HOA	home owner association
HOB	heat-only boiler
HVAC	heating ventilation and air conditioning
IQC	indefinite quantity contract
IRR	internal rate of return
LLC	Limited Liability Company
kWh	kilowatt hour
MWh	megawatt hour
O&M	operations and maintenance
PC	production cooperative
PIU	project implementation unit
RoA	Republic of Armenia
TPP	thermal power plant
UHP	urban heating project
UHS	urban heating strategy
USAID	United States Agency for International Development
USD	United States dollar
VAT	value added tax
WB	World Bank

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Executive Summary

After the collapse of the Soviet Union and the creation of the Republic of Armenia, the country experienced a drastic deficit of fuels due to the temporary fuel blockade, and the growth of market prices for natural gas, electricity, equipment, and general operations and maintenance (O&M). This, together with the worsening social-economic condition of population, resulted in low collection rates for heat services—as low as 15-20%—with consequent bankruptcy and collapse of the heat supply companies. The trend moved towards unbundling the large heating systems and establishing smaller, more competitive alternatives. The collapse of the Soviet Union dramatically affected on the heat supply system of Armenia. Consequently, district heating systems have been deteriorating, leaving practically no district heating in the country.

As a consequence of the vast decline in the coverage of district heating and gas supply systems (currently at 6% and 18% of 1990 levels, respectively), an ad hoc mix of other urban heating alternatives appeared. At present, in areas where district heat and hot water supply are not available, urban and rural households rely on electricity, natural gas, coal, diesel fuel, kerosene, firewood, and dung, listed in the order of their affordability based on the consumers' level of affluence.[1]

At present, the majority of apartments in urban residential buildings are heated by individual, apartment-level natural gas and/or electric heaters. A gradually declining share of households still uses wood for space heating, predominantly in rural areas. As for central heating, a small number of buildings are supplied by newly constructed or rehabilitated small-scale heat-only boiler (HOB) systems, while very few buildings still receive district heat. Such a mix of heating options and fuels in residential and public buildings in Armenia, formed as a result of the sharp decrease in central heat and gas supply to the population, is extremely inefficient from an economic perspective as well as energy conservation. Not only is the country-wide inefficient heating increasing dependence on imported fuels in Armenia—a country with no indigenous fossil fuel reserves—but it is also adversely affecting the environment through the use of dirtier fuels, low efficiency heating equipment, and deregulated choices of heating technologies.

In this regard, experts, policymakers, public groups and donor agencies have emphasized the acute need for major restructuring of the heating sector to rehabilitate the heat supply and create a heat supply for the population that is affordable, efficient, environmentally friendly, controllable and commercially viable. Such restructuring should guarantee high efficiency of generating facilities to ensure economic and environmental sustainability while developing targeted social assistance schemes for low-income households.

The following rehabilitation scenarios for heat and hot water supply services are currently being discussed as alternatives to the current situation:

- District heat supply (heat-only or combined heat and power (CHP) generation);
- Small scale centralized heating (also called decentralized) systems designed for one to several buildings); and
- Individual heating with gas heaters (or boilers).

[1] Decentralizing Residential Heating in Armenia: Review of Pilot Projects, by A.Pasoyan, A.Kharazyan, Alliance to Save Energy, 2004 (DRH Review - ASE)

In the absence of a general coordinated solution, all of the above options have found applications with both suppliers and consumers available in the market. All options have their advantages and drawbacks. District heating is economically and environmentally preferable in the long-term. However, decentralized (including small-scale centralized) heating systems designed for a small group of buildings are more attractive in the short-term, given attributes such as their manageable investment size, demand flexibility, simplicity, and shorter payback periods.

1 Introduction

The present report describes the evolution and current state of Armenia's heat supply system, and the recent policy developments in the country's heat supply rehabilitation in the context of energy sector legislation. The paper further summarizes the involvement of international organizations, donor-funded heat sector programs and pilot projects, and the centralized and individual heat supply options available to urban households. In the context of strengthening civil society and local self-governance, the analysis addresses the existing institutional and socioeconomic issues for heat supply rehabilitation progress, including the involvement of home owner associations, consumer organizations, and regulatory, legal and lending institutions. Furthermore, this report addresses health and safety, education, and environmental concerns of the current unsustainable heating practices. From the analysis conduced here of policy, economic, technical and cross-cutting issues—and drawing upon the extensive research and analyses conducted by other donor-assisted programs—the report provides recommendations for further reform and restructuring in the heat sector to promote efficient, affordable, safe, environmentally friendly and economically viable heating options throughout the country.

2 Evolution and Current Status of Armenia's District Heat Supply Sector

Armenia, as a part of the former Soviet Union, held a leading position among other soviet republics in centralized heating of residential and public buildings. Particularly after the 1970s, the newly built residential buildings were heated mostly through district heating systems. The total centrally-heated area encompassed 55% of all residences—about 36% of the housing stock and 90% of the apartment buildings—for a total of 14.2 billion m^2, including Yerevan with 9.2 billion m^2. Centralized heating systems annually produced about 20 to 22 million Gcal (about 88 billion GJ) of thermal energy, of which more than 60% was used for heating and hot water supply.

Armenian district heating systems were operating with heat-only-boiler plants (HOBs) and CHP plants. HOB stations were located in the cities of Yerevan and Gumri: in Yerevan HOBs were commissioned during 1971-91 with total installed thermal capacity of 1465.6MW, and most of them were operated until the heating season of 2003-2004 with interruptions due to energy crisis of the 1990s. The Gumri-Mayisian HOB house was commissioned in 1992 with installed thermal capacity of 314MW, and operated until the heating season of 2002-2003, providing heat to the Ani district of the city of Gumri. The technical and economic characteristics of heating systems with heat-only-boilers are summarized in Annex I.

Three thermal power plants (TPPs)—Hrazdan TPP, Yerevan TPP and Vanadzor TPP—were commissioned in Armenia during the period from 1963 to 1976. The current owners of the pants are: Hrazdan TPP, the Government of the Russian Federation (ownership transferred through debt-for-asset swap); Yerevan TPP, the Ministry of Energy of Armenia; and Vanadzor TPP, the Russian company Zakneftgasstroy–Promethey (although Vanadzor

TPP is currently out of operation). The main technical characteristics are summarized in the table below.[2]

Table 2.1. Main Technical Characteristics of Three Armenian TPPs

CHP plant	Electric capacity	Thermal capacity	Connected heating load	Connected hot water load	Total load
	MW				
Yerevan TPP	250	750	166	36	202
Hrazdan TPP	300	650	61	16	77
Vanadzor TPP*	96	410	255	45	300
Total	646	1810	482	97	579

**The Vanadzor TPP, which was designed for industrial steam supply and district heating, stopped operation in the mid-1990s as both the municipal government bodies and the crisis-struck industrial enterprises refused to purchase heat supplied by the plant.*

After the collapse of the Soviet Union, Armenia experienced an economic and energy blockade: primary fuel and electricity prices rose, equipment and O&M costs increased, the socio-economic well being of the population fell, and the heat service fee collection rate dropped to 15 to 20% of supplied heat. This degraded the economic performance of the heat supply companies to the point where they fell into bankruptcy and collapse. Over the past 15 years, the central heat supply market has gone from serving 14.2 million m^2, to only 0.5 million m^2 (see **Figure 2.1**). The figure shows a precipitous decline of over 75% in the total centrally heated space in Armenia between 1991 and 1996, followed by a further 14% decline from 1996 to 2005.

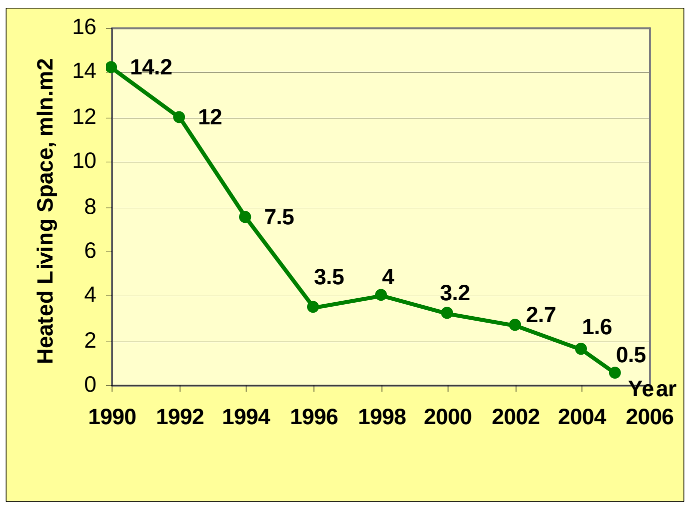

Figure 2.1. Living Area Heated Through Centralized Heating Systems from 1990 to 2005

The economic and energy blockade of the early 1990s caused by the Nagorno Karabakh conflict dramatically affected the centralized heating systems of Armenia, causing a decline it thermal energy production to 0.29 Gcal in 2003/2004 and 0.08 million Gcal in the 2004/2005 heating season (of which more than 90 percent was used for heating).

Centralized district heating systems have long transmission pipelines that often traverse complicated urban landscapes, making maintenance, damage detection and repair difficult and expensive. District heating had a number of other disadvantages, such as:

- low service quality and reliability;
- absence of end-use regulation;

[2] Heat Energy Market Assessment Report, USAID/Residential Heating Report, 2006 (Heat Energy Market Assessment Report - USAID/RHP)

- lack of transparency in pricing mechanisms;
- tariffs too low for cost-recovery combined with ineffective subsidy mechanisms;
- low efficiency of outdated and obsolete heating equipment;
- absence of heat consumption metering;
- complex hydraulic regimes of heating networks and large heat carrier losses; and
- expensive heating network construction and operation and maintenance (O&M), along with limited service lifetime.

As a result, the majority of district heating systems in Armenia were shut down, giving a slow start to the decentralization trend in the heat market. (See Annex II describing the current status of the heat supply systems and gasification throughout Armenia.) **Table 2.2** summarizes data on centralized heat supply from TPPs in Armenia during the 2004-2005 heating season: thermal energy, heat losses, purchased thermal energy, and tariffs. The heat tariff calculation methodology used for centralized heating systems with TPPs or boiler houses with a capacity equal to or greater than 5.8MW is given in Annex V.

Table 2.2. District Heat Supply Status During the 2004-2005 Heating Season

#	Indicators	Unit	Yerevan TPP CJSC	Hrazdan urban community "Heating division" CJSC	TOTAL
2004/2005 Heating Period					
1.	Total surface of residential buildings	1000 m²	226	507	733
2.	Living surface of residential buildings	1000 m²	124	340	464
3.	Length of the heating season	day	90	120	-
4.	Total production of thermal energy (including heat losses in networks and plant's own consumption of heat)	1000 GJ	93.64	238.13	331.77
5.	Heat losses in networks and plant's own consumption of heat - absolute units	1000 GJ	16.86	17.72	34.58
	- percentage	%	18	7.44	-
6.	Total purchased thermal energy	1000 GJ	76.78	220.41	297.19
6.1	- for residents	1000 GJ	70.52	211.86	282.38
6.2	- for other consumers	1000 GJ	6.26	8.55	14.81
7.	Heating tariff without VAT	AMD/GJ	2355	1672	-
8.	Heating tariff including VAT	AMD/GJ	2826	2006	-
9.	Tariff for residential space heating without VAT	AMD/m²	1337	1389	-
10.	Tariff for residential space heating including VAT	AMD/m²	1605	1667	-

During the last few years, only three large thermal plants were operating to provide district heating to a few areas in Armenia: Yerevan TPP, Hrazdan TPP and Gumri "Mayisian" heat-only-boiler house, in the cities of Yerevan, Hrazdan and Gyumri, respectively. However, the operation of Majisyan boiler house was stopped in 2004 because "Gyumri heat supply", a closed joint-stock company (CJSC), went into bankruptcy due low collection rates, along with the failure of the Gyumri Municipality to provide the committed heat subsidy funds. During the 2004-2005 heating season only Yerevan and Hrazdan TPPs supplied heat to a few residential areas and a few industrial consumers.

The heat supply system fed from the Yerevan TPP operated until 2005. The main reasons for its interruption were high losses of heat and water from the heating system networks, a transition of relatively large consumers (hospitals, schools) to more reliable and higher quality local heating options (boiler houses, electric heaters, etc), and a low collection rate of heating fee. Liquidation of the Yerevan heating company soon followed.

Even in the remaining district heating systems, heat losses from the distribution networks are high and centralized heat supply systems do not provide affordable heat of appropriate quality. Consumer satisfaction surveys reveal that the residents of a heated district in the city of Hrazdan, supplied by the Hrazdan TPP, are not satisfied with the heat quality. The average indoor temperature during the 2005-2006 heating season was between 14 and 15^{o}C instead of the normative 18 ^{o}C and the heating season was about 100 days instead of the normative 202 days. (The heating degree-day (HDD) indicator was 1620 HDD instead of the normative value of 3980 HDD for the city of Hrazdan.) As a result, the residents use electricity and/or other energy sources for supplemental heating, which poorer households cannot even afford. This situation created the need for policy intervention to promote more efficient and affordable alternatives, which would be better suited for market conditions, current fuel prices, customer needs and business requirements.

3 Heat Supply Policy Reform and Restructuring Efforts

Given the importance of heat supply rehabilitation in Armenia, the national government, international organizations and technical experts have been actively involved in discussions on rehabilitating Armenia's heating system.

3.1 Armenia's Urban Heating Strategy

In early 2001, the Urban Heating Strategy (UHS) was developed, under the leadership of the Ministry of Finance and Economy, with support from the World Bank and a variety of initiatives and funding sources to help prepare this strategy (including support from EU TACIS, UNDP and USAID). The Government adopted the UHS on September 5, 2002 (Decree 1384 N).[3]

The objectives of this Decree were to achieve:

- reliable, high-quality, efficient and affordable heat supply;

[3] Armenia Urban Heating Strategy, Summary Report and Recommendations, The World Bank, 2002 (Armenia UHS - WB)

- environmental and health safety;
- energy savings; and
- the opportunity for individual consumers to regulate their heat consumption.

The key urban heating principles defined in the Decree described following goals:

- full commercialization of the heat supply system activities (absence of public funding, subsidies and cross financing);
- complete cost recovery from fees;
- formation of a competitive heating market and application of contemporary heating technologies; and
- gradual reduction of public management in the heating market (heating tariff liberalization and the elimination of construction and operation licensing procedures).

Within the framework of the Government's Urban Heating Strategy, the Public Service Regulatory Commission (PSRC) of the Republic of Armenia (RoA) developed amendments to the Energy Law, Water Code and Civil Code to promote market relations and private capital formation in the sector; it ratified by the President of the RoA on 4 February 2004). One of the amendments was to the Article 23 of the Energy Law, eliminating regulation of thermal energy production, transmission and distribution activities with no more than 5.8 MW installed capacity, with licensing and tariff approval procedures by PSRC.

In the Urban Heating Strategy the foreseen development was divided into three phases:[4]

→ *Year 1-2: "Survival"* – keeping the existing centralized heating systems operational with minimum investments and taking the first measures to develop and test more sustainable approaches.

→ *Year 3-5: "Recovery"* — developing and starting the implementation of those heating options considered as the most feasible (Project Immediate Object 2).

→ *Year 6-25: "Growth"* – attracting investments, as applicable, for the rehabilitation of centralized heat supply systems and/or more decentralized options, depending on their technical and financial feasibility in each city and city district concerned (Project Immediate Object 3).

According to the Strategy, the existing district heating systems of the country should have been kept operational during the "survival" period and entered into a "recovery" stage of the most feasible heating options, with development and implementation starting by 2005. However, no district heating systems, with the exception of a small part of Yerevan and Hrazdan district heating systems, survived during the first phase. The latter, according to the Hrazdan municipality, will not operate during 2006-2007 heating season.

With consideration of the current state of the country's heating systems, the reconstruction and full capacity operation of existing DH systems could be a possible option for further development of the heating sector, although it requires high initial investments. On the other hand, while supporting the preservation and rehabilitation of district heating systems, the Urban Heating Strategy presumes the development and dissemination of independent systems (small-scale centralized heating systems connected to one or more

[4] Armenia – Improving the Energy Efficiency of Municipal Heating and Hot Water Supply, Project Brief, UNDP/GEF/00035799, 2005

buildings). And currently, the heating system rehabilitation follows both the centralized (district heating) and decentralized (small-scale centralized or individual) systems.

3.2 Governments Initiatives for Promoting Heat Supply Rehabilitation

After the adoption of the Urban Heating Strategy a number of legal-normative acts relating to the sector were adopted, which are presented in the **Box 1**. All these legal documents were aimed at rehabilitating Armenia's heat supply through measures such as eliminating barriers for residential heat supply, creating incentives for the most efficient heat supply options, and developing safety regulations for gas appliances.

Box 1. Energy Sector-Related Legal-Normative Acts Adopted in 2002-2005

- The Law of the RoA on "Energy Saving and Renewable Energy", 9 November 2004.
- The Law of the RoA on "Amendments to the Law of the RoA on Energy", 25 November 2003.
- The Order of the GoA No. 2024-N on "Regulations for Restoring (Reconstructing) Gas Supply Systems of Multi-Apartment Buildings", dated 5 December 2002.
- The Order of the GoA No. 1170-N on "Amendments to the Government Order No. 20242-N dated 5 December 2002", dated 4 August 2005.
- The Government Order No. 1112-N on "Transfer of Property to Yerevan Municipality", dated 21 August 2003.
- The Government Order No. 785-N on "Amendments to Government Order No. 1112-N on Leasing of Heat Supply Facilities", dated 13 May 2004.
- The Government Order (Protocol) No. 24 on "Strategy for the Development of the Energy Sector within the Context of the Development of the Republic of Armenia", dated 29 June 2005.
- The Government Order No. 509-N on Pilot Projects of Heat Supply System Rehabilitation with Implementation of Heat and Power Cogeneration Units, dated 13 April 2006.
- The Ordinances of Yerevan Municipality on Leasing Heat Supply Facilities (Boiler Houses, Mini DH Networks) out to Private Citizens and Businesses for Heating and Hot Water Supply to Multi-Apartment Buildings and other Buildings.
- "Rules for Gas Supply and Use" and "Safety Procedures for Gas Appliances" - currently in the process of approval by the Public Services Regulatory Commission.

On 4 August 2005 the Government of Armenia adopted Decree No. 1170-N on "Changes to the Order of the Government of Armenia No. 2024-N on "Temporary regulations for restoring (reconstructing) gas supply systems of multi-apartment buildings", dated 5 December 2002, which ensures more effective restoration of gas supply to multi-apartment buildings and defines certain conditions for individual gas heating systems.[5]

[5] Possibilities for Reconstructing and Improving the Energy Efficiency of Municipal Heating in the RA, UNDP/GEF/00035799 "Armenia - Improving the Energy Efficiency of Municipal Heating and Hot Water Supply", 2005 (Possibilities for Reconstructing and Improving EE Heating & HWS – UNDP/GEF)

To support the development of combined heat and power (CHP), in 2006 Government Decree No. 509-N on "Pilot Projects of Heat Supply System Rehabilitation with Implementation of Heat and Power Cogeneration Units" decreed that the tariff for electricity generated by cogeneration technologies shall not exceed that for the electricity feed-in for Hrazdan TPP for that year. In 2006, this value – 15.917 AMD/kWh without VAT – is considered as a tariff cap for electricity, but the heat tariff is still calculated by the "residual" method.[6] This is a very promotional tariff, since Hrazdan TPP is the least efficient and most fuel-intensive generation source of the country.

3.3 DONOR TECHNICAL ASSISTANCE PROGRAMS IN HEAT SECTOR

Numerous international and local organizations have recently implemented wide-scale measures to support the Urban Heating Strategy by developing, establishing and strengthening energy service companies (ESCOs), implementing energy efficiency and energy saving pilot projects, and promoting renewable energy use and public awareness, including media and general educational programs. In addition to the Urban Heating Strategy, a number of donors funded heat-related projects which developed heating plans, implemented pilot projects and analyzed techno-economic features of possible heat supply options in different parts of Armenia. This section provides a brief overview of all donor efforts in heat sector. The techno-economic features of the implemented projects are presented in Section 6 of the present report.

A. The United States Agency for International Development (USAID)

USAID has implemented various programs in the heating sector including three in residential heating. Two residential projects were aimed at switching from electricity, wood and oil application to environmentally and economically more beneficial natural gas. USAID technical assistance installed individual (apartment-level) gas heaters' in Yerevan and Gumri and helped rehabilitate multi-apartment building heating with a local boiler house, where the service is provided on the basis of heating contracts between the private heat supply company and residents of one of the Yerevan buildings. In addition, the billing for consumed heat is conducted partially per heated space and partially based on metering device (allocator) reading. The key heat-related programs if USAID in Armenia are as follows:

A.1 Residential Heating Project implemented by USAID[7]

The Project was launched in July 2005 to provide assistance to the Republic of Armenia in implementing the Urban Heating Strategy adopted in 2002, identify efficient and least cost heating solutions for different regions of Armenia. The Project also intended to assist in solving a number of institutional problems for promoting the continued priority of transparency and efficiency of operation in order to improve the quality of services delivered to customers, increase the

[6] *This method is based on the difference between revenue from electricity purchase with the electricity tariff, which does not exceed the tariff for electricity feed-in for Hrazdan TPP, and annual actual costs.*

[7] www.heat.am

collection rate, and support the creation of sustainable commercial energy market.

The main objectives of the Project were to:

a) review and assess the existing situation in the residential heating sector;
b) develop sustainable, reliable, affordable and efficient options of rehabilitation of heating systems in the residential sector of the Republic of Armenia;
c) provide recommendations for updating the Urban Heating Strategy adopted in 2002 and in case of approval, support the development of an implementation plan;
d) support R2E2[8] in developing, selecting and submitting viable heating projects for loan financing;
e) conduct a feasibility study and estimate the expenditures needed for about 15 projects with the lowest rehabilitation costs, and implement these projects in Yerevan and other regions of the Republic through a grant awarded by USAID;
f) help private companies and condominiums to strengthen their capacity to implement effective and sustainable heating system operation, including the calculation of fees and billing;
g) help Condominiums and Condominium Associations to improve their capacity to organize and manage heat infrastructure rehabilitation and renovation and render proper services to the customers.

Nevertheless, most of above-mentioned objectives were not fulfilled due to termination of the Project in November 2006. The most important outcomes of the Project include the Municipal heat supply plans for the cities of Sevan and Spitak.

A.2 *“Armenia Energy Efficiency, Demand Side Management and Renewable Energy Resources Program”, implemented for USAID by Advanced Engineering Associates International (AEAI)*[9]

The Program, ongoing sine 2001, aimed at creating a market demand for EE and RE services providers, creating employment for EE and RE services providers, strengthening ESCO’s as an instrument for meeting this demand.

The list of AEAI heating/weatherization projects includes municipal buildings such as the Armenian Public Services Regulatory Commission Office, Energy Institute, Pushkin School #8, IT Regional Academy building, medical institutions - Nork Marash Center buildings, Policlinic #8 in Yerevan, Polyclinic #1 and Integrated Services Center in Vanadzor as well as several residential buildings in Yerevan and Gumri. In the Erebuni Branch of Electric Network of Armenia, Armenia Medical Center and Armrusgasprom, USAID has sponsored the technical upgrading of electric substations including the automation systems in order to reduce the stand-by losses from transformers.[10] The Program has worked to create and strengthen the energy service companies and implement pilot heating projects

[8] See bullet C of this chapter.

[9] www.aeai.am

[10] DRH Review – ASE

in public and residential buildings, while other USAID programs have worked to reform and strengthen the energy sector legislation.

A.3 Municipal Network on Energy Efficiency, implemented for USAID by the Alliance to Save Energy

This project, ongoing since 2001, involves the following:

- Promoting energy policy reform by establishing the Armenian Energy Efficiency Council.
- Providing technical assistance to the Ministry of Energy of RoA in drafting the Law on Energy Saving and Renewable Energy of Armenia, and the National Program on Energy Saving and Renewable Energy.
- Conducted Energy Efficiency Trainings and Awareness Campaign: provided local and regional training for condominiums and municipal officials on energy efficiency solutions in heating and multi-apartment housing, and financing tools; published and disseminated over 700 copies of residential EE advice booklets.
- Established Micro Revolving Funds[11] for building energy efficiency projects in Gyumri and Vanadzor.
- Provided software tools and guidebooks for implementation of building energy efficiency measures, including the Building Energy Efficiency Project (BEEP) software adapted in Armenian and Russian.
- Over 200 housing associations and building managers and 12 cities were trained on building energy efficiency practices;
- Training in building energy efficiency project and business plan development was conducted for 25 municipal and residential building managers.
- Over a dozen publications and analytic papers were produced on various efficiency aspects, including energy legislation, building management, residential heat supply, gas appliances, and energy audits.

A.4 "Armenia Electricity and Natural Gas Sector Reform Program, Energy IQC, 2001-2003", implemented for USAID by PA Government Services

The Armenian office of the US-based PA Government Services, Inc. implemented the Fuel Substitution pilot project in 2001. The main goal of the project was to identify and evaluate the advantages of switching from electric power to natural gas heating. Individual gas heaters were installed for residential space heating. Analysis and recommendations were presented pertaining to energy efficiency measures in heating, water supply, electricity consumption, and gas supply. The project involved 114 apartments and 33 private homes.

A.5 Armenia Local Government Project, implemented by The Urban Institute

The Urban Institute (UI) implemented the Armenia Local Government Project (LGP) on behalf of USAID from January 2000 to May 2003. The UI's activities under this project comprised the following components: government decentralization and association strengthening; local government capacity and

[11] *The Funds provide loans with 0% interest rate and repayment period of 6 months and aim to develop the means and methods for condominiums to increase energy efficiency, improve management and heat conservation in common areas, and assist condominiums in maintaining the building stock.*

service delivery improvement; citizen participation; and condominium association development and strengthening.[12]

B. Heating and Multi-Apartment Management Bodies' Support Project (the WB Urban Heating Program, UHP)

This Program, started from 2001, implemented by the World Bank, Ministry of Finance and Economy of Armenia, worked to test various technical and lending solutions with condominiums and ESCOs—as well as established lending and grant mechanisms—to provide capital grants to the poor for such individual apartment heating systems. The main objective of this project was to increase the number of urban households that have access to and pay for affordable, safe and environmentally sustainable heating services. The approach to achieving this end was to stimulate the creation and effective functioning of self-regulating community organizations, and to create the market conditions for the commercial provision of these services. Through a community-driven process, the project will contribute to significantly reduce the barriers to the provision of more efficient, environmentally sustainable and affordable heating and other communal services on commercial terms. The project investigated the following heat supply options:

1) Rehabilitation and modernization of the existing centralized (district) heating systems.
2) Heat and domestic hot water produced in gas-based CHP plants or heat-only boilers (large or small) and delivered to buildings through a network of hot-water pipes.
3) Autonomous heating systems where small-capacity gas-based boiler- or CHP-plants supply heat and hot water to between one and three multi-apartment buildings.
4) Individual heating of apartments (and individual houses) with natural gas, electricity, wood or other available fuels.

The "Thermosupply Programs" Project Implementation Unit (PIU), set up to implement UHP, conducted six pre-qualified pilot projects in 2004 to provide qualitative, affordable and metered services while promoting the establishment and capacity building of entities rendering these services (condominiums and private entities). Implemented projects involved approaches that have not been previously tested, particularly power and heat co-generation, installation of horizontal internal network in apartments, and selling and buying of heat from Yerevan TPP through private entities. The pilot projects followed the following principles:

- Rehabilitation of heat supply networks through participation of stakeholders and further operation,
- Commercialization of heat supply,
- Regulation of heat consumed by residents,
- Rehabilitation of heat sources through introduction of co-generation and boiler-house capacities,
- Heating through installation of internal horizontal network.

The Program started within the frames of Urban Heating Strategy, funded by WB with support from EU TACIS, UNDP and USAID. The PIU was transformed into the Armenian

[12] Final Closeout Report for Armenia Local Government Project, by Samuel L. Coxson, USAID/The Urban Institute, 2003

Renewable Resources and Energy Efficiency Fund (R2E2) in 2005, described below, which would carry on the functions of the PIU with respect to the WB Urban Heating Program.

C. R2E2 Fund

The Government of Armenia founded the Renewable Resources and Energy Efficiency Fund (R2E2 Fund) to increase the use of clean, efficient, safe and affordable heating technologies, and improve policies to promote renewable energy and energy saving. For more information about the Fund see the Section 4.5 on Lending Institutions.

D. UNDP/GEF "Armenia - Improving the Energy Efficiency of Municipal Heating and Hot Water Supply" Project

The project, ongoing since 1999, consisted of two phases:

Phase 1: "Removing Barriers to Energy Efficiency in Municipal Heat and Hot Water Supply"*, implemented by UNDP/GEF/Armenia[13], 1999 - 2002*

Identified and produced recommendations to overcome the numerous barriers encountered in the process of restoring municipal heat-supply and raising its energy efficiency, and to identify the overcoming measures. Moreover, it aimed at choosing the most rational option of heat supply development strategy, which will be based on an economic and environmental analysis, and preparing a large-scale project afterwards.[14]

Phase 2: "Armenia – Improving the Energy Efficiency of Municipal Heating and Hot Water Supply"*, UNDP/GEF/Armenia[15], 2005 - ongoing*

The goal of this project is the reduction of greenhouse gas (GHG) emissions resulting from the heat and hot water supply practices in Armenian cities. Within this framework, the project will: (i) strengthen the role of condominiums in collectively organizing and managing heat and hot water supply services at the building level; (ii) support the restructuring and capacity building of the existing district companies to improve both their service quality and operational efficiency; (iii) support the new decentralized service providers to commercially run, market and diversify their businesses, in order to promote the use of alternative environmentally clean and energy efficient technologies and to structure financing for the required investments in areas that do not sustain the centralized district heating services; and, (iv) utilize the results, experiences and lessons learned for advancing the sustainable development of the heat and hot water services in Armenia with a specific emphasis on the GHG emission reduction aspects. The program conducts capacity building and other technical assistance activities and closely cooperates with the other donors including the R2E2 Fund (former Urban Heating Project funded by WB/IDA), the Government of Netherlands funded Industrial District Heating Development project and the envisaged USAID funded activities in the field of energy and environment.

Together with "Yerevannakhagits" CJSC and Ramboll consulting company, the Project studied the feasibility of heating system restoration alternatives for Avan and Davitashen districts of Yerevan.[16]

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[13] http://www.nature-ic.am/ClimateChange/Undp_Gef_Projects/eco-heat/Remov_home.htm

[14] DRH Review, Alliance to Save Energy

[15] http://www.nature-ic.am/ClimateChange/Undp_Gef_Projects/eco-heat/Heating_eng.htm

[16] Possibilities for Reconstructing and Improving EE Heating & HWS – UNDP/GEF

E. The Government of Netherlands

The Government of Netherlands supported the establishment of a pilot local heating system rehabilitation through an Armenian-Dutch joint venture – Eco-Engineering, which supplied heat based on contractual arrangements between the private heat supplier and the building management body – the condominium association in Yerevan.

F. The Jinishian Memorial Foundation

The Foundation implemented a pilot project setting up a local heating system on the roof of a multi-apartment building in Gumri, where heat supply is managed by the condominium association and the building; collection is carried out based on the individual apartment-level heat meters.

G. Other project implementers

Simultaneously, the local authorities (Aparan, New Nork of Yerevan, Charentsavan, Vanadzor, etc.) as well as different donor agencies (including Save the Children, Lincy Foundation, KfW and GTZ) have initiated and implemented a great number of projects aimed at strengthening local government and condominiums, energy conservation and renewable energy development, as well as rehabilitation of local heat supply in residential and public buildings (schools, hospitals, institutional facilities).

The key tasks and objectives of the main donor-funded and non-donor funded intervention addressed each key problem in heat supply sector of Armenia are summarized in matrix format in Annex III.

4 Institutional Issues

4.1 LOCAL AND NATIONAL GOVERNMENT

Most of the municipalities or municipal heating CJSCs are the owners of the old heating assets including boiler houses, heat supply networks, etc. Based on the requirements of Government Decree No. 1384-N dated 5 September 2002, Yerevan municipality started discussions in early 2004 on leasing out heat supply facilities (boiler houses and mini-DH networks) to private citizens and businesses with the objective of rehabilitation and reconstruction of the city's heating systems.[17]

Yerevan municipality has about 350 boiler houses and heat distribution points on its balance sheet and about 40 boiler houses are rented out to private sector as well as residential sector representatives: ESCOs and multi-apartment building management bodies. The municipality set a very low rent to support small scale centralized heating initiatives. To provide even more incentive for rehabilitation of heat supply from these boiler facilities, the municipality even waived the rent for non-heating months. The municipality provides follow-up monitoring of the reconstruction and rehabilitation works and operation of the boiler houses to make sure that the rented units are being used for heating purposes. If the heat service is not running properly within 3 years, the contract will be terminated.

[17] Possibilities for Reconstructing and Improving EE Heating & HWS – UNDP/GEF

During the last few years, in cities with small-scale centralized heating systems, the municipalities played a significant role in the formation of heating fees and collection mechanisms. For example in few cities of Armenia, the municipalities withhold salaries of non-payers who work for either municipalities or local large companies having agreements with municipalities. In the city of Jermuk, the municipality battled non-payment by withholding 10 to 15% of non-payers' salaries to cover heat arrears. Similar measures were taken also by the municipality of Gumri. However, this approach was not without controversy, because there were cases when heating debts of the people, who did not work for municipalities or local large companies, withhold from salaries of their relatives, who worked for municipalities or local large companies and who did not receive heating.

In the city of Charentsavan, the municipality started subsidizing the heat tariff when surveys revealed that only 18 to 20% of residents were willing and capable of paying the previous high tariff. However, when only 18% paid their deposit, the mayor appealed to the government, and a decision was made that in the cases where residents pay 30% of the season fee, they could receive heating without further payment.[18]

In individual cases, negotiations with the local government have achieved financial contributions for the establishment of new heat supply systems. For example, in a loan-funded project for rehabilitation of heat supply, the Qanaqer-Zeytun municipality of the city of Yerevan subsidized about 4% of the 10% required co-funding from the residents of the "Zeytun-1" and "Medik-2" condominiums that took out a $40,000 loan for rehabilitation of their heating system, taking into consideration the large number of poor families in the condominiums. [19]

The local authorities in the cities of Aparan, Yerevan (New Nork district), Charentsavan and Vanadzor—together with different donor agencies including USAID, Save the Children, and the Lincy Foundation—participated in a number of projects aimed at rehabilitating local heat supply system in residential and public buildings (schools, kindergarten, hospitals, institutional facilities). For example: the New Nork municipality initiated local heating of four residential buildings and the neighborhood kindergarten in the framework of the municipal heating project for the 2003/2004 heating season; the municipality of Aparan city—with the assistance of the Government of Armenia, the Ministry of Urban Development of Armenia and "Armenia" Fund—initiated and installed small-scale centralized heating systems for 10 multi-apartment buildings in Aparan.[20]

The remaining issues for local governments with regard to their involvement in the heat sector include the following:

- Lack of municipal budget resources to be directed into full rehabilitation and resumption of urban heat supply: while budget constraints are common in all municipalities, their magnitude varies from town to town. In some municipalities, 10 to 30% of the required investment can be mobilized locally, while in others the municipality will not even be able to covering heating bills for low-income households.

[18] Armenia Urban Heating Strategy Study (Demand Analysis): Qualitative Assessment Report, COWI. WB/TACIS 2001

[19] DRH Review – ASE

[20] DRH Review – ASE

- The current financial and legal framework does not allow municipalities to issue bonds and attract financing for municipal heat supply projects.
- In the initial privatization process, all the potentially attractive DH system assets were privatized for commercial purposes, with the remaining assets either leased for heat supply operations, or left as a deteriorated, depreciated and cost-intensive asset on the municipal balance sheet that requires constant care and administrative involvement. The municipalities do not possess the technical skills, experience or flexibility to attract foreign investors and lead productive negotiations with them. They need technical assistance in designing privatization or lease agreements so that national, strategic and consumer interests are not violated.

4.2 REGULATORY AND LEGAL INSTITUTIONS

The Public Services Regulatory Commission (PSRC) has five Commissioners appointed by the President of the Republic of Armenia, upon the RoA Prime-Minister's nomination, based on the annual rotation principle. The Commission gives licenses for thermal energy production, transfer, distribution; building of thermal energy transfer and distribution networks. The PSRC has developed amendments to the Energy Law, Water Code and Civil Code to promote market development and private capital formation in the sector (ratified by the President of the RA on 4 February 2004). For example the amendment on Article 23 of the Energy Law decrees that heat supply systems with no more than 5.8MW installed capacity are not regulated by PSRC.

4.3 HOUSING INSTITUTIONS

The DH strategy delegates an important role to multi-apartment building management bodies in the organization and operation of heating systems. And there are many multi-apartment building management bodies in Armenia, which were established for heat supply rehabilitation/construction and operation purposes. There are currently 826 registered home owner associations (HOAs) in Armenia (608 of which are in Yerevan), and the number of buildings managed by them accounts for 78% of the total housing stock of the Republic.

According to the law of the RoA on "Management of Multi-Apartment Buildings", condominiums have the following responsibilities:

- to manage the common shared property in multi-apartment buildings in compliance with regulations;
- to represent and protect the common interests of property (apartment) owners of multi-apartment building in state and local self-governing, judicial and other relevant bodies, in cases provisioned by the law; and
- other responsibilities, such as making contracts with organizations providing utility services, including heating, which do not contradict Armenia's legislation.

The successful heating pilot project experience in different cities of Armenia shows that condominiums can effectively organize the rehabilitation/construction and operation of their heat supply systems. For example, the "P. Sevak 106" condominium got a loan from a World Bank (WB) Urban Heating revolving fund, and with the help of the "Thermosupply Programs" Project Implementation Unit State Institution (PIU SI) it constructed a small-scale centralized heating system (roof-top boiler house) for their building #106 on P. Sevak street. Currently the condominium operates the heating system and is repaying the loan on schedule. One of the most significant keys to success for such project implementation is having a well organized and purposeful condominium. More information on this project, including lessons learned, is in Annex VI: "Case Study - Restoration of the Heating System of Residential Building #106 on Paruyr Sevak St.,Yerevan, Armenia".

In spite of these successes, however, condominiums still have major institutional and technical problems, including:

- Weak capacity for building management, project development, financial planning and management, fund-raising, human resources, reporting and customer/member relations.
- Poor creditworthiness due to their new status, slow development, failure to collect service fees, and failure to conduct creditworthy accounting, bookkeeping and reporting.
- Difficulty securing the necessary number of votes for strategic decision-making with respect to heat supply issues; the situation is exacerbated by the growing number of autonomous apartment-level solutions) and the significant share of absentee households (~20%);
- The need, often, to sign individual loan repayment and service supply contracts with each households due to mistrust and lack of experience of purchasing utility services from the intermediary.

The main directions of activities of already established condominiums with regard to heating should be to:

1) contribute to the restoration of heating systems in buildings by ensuring collective decisions through advocacy among building residents, which will serve as the basis for legally flawless and economically justified contractual agreements;
2) to make contracts with heat supply organizations and to collect heating fees; and
3) to ensure the participation of socially vulnerable families in the decision making process, and to support those families in the process of applying for the financial assistance available to low-income families participating in heat supply rehabilitation projects.[21]

4.4 CONSUMER ORGANIZATIONS

There is a non for profit, non governmental organization called Protection of Consumers' Rights (PCR), which conducts advocacy, lobbying and campaigning activities, provides advice to consumers, and raises awareness on legal issues as well as independent monitoring. PCR implements activities in the sphere of food safety, legal act improvements and public utilities, but it does not have sufficient experience to provide heating-related consultancy.

Under the UNDP/GEF Project "Armenia - Improving the Energy Efficiency of Municipal Heating and Hot Water Supply", the Condominium Advisory Center was established. It provides consultancy services and institutional support to the residents of multi-apartment buildings for organization of heat and hot water supply. The list of consultancy services includes:

[21] Possibilities for Reconstructing and Improving EE Heating & HWS – UNDP/GEF

- ✓ legal issues and contracting;
- ✓ commercial service provision (utility and building maintenance);
- ✓ business planning and management;
- ✓ selection of the service type,
- ✓ selection of operation and renovation companies through bidding and procurement;
- ✓ mandatory norms provision; basics of energy auditing, space heat conservation, efficient lighting, heat and water supply;
- ✓ monitoring and evaluation of commercial service provision and investment activities;
- ✓ identification of legal bottlenecks and participation in legislative reform and lobbying;
- ✓ poverty issues and social safety systems;
- ✓ environmental and safety standards;
- ✓ and communication and public outreach.

4.5 LENDING INSTITUTIONS

The field of lending activities for heat supply projects on the municipal, energy private sector and community levels is not yet well developed. To address this situation, the World Bank-funded Urban Heating revolving fund was established to stimulate the field. The revolving fund provided soft loans to multi-apartment building management bodies and energy supply companies to implement heating pilot projects through the "Thermosupply Programs" PIU SI, within the framework of the Advance for the Preparation of Urban Heating Project from 2003 to 2005. The heating pilot projects included construction of small-scale boiler houses, rehabilitation of existing boiler houses and heat supply networks. A successful heating pilot project on the Restoration of the Heating System of Residential Building #106 on Paruyr Sevak Street in Yerevan implemented under this Program is presented in Annex VI. The loan repayment period was 10 years with a three year grace period and 5% annual interest rate.

Presently, the Renewable Resource and Energy Efficiency Fund (R2E2 Fund) is in charge of implementing the WB Urban Heating Project. The R2E2 Fund was established by the Government of Armenia with the objective of promoting the development of renewable energy and energy efficiency markets in Armenia and facilitating investments in these sectors. The Fund is owned by the Government of Armenia, governed by the Board of Trustees, and managed by a qualified management team. The Fund's main objectives are: removing barriers and creating market conditions for commercial provision of heating services, providing long-term financing to service providers and consumers for their investments in heat supply systems and energy efficiency measures, and promoting efficient and safe boilers, heaters, and equipment to meter and control fuel and heat consumption. In addition, the Fund has a grant component for the poor and provides assistance to low-income households (see Chapter 5.5 on Social Assistance for Heat Supply).

The Fund finances investments for heating residential buildings, including a sub-component of "Lending to Project Beneficiaries", the objective of which is to provide sub-loans to the Participating Financial Institutions (PFI) for on-lending to the beneficiaries within the framework of Urban Heating Project. As a result, the PFIs (banks) set interest rates that are quite different from the WB PIU terms and conditions. The interest rates are negotiated separately for each individual case and range from 13 to 24 percent annually. In this respect, regardless of the size of the R2E2, there is still need for more and cheaper financial resources to accelerate the investments in the heat sector.

Residential Heating Projects

Investments eligible for funding are classified as follows:

- ***Individual heating***
  - Procurement and installation of gas heaters or boilers;
  - Procurement and installation of metering and consumption controlling equipment;
  - Gasification for heating purposes;
  - Other investments to increase energy efficiency of apartments and buildings.
- ***Centralized and autonomous heating***
  - Production, procurement, and installation of boilers;
  - Rehabilitation and construction of external and internal distribution systems;
  - Procurement and installation of metering and regulating equipment to measure and control heat;
  - Other investments to increase energy efficiency of apartments and buildings, including insulation of roofs, windows and common spaces;
  - Cogeneration of power and thermal energy.

Loan Types: The Subsidiary Loan Agreement defines two types of loans to be provided:

1) less than US$ 5,000 to finance rehabilitation works of individual internal heating networks and/or procurement of individual heating devices or internal gasification works;
2) more than US$ 5,000, to finance the heating infrastructure installation or rehabilitation.

Beneficiaries: energy supply companies, multi-apartment management bodies, municipalities, and individual home owners will be able to access funding for heating infrastructure investments.

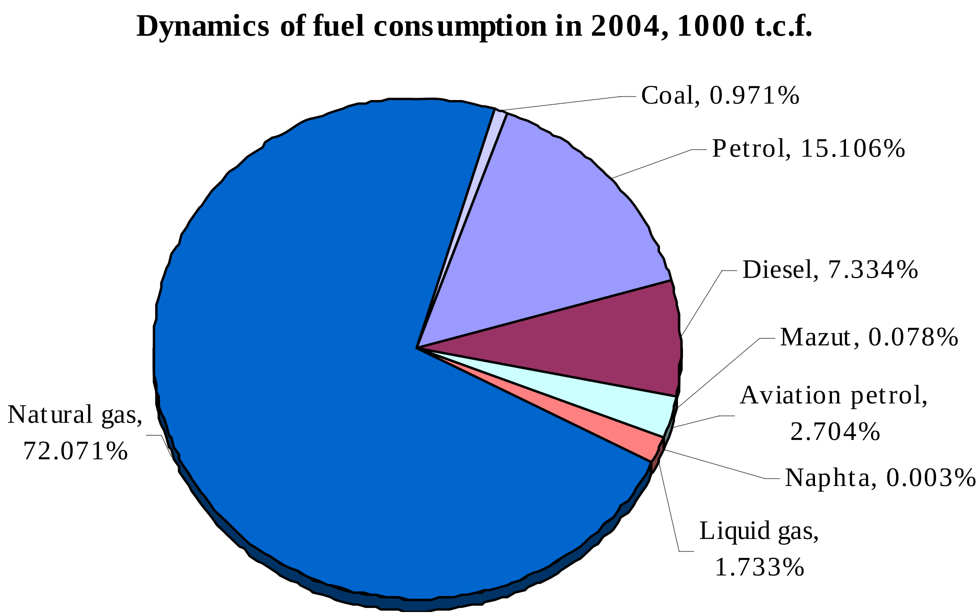
Participating Financial Institutions: at present, three banks are selected (Ardshinbank, ACBA, Cascade Bank), two of which have already signed Subsidiary Loan Agreement with Fund (ACBA, Cascade Bank) and ACBA has already received the first amount in June 2006. The banks will determine the sub-loan terms (interest rates, periods, etc) under the provision of the Subsidiary Loan Agreement and furnish Quarterly Progress Reports on allocated sub-loans.

5 Current Fuel and Energy Efficiency Markets

5.1 Current Fuel Mix

Armenia does not have proven fossil fuel reserves (including natural gas and coal), and wind and solar were not found to be viable generation options to meet base load requirements for Armenia. Only gas-fired, hydro, and nuclear generation options comprise the base of electric energy generation at present and for the foreseeable future. For thermal power plant operation, Armenia fully depends on imported gas.

Figure 5.1. Fuel Consumption Structure, 2004



Several fuels are used for heating purposes by residential households, including the partially functioning district heating system or a mix of electricity, natural gas, firewood, coal, diesel fuel, kerosene and manure (see **Figure 5.1**). The choice of fuel type for heating depends both on the availability of the source and household affluence.

Surveys conducted by the Alliance[22] and the "Termosupply Programs" PIU[23] revealed the main fuel types used by households for heating during the 2001-2002 and 2004-2005 winter season. **Figures 5.2** and **5.3** show that in 2001-2002, most of the surveyed families heated their apartments with electricity and wood; an insignificant part used oil and liquefied gas; and between 1% and 6% (depending on the season) used a combination of fuels depending on what they could fetch. In 2001/2002, 11% of surveyed households did not use any fuel specifically for heating (although there are cases when a single room is heated from the accompanying heat of the cooking appliances); this number significantly decreased for the heating season of 2004-2005.

The share of natural gas heating is zero in Figure 5.2, because the gasification level of multi-apartment buildings was low during 2001-2002, and the buildings surveyed were not covered yet. Nevertheless, heating with natural gas gradually replaces the heating with electricity due to intensive gasification of residential buildings in the country in recent years, in particular, the gasification level of 2004-2005 increased by 39% compared to the heating season of 2001-2002.

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[22] Armenia Urban Heating Project, JSDF Seed Fund, Project Completion Report, by National Association of Condominiums Owners and Alliance to Save Energy, 2004

[23] Survey of the Thermal Energy Supply Situation in Urban Settlements of Armenia, "Termosupply Programmes" PIU SI of the Ministry of Finance and Economy of RA, Economic Development and Research Center, 2005

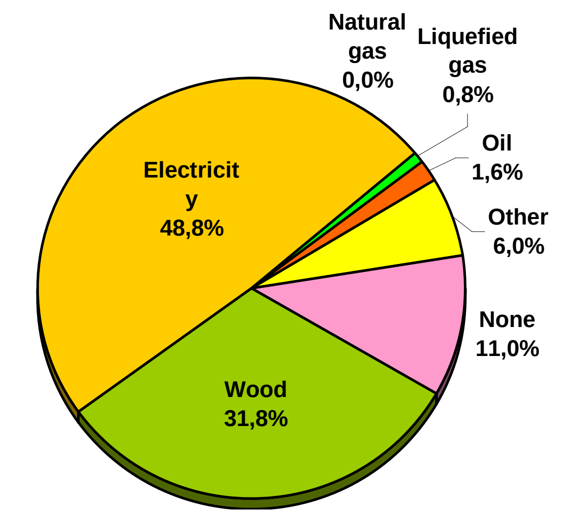


Figure 5.2. Fuel Sources for Heating (Excluding Centralized Heating), 2001-2002 Heating Season

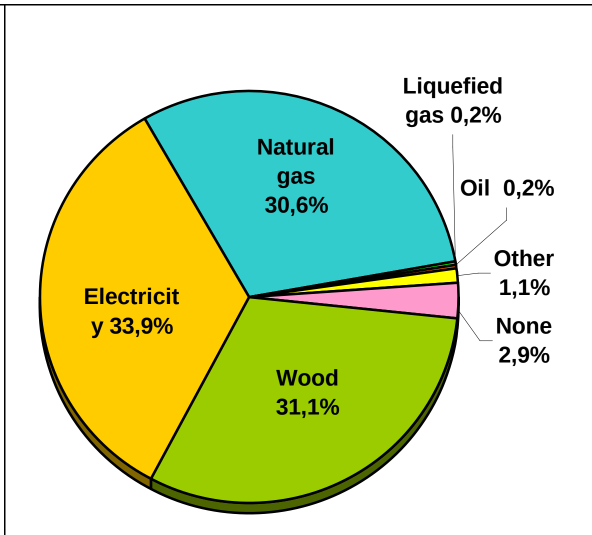


Figure 5.3. Fuel Sources for Heating (Excluding Centralized Heating), 2004-2005 Heating Season

Although the use of natural gas for individual heating is not recommended over central heating, it is a more affordable option than electricity, and more environmentally friendly than direct burning of other hydrocarbons inside residential dwellings. Intensive gasification also allowed new or rehabilitated HOBs to operate on gas-fired boilers. The next section describes the development of the gas supply market and its impact on urban heating. In households where the main heating fuel was firewood, natural gas is not competitive. Not only wood is cheaper, but it can be found for free through illegal tree-cutting in public forests and parks.

5.2 Gas Consumption in Residential Sector

Currently, the bulk of fossil fuel consumed in Armenia is natural gas (see Figure 5.1 above). Natural gas consumption is significant and is currently growing in the power sector: the use of natural gas by sector breaks down as 73%, 15% and 12% in the power, industrial and residential sectors, respectively. The latter is a fast growing market, due to intensive rehabilitation of the dysfunctional old gas supply networks and the massive switching from electricity and other fuels to natural gas for apartment heating, cooking and hot water preparation purposes. Although gas imports have dropped drastically during the economic/energy crisis years, they have been growing over the past 5 years. **Box 2** provides a brief overview of the gas sector development since its creation and the gas import trend. Statistics on the number of natural gas customers in recent years is presented in the **Table 5.1** below.

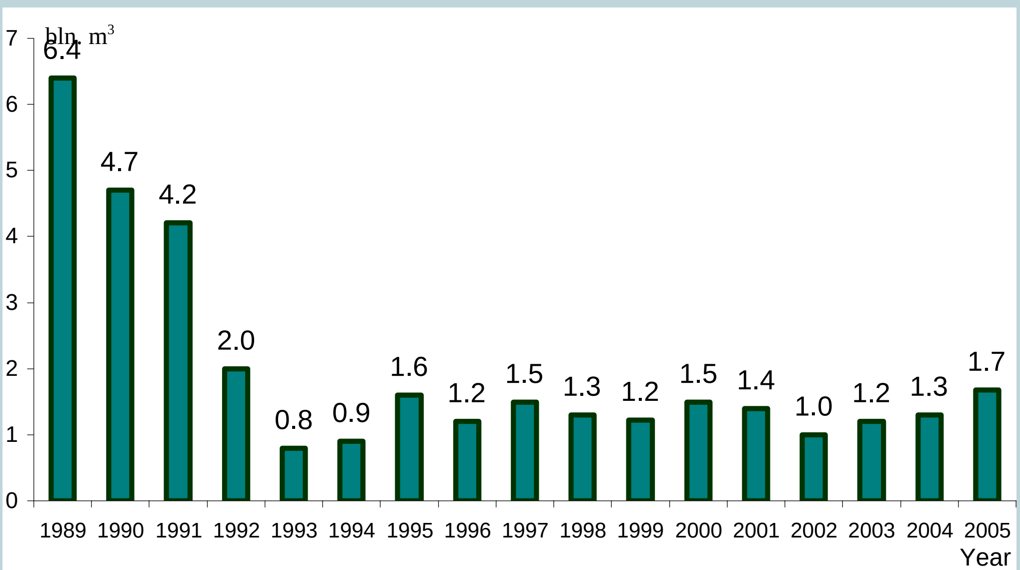
In recent years, "Armrusgasprom" CJSC made significant investments in the rehabilitation and improvement of Armenian gas distribution system including the introduction of the metering system. The number of residential gas consumers continues to increase, as more multi-apartment buildings are being gasified. Furthermore fee collection also improved and reached up to 100%. The new customers not only pay a connection fee of about US$150-200, but also about a $100 refundable security deposit. The individual natural gas heating is promoted by "Armrusgasprom" CJSC by the ongoing intensive expansion of the gasification infrastructure in residential areas.

Box 2. Overview of Armenian Gas Sector Development

The gas sector of Armenia, designed and started up in early 1960s, operated through the natural gas import from Azerbaijan, Russia and other Soviet republics and also indirectly from Iran through the former Soviet gas supply system via Georgia and Azerbaijan. The crisis in the country's gas sector started in 1992. As after the collapse of the Soviet Union in 1991 the natural gas supply to the country decreased sharply and the gas supply via pipelines through Azerbaijan were suspended since mid 1991 due to the war of Nagorno Karabakh, the only operating gas-transportation pipeline via Georgia remains, which was regularly interrupted by acts of sabotage and explosion.

However, the energy crisis of the country was overcome in 1995 and a gas sector development strategy program was developed and implemented in 1997-98. The Program had targets of rehabilitation and modernization of gas distribution networks; reforming and privatization of the gas sector; and diversification of gas-transporting routs to Armenia. During 1991-94 the public and residential buildings were without heat and the entire population suffered below-zero temperature winters with electricity supply of 2-3 hours per day.

The graph below shows the Dynamics of natural gas import levels during 1989-2005 (*Source of statistics:* Heat Energy Market Assessment Report - USAID/RHP)



According to the rules and regulations of the Public Services Regulatory Commission, natural gas consumers in the Armenian gas sector are categorized into two groups: consumers with consumption over 10,000 m^3/month (wholesale tariff) and consumers with less than 10,000 m^3/month (retail tariff). This tariff mechanism is created to support the large gas consumers, thus creating a cross-subsidy mechanism where residential consumers subsidize the cost of gas consumption in the industrial, commercial and power sectors. However, in case of small central heating systems, the monthly gas consumption often approaches the wholesale threshold, and boiler operators intentionally use the fuel and heat energy wastefully to qualify for the cheaper tariff. Hence, the diversified tariff mechanism creates an obvious disincentive for energy efficiency.

Table 5.1. Dynamics of Natural Gas Customers

Year	Total number of customers	Number of residential customers	Residential consumer growth rate
1999	70,162	69,760	
2000	101,613	101,003	44.7 %
2001	113,259	112,494	11.7 %
2002	132,925	132,160	17.4 %
2003	187,918	185,690	40.9 %
2004	272,127	268,316	44.8 %
2005	364,115	360,637	33.7 %

Source: Heat Energy Market Assessment Report - USAID/RHP)

Starting in April 2006, Russia raised the gas price for Armenia from US$54 to US$110 for 1000 m^3. This translated into a gas sales price rise by ArmRusGasprom from 59 to 90 AMD/m^3 for consumers with monthly consumption below 10,000 m^3; and from US$79.10 to US$146.51 per 1,000 m^3 for consumers with monthly consumption over 10,000 m^3. To mitigate the negative impact of this drastic gas price increase on the population as well as on industry, the Government of Armenia allocated $180.0 million to subsidize the increased gas price.[24] As of April 10, 2006, the state subsidizes 25 AMD of the current 90 AMD charged for one cubic meter of gas for all consumers with below 10,000 m^3/month consumption and US$52.01 of the US$146.51 charge for 1,000 m^3 for all consumers with over 10,000 m^3/month consumption. The subsidy will be in place for three years.

In November 2006, ArmRosgasprom applied to the Public Services Regulatory Commission (PSRC) to revise the current gas tariff. The Commission intends to partially satisfy the application, proposing that the gas tariff raise from $146.51 to $153.26 (in AMD equivalent) instead of ArmRosgasprom's proposed $178.72 for industrial enterprises. On the other hand, the Commission proposed a reduction in the gas price for the population using less than 10,000 cubic meters, from AMD 90 to AMD 84 per cubic meter; ArmRosgasprom had proposed leaving the tariff unchanged.[25] These new tariffs came into effect January 1, 2007.[26]

The rationale for these prices is to allowing industry to enjoy subsidized gas tariffs for another three years in hopes that products made in Armenia will be competitive in foreign markets. However, Russia will be reviewing the gas price in three years, and a new rise is likely given that the sales price for Armenia is still well below the international market price. Under such circumstances, the temporary, artificially low energy prices, particularly for energy-intensive industries such as cement production, will eliminate incentives for energy efficiency. When the subsidy is terminated and prices rise further, consumers will not have made the efficiency improvements needed t make them ready for the growing energy costs. These subsidies impede the market for energy efficiency products and services and the implementation of the recently adopted Energy Saving and Renewable

[24] *To generate these funds, the Armenian Government sold the fifth unit of the Hrazdan Thermal Power Plant to Russia.*

[25] ARKA, Yerevan, November 27, 2006

[26] http://www.psrc.am/en/?nid=218 (last visited on March 5, 2007)

Energy Law. They also hinder the ability of Armenia to take advantage of the Kyoto Protocol Clean Development Mechanism, as well as other government, public and IFI initiatives aimed at improving energy efficiency in the industrial, commercial and residential sectors.

It is noteworthy that if the Armenian Government's allocated $180 million subsidy were targeted towards the implementation of energy efficiency measures in 21,911 multi-apartment buildings of the country, each building would receive $8,215, which is enough to implement weatherization of apartment doors and windows as well as building envelope. More thorough analysis of the linkage between gas price subsidies and weatherization implementation is provided in the study by Alliance to Save Energy titled Addressing Affordability of Utility Services in Urban Housing in Armenia: Energy and Water Efficiency Solutions.

5.3 AVAILABILITY OF ENERGY EFFICIENCY PRODUCTS AND SERVICES

The recent initiatives, technical assistance programs, and financing mechanisms promoting rehabilitation of urban heat supply have generated an increased demand for state-of-the-art heating equipment. This newer equipment not only yields a higher quality heat supply, but is also environmentally friendly, energy efficient, and creates incentives for saving and an improved fee payment culture by allowing both the proper control and monitoring of heat. Although Armenia imports most heating equipment from other countries, mainly from Russia, the U.S., Europe and Iran, local manufacturers also produce some of the equipment required for rehabilitation and construction of efficient heating systems.

Thanks to USAID efforts over recent years, the energy service provision field has started to fill with private companies providing a wide spectrum of energy services such as weatherization of buildings and heating networks, the design, mounting and maintenance of boiler houses, and consulting. Although this is a new sector of the economy, there are over twenty companies specializing in the provision of one or several energy services. Some of the companies use their own locally produced heating equipment and weatherization materials while others use predominantly imported equipment and materials (e.g., Russian, German and Italian).

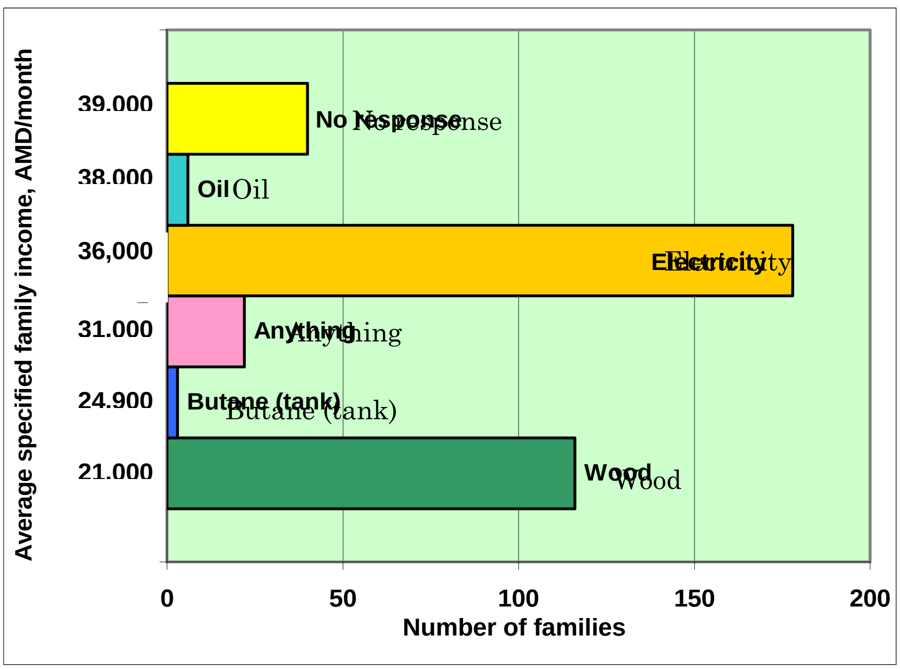
For example, South Therm, Ltd. is a good example of an energy service company (ESCO), that has successfully constructed a heating system for one residential building, continued to maintain and operate it, and supplied heat through a contractual relationship with the residents of the building #33 on Sayat-Nova street in Yerevan. The initiative was so successful that the company currently serves seven buildings (see Chapter 6.4 on Heating Pilot Project Implementation in Armenia and their Techno-Economic Features). Nevertheless, high interest rates and legislative gaps still hamper the application of ESCO financing schemes.

Other examples of efficiency providers are Arjermek Ltd and Ecoperlit LLC, which produce weatherization materials from local, environmentally friendly raw materials: Arjermek produces rock-wool (based on basalt super-thin fiber) mattes and cords, and EcoPerlite produces perlite slabs for insulation of vertical and horizontal surfaces of buildings. The Stone and Silicates Research-Production Project Institute CJSC manufactures granulated foam glass. The Mekusich Production Cooperative (PC) and AR&AR Engineering Ltd., local heat equipment producers, specialize in installation of heating equipment and appliances, operation and maintenance, production of boilers which have received ISO certificates. Local companies produce energy efficient windows from local and imported materials using imported technologies. Detailed information about local and foreign producers (companies) as well as information on technical features of their produced heating equipment and weatherization materials is available in the Report on Armenian Heat Supply and Heating Equipment Market Assessment prepared by the Alliance to Save Energy. [27]

5.4 SOCIOECONOMIC CONSIDERATIONS IN HEATING FUEL CHOICE

About 365 residents of multi-apartment buildings were surveyed in four cities of Armenia (Yerevan, Sevan, Charentsavan and Hrazdan) in November 2003.[28] The correlation between household income and the choice of different heating sources (except DH) is illustrated in **Figure 5.4**. The use of natural gas is not mentioned in the figure because the surveyed multi-apartment buildings were not yet gasified as of 2001-2002.

Figure 5.4. Correlation Between Average Household Income and Choices of Heating Source (Excluding DH) for the 2001-2002 Heating Season



For reference, the official exchange rate was 564.86AMD per USD on 22 December 2001

The survey results showed that families continue using firewood for heating, and that households with average monthly income below AMD 31,000 use wood or any other kind of different type of fuels they can find. Obviously, the first and foremost reason for using dirty fuels is low income. Consequently, dirty fuel burning leads to environmental and health problems discussed in Chapter 5.6 on Cross Cutting Concerns: Health, Social, Safety,

[27] The electronic copy is available at http://www.munee.org/go.idecs?i=576&alt=22.

[28] Armenia Urban Heating Project, JSDF seed Fund, Project Completion Report, by National Association of Condominiums Owners and Alliance to Save Energy, 2004

Education and Environmental. This issue can be fully or partially resolved by providing an alternative by rehabilitating the existing central (district or autonomous) heating systems with energy efficient technologies.

The same survey revealed that the overwhelming majority of households (91 percent) would prefer above other heating options a reliable centralized heating system as their main source of heating, if cost was not an obstacle; 90 percent said that they would like a functioning centralized heating service, even though the service would cost more than their current heating costs; and roughly 85 percent of poor and non-poor households expressed a desire for centralized heating because of its convenience.

When households were asked about their willingness to pay for an improved DH during the entire heating season, the answers ranged between $50 and $100 annually. The improved heating system should (i) provide sufficient heat to fully heat apartments, (ii) maintain a minimum of 16°C on a reliable basis 24 hours a day, for as many days per year as the consumers want, (iii) be installed at no cost to the household; (iv) allow end-use control of the heat consumption; (v) issue bills for the improved service based on meter readings of the actual amount of heat consumed, and (vi) allow payments to be spread over 12 months (a "distributed payment option"). The survey results are presented in the **Figure 5.5**. [29]

As can be seen from Figure 5.5, in 2002 the probabilities for choosing improved system at DH service prices are as follows (with USD costs based on the July 2002 exchange):

- about 80% for annual payments of 24,000AMD (42 USD),
- about 60% - for 36,000AMD (64 USD),
- about 40% - for 48,000AMD (85 USD),
- about 25% - for 60,000AMD (106 USD).

It is not a surprise that the probability for poor households to choose the improved DH, especially at higher prices, was low. Thus, the low-income level as well as high level of unemployment can be serious barriers to rehabilitation and construction of energy efficient heat supply systems. However, the recent studies show that the affordability to pay for centralized heating has improved significantly.

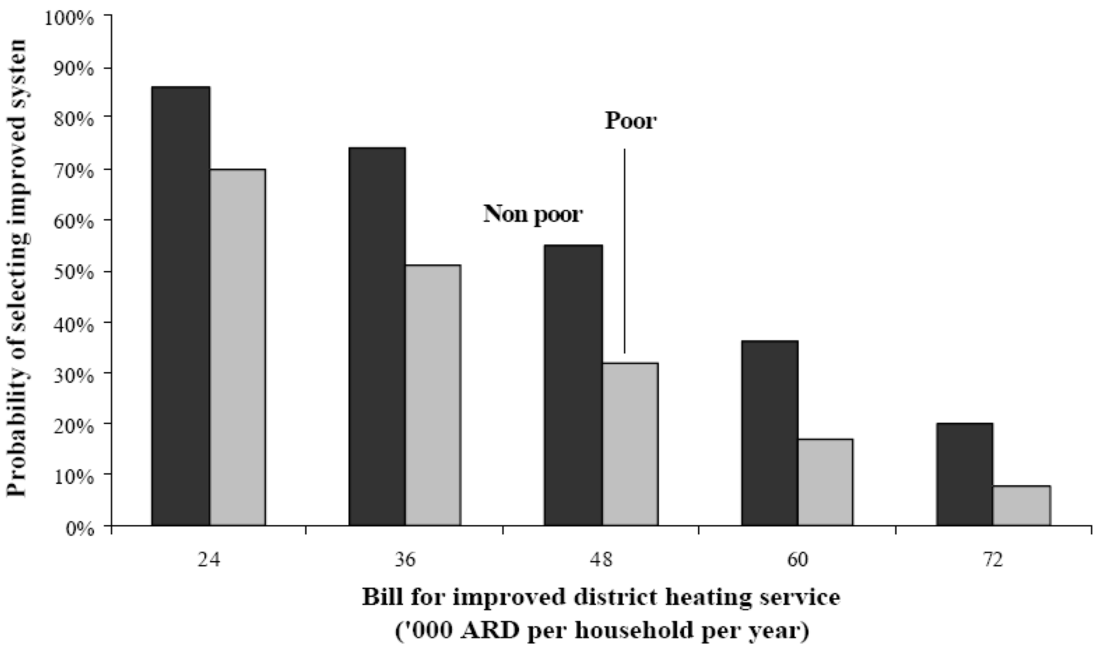
Households who heat their apartments with small-scale centralized heat supply system (see Annex VI: Case Study - Restoration of the Heating System of Residential Building #106 on P. Sevak St.) pay the heating fees shown in **Table 5.2**.[30] Most of the surveyed residents are satisfied with the quality of received heat, therefore they pay for heating and the current average fee of about 125 USD/year per apartment is affordable for them.[31] This demonstrates that an appropriate quality of heat supply in accompanied by an improved willingness to pay, which helps accelerate the pace of centralized heat supply rehabilitation.

[29] Armenia UHS - WB

[30] Lessons Learned from Recent Pilot Projects and Other Heating Projects, USAID/Residential Heating Project, 2006

[31] Lessons Learned from Recent Pilot Projects and Other Heating Projects, USAID/Residential Heating Project, 2006

Figure 5.5. Preferences for Improved District Heating (Percent)



For reference, the official exchange rate was 565AMD per USD in July 2002.
Source: Calculated from 2001 household survey data (Gonzalez/Lampietti (2002)

Table 5.2. Amounts Paid for District Heating by the Residents of Building #106 on P. Sevak St.

Apartment	Heating fee			
	AMD/month	USD*/month	AMD/year	USD*/year
1-room apartment	12,300	27	49,200	108
2-room apartment	16,500	36	66,000	145
3-room apartment	15,763	35	63,052	139
4-room apartment	20,143	44	80,572	177

**For reference, the official exchange rate was 455.22 AMD per USD on January 17, 2006.*

5.5 Social Assistance for Heat Supply

The only utility-related subsidy provided by the Government of Armenia is the natural gas subsidy (see Chapter 5.2 on Gas Consumption in Residential Sector). At present, there is a subsidy provided to the residents of Armenia – the Family Poverty Benefit Program – which is calculated based on the score given to each family gets according to the current legislation. (More detail see Addressing Affordability of Utility Services in Urban Housing: Energy and Water Efficiency Solutions, by Alliance to Save Energy, 2006.) However, considering the cross-subsidy that residential consumers have to pay to allow for a cheaper tariff for larger industrial consumers, the residential consumers would have been better off if both the state subsidy and the cross-subsidy were eliminated.

Although there are no state subsidies for heating, some general social assistance is provided:

1. Local government has a social budget, which is allocated for emergency needs of lo-income households. In most cases, these are cash remittances to cover utility bills for pensioners based on majority vote of the community council. There were cases of loan-assisted heat supply rehabilitation pilot projects, where the municipality provided funds to cover the contribution required of the participating low-income households, or in some cases the municipalities cover the heating fees for poor families.
2. Within the framework of the WB Urban Heating Project, $4 million was allocated, of which $3 million came from an IDA loan borrowed by the GoA and $1 million ws allocated by the GoA. The project was for grant assistance to low income households to make capital investments to rehabilitate heat and hot water supply systems. Eligibility is based on the official listings of the existing Family Poverty Benefit Program. Another $3 million has been received from the British Global Partnership for Output-based Aid (GPOBA) for the same purpose.[32] These funds will be used for either covering the investment portion of low-income households in building-level heating projects, or allow such families to install apartment-level gas heaters where building-level solutions are not feasible.

Another significant barrier for centralized heat supply system rehabilitation is the low collection level of heating bills and/or advance payments (for gas and system start up adjustment). This occurs not only because of social problems and the low quality of heat supply services, but because of bottlenecks in the heating system design and operation (see Annex VII: Case Study on Restoration of Heat Supply in Residential Buildings of Jrashat Condominium in Yerevan). The collections problem is further aggravated by the large number or absentee owners which is widespread in Armenia due to massive emigration. Another problem is the absence of effective customer organizations that would be able to contract for communal services.

5.6 CROSS CUTTING CONCERNS: HEALTH, SOCIAL, SAFETY, EDUCATION AND ENVIRONMENTAL

The widespread use of inefficient, polluting and unsafe heating technologies in multi-apartment buildings and schools comes with considerable drawbacks for users, such as high recurring costs, visible smoke and associated health and environmental effects inside and outside buildings, and safety hazards.

Social Impacts

Heating-related expenditures for the 4four to six months of the heating season consume a significant portion of household income and contribute to poverty. During the winter months, up to 50% of family expenditures are used for heating purposes. Socioeconomic issues are discussed in Chapters 5.4 and 5.5 of this report.

[32] Project Appraisal Document on a Proposed Credit in the Amount of SDR 10 million (US$ 15 million equivalent) to the RA for an Urban Heating Project, The World Bank, June 3, 2005

Health Impacts

According to a survey conducted by the World Bank in Armenia, only 29% of urban multi-apartment households have not had illness due to dwellings insufficiently heated during the winter of 2004-2005 (for example, over 14 percent of population had colds and over 60 percent had influenza). Naturally, children and the elderly are more vulnerable to colds and other illnesses due to under-heated living space and public buildings (e.g. schools or hospitals), or other consequences of unhealthy heating, such as polluted or very humid indoor air and temperature fluctuations between rooms. **Figure 5.6** shows an increased risk of disease in apartments which are heated partially or not heated at all. [33] The figure also shows the increased vulnerability for children. Based on a 2002 household survey, 3,467 annual life years are lost per 100,000 children under five, and 120 life years lost per 100,000 women, due to indoor urban smoke exposure. Moreover this survey found that smoke exposure related health problems, such as upper respiratory diseases, headaches, sore eyes, swelling of extremities and blood circulation problems, are especially pronounced among poor households.

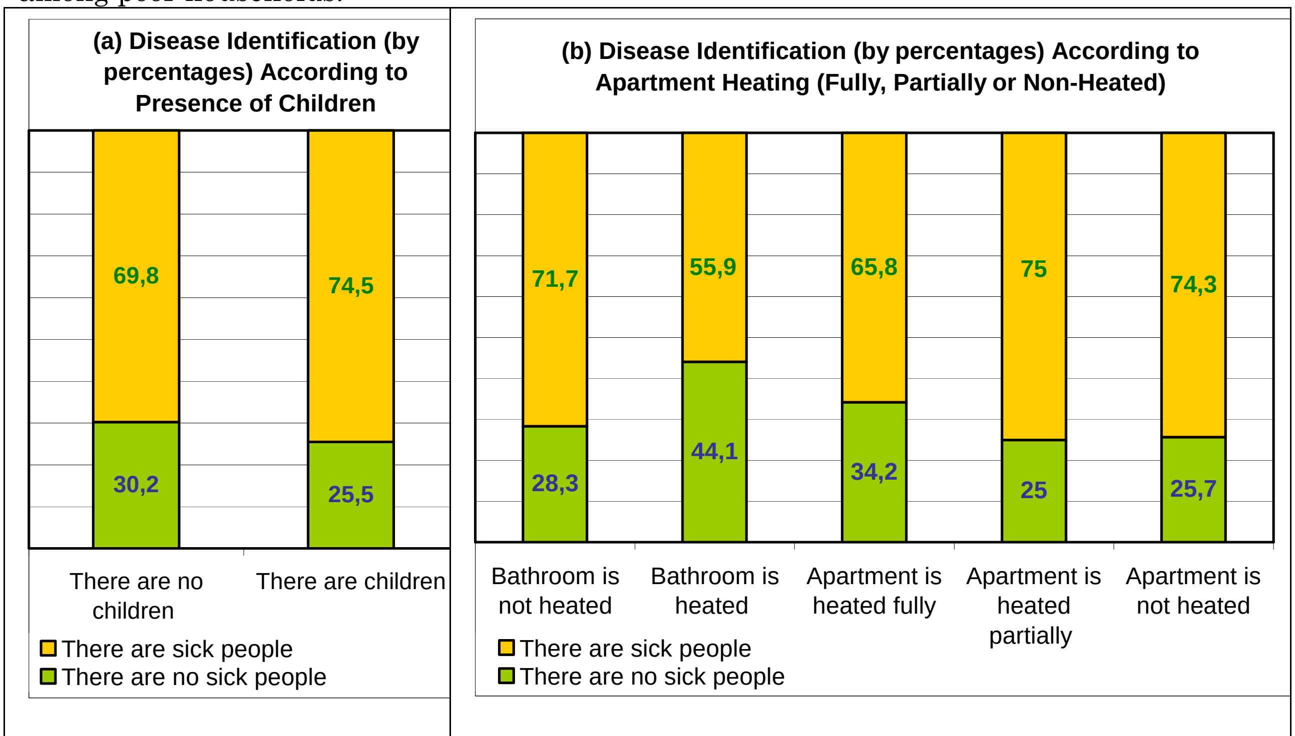


Figure 5.6. Correlation Between Disease and Apartment Heating

Safety

Deaths and injury to people caused by gas and CO poisoning, fires and explosions have become a serious problem and they continually grow with the increasing gasification of the country. Statistics on the number of gas sector accidents that occurred in the country during the period from 1999 to 2005 are shown in the **Figure 5.7**. The accidents occur mostly because the population is not aware of proper gas appliance operation and regulation, along with the insufficient level of service provided by gas companies and the deteriorated conditions of many of the pipes. The GoA together with PSRC undertook a

[33] Survey of the Thermal Energy Supply Situation in Urban Settlements of Armenia, "Thermosupply Programmes" PIU SI of the Ministry of Finance and Economy of RA, Economic Development and Research Center, 2005

number of activities to mitigate further possible accidents. On July 8, 2005, the PSRC adopted resolution No. 92-N, “Rules for Natural Gas Supply and Use”, which defined the rules and conditions for natural gas supply system construction/restoration as well as distribution system operation and technical maintenance.

According to this resolution, Armrusgasprom CJSC is responsible for the inspection and testing of the in-house gas consumption systems and technical servicing of the gas distribution system. The resolution entered into force on November 1, 2005. Furthermore, aiming to raise public awareness on gas-use safety, Resolution No. 199 was adopted by PSRC on December 2005. According to this resolution the “Gas Supply Contract for Residential Consumption between the Supplier and the Customer” includes a section called “Safety Rules and Requirements for In-house System Use and Routine Residential Gas Use”. The USAID Residential Heating Project has helped ArmRusGas develop gas safety leaflets and public service announcements. For individual gas heating, it is also noteworthy that, under circumstances of general failure to maintain the norms and at least annually clean/revamp the smoke outlets, there is a serious threat to the health and the lives of the residents.

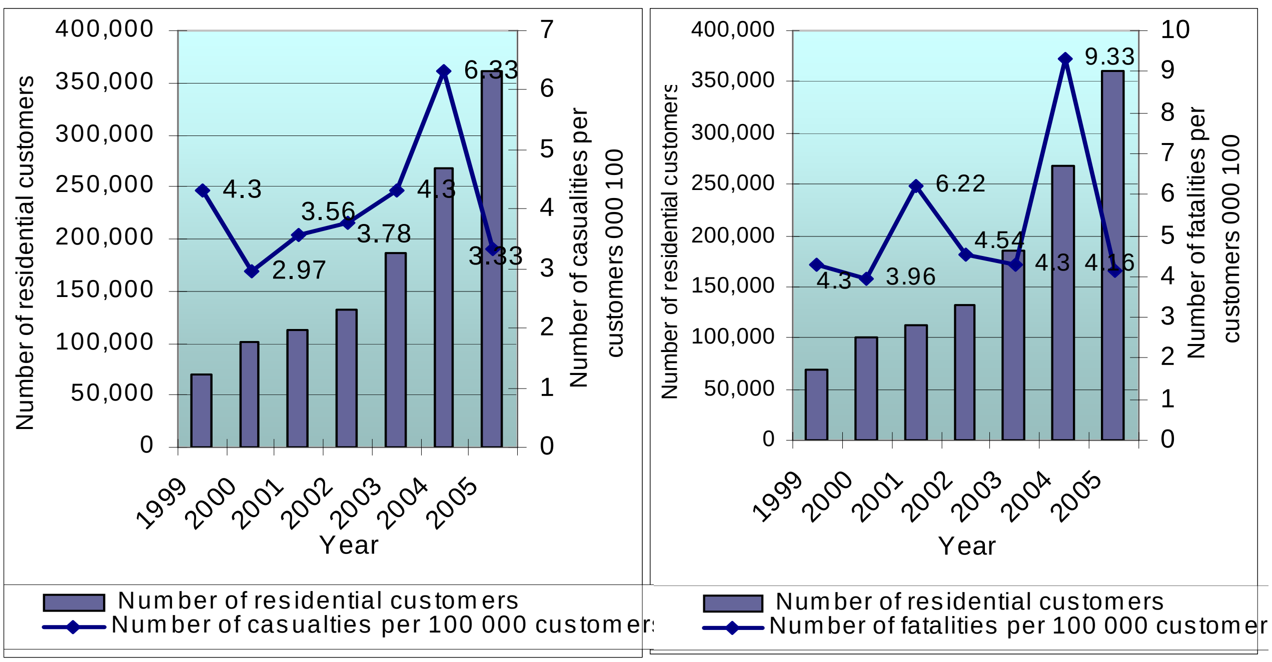


Figure 5.7. Statistics on Gas Sector Accidents (Casualties and Fatalities)
Source: “Armrusgasprom” CJSC, (Heat Energy Market Assessment Report - USAID/RHP)

Heat-Assisted Education

Due to the lack of adequate heating, many schools either do not function during the winter months (average idle winter time in urban schools in 2004 was one month) or the classrooms are not heated properly (even in heated schools the temperature is often below 8^{o}C). They are also very much polluted due to the on-site combustion of fuels such as wood and kerosene. The end result is a reduced quality of education and negatively health impacts on the students.

Currently, there are at least three programs directed at creating healthy and safe heating in Armenia's schools, including the following:

1) the USAID/EIICG School Heating Program;
2) the school heating component of the WB Urban Heating Project ($6.25 million: $5 of which is allocated by IDA and $1.25 million by the GoA);[34] and
3) The Government Social Investment Fund to help rehabilitate heating for schools.

Environmental

The extensive use of wood for heating purposes started in the energy crisis period of the 1990s and continued for over ten years, contributing significantly to deforestation and air pollution, as well as detrimental health impacts, particularly for the young and old. From the perspective of environmental protection, inappropriate heating systems have both local and global environmental impacts, such as poor air quality, accelerated climate change, acid rain, and the unsustainable use of forest resources. These factors should be taken into consideration when developing further environmental policy.

The United Nation Framework Convention on Climate Change, the Kyoto Protocol and European Union Directives on limiting emissions, as well as the Convention on Long-Range Transboundary Air Pollution of the European Economic Commission, can play an important role in the formulation of national environmental policy that influences energy policy, such as the implementation of energy saving technologies in heating systems; the promotion of combined heat and power production (CHPs), and the rehabilitation of district heating systems to replace small, individual heating systems.

6 Techno-Economic Features of Heat Supply Options

This section discusses the available centralized and individual heating options for urban heating in Armenia and compares the possible central heating options for different situations in Armenia. The main objective of this section is to facilitate the choice of heat service for the population of a country with a high dependence on imported fossil fuel. This will be done by describing the technical, administrative, regulatory and other strengths and weaknesses of various heating systems, and by comparing their efficiency, safety and affordability parameters. The available heating options, disregarding home-made wood and kerosene stoves, include the following:

1. ***Centralized heating*** (both new construction and rehabilitation of existing facilities), including:
    a. District heat with HOB
    b. CHP/DH
    c. Small centralized heating (non-DH): an individual HOB for one to several buildings.
2. ***Individual, apartment-level heating*** using:
    a. Apartment gas-fired boilers for heat and hot water preparation

[34] Project Appraisal Document on a Proposed Credit in the Amount of SDR 10 million (US$ 15 million equivalent) to the RA for an Urban Heating Project, The World Bank, June 3, 2005

b. Room direct-gas space heaters.

The following sections describe the techno-economic features of the above heating options, their advantages and drawbacks.

6.1 CENTRALIZED HEATING REHABILITATION POSSIBILITIES

Old or new district heating systems will be able to provide the required quality of heating and hot water supply, as well as individual control by the residents, only after major repairs and investments. It is necessary to equip the heating system with modern, efficient heat exchangers, automatic regulators and control, and measurement devices. Taking into consideration the current state of the heating systems presented in the Chapter 2, there are two main directions for rehabilitation/construction of DH systems in number of cities, which will ensure efficient heat supply system:

1) Reconstruction and upgrade of existing systems with modern equipment, and
2) Construction of new DH systems using modern efficient technologies.

Both trends can include heat-only as well as cogeneration systems concepts.

District Heating

Few options for DH rehabilitation for number of areas in Armenia were analyzed by donor funded projects: the UNDP/GEF Project together with a local design institute studied the heating system restoration alternatives for Avan and Davitashen districts of Yerevan with consideration of reconstruction of a HOB House to Combined Heat and Power Plant (CHP);[35] the USAID Residential Heating Project developed municipal heat supply plans for the cities of Sevan[36] and Spitak discussed in the next sub-chapter.

Small Scale Centralized Heating

A small group of buildings or single building receiving heat from a local boiler house with small capacity. Because such systems do not supply a full district, some experts also refer to them as decentralized heating systems. The boiler house is situated not far from the buildings (it can also be located on the roof of a building) and the heat is supplied only through distribution pipelines. The heat carrier temperature does not exceed 95°C. There is no district heating substation and main heating networks in such systems. The scheme is simple and not expensive; heat loss from the distribution network is relatively small due to its small length.

6.2 COMPARISON OF CENTRALIZED HEAT SUPPLY OPTIONS

The USAID Residential Heating Projects has compared heat supply options for a particular area in the city of Sevan in Gegharkunik marz of RA through the development of the heat supply scheme/plan for this city. [37] The heat supply plan for Sevan was developed according to Government Order No. 509-N on Pilot Projects of Heat Supply System Rehabilitation with Implementation of Heat and Power Cogeneration Units, adopted 13 April 2006.

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[35] Analysis of the Energy Efficient Heat Supply Options of the Multi-Apartment Buildings in the RA, UNDP/GEF/00035799 "Armenia - Improving the Energy Efficiency of Municipal Heating and Hot Water Supply", 2006; and Possibilities for Reconstructing and Improving EE Heating & HWS – UNDP/GEF

[36] Heat Supply Scheme for City of Sevan, USAID/Residential Heating Project, Yerevan 2006 (Heat Supply Scheme for Sevan - USAID/RHP)

[37] Heat Supply Scheme for Sevan - USAID/RHP

This heating plan includes heat supply rehabilitation based on territorial zones, each with different building types and heat load densities. One of the zones studied has features typical for the rest of Armenian urban settlements, and the applicability of a variety of possible heating options. Heating options applicable for such typical municipal zones are described below.

Option I - Individual boiler house

This option assumes one boiler house per building. The techno-economic features for two typical buildings (36- and 40-apartment buildings) were analyzed for this option. The designed heat loads for typical buildings are given in **Table 6.1**.

Table 6.1. Typical Heat Loads for Armenian Apartment Buildings

Typical buildings	Heating load	Hot water load	Total heat load
	kW		
36-apartment	210	63.6	273.6
40-apartment	225	71.2	296.2

Option II - Autonomous boiler house for micro-district

This option assumes a boiler house per micro-district with about six to ten buildings of similar type (the designed heat load for the typical micro-district in Sevan is 1798.4kW, including 1407.3kW for heating and 391.1kW for hot water supply).

Option III - Boiler house for group of micro-districts

In this option a boiler house per three micro-districts with 20 to 30 buildings is presumed. The heat load for groups of micro-districts is calculated as given in **Table 6.2**.

Table 6.2. Heat Loads for Boiler Houses Serving 20 to 30 Buildings

Group of micro-districts	Heating	Hot water	Total heat
	kW		
Group 1: micro-districts #1, 2, 3	5380.3	1595.5	6975.8
Group 2: micro-districts #4, 5, 6	5022.4	1443.0	6465.4

Option IV – Central boiler house for a whole county of micro-districts

In this option a boiler house provides heat to all micro-districts in an entire county. Therefore, the designed heat load for this system is the sum of the calculated heat loads of over 30 multi-apartment buildings. (In Sevan the heat load is 10402.7 kW, the hot water load is 3038.5 kW, for a total heat load of 13441.2 kW.)

Option V - Combined heat and power plant for a whole county of micro-districts

Combined heat and power (CHP) is considered the best for energy savings and the use of energy efficient technologies. The techno-economic calculations are made for a centralized heating system with CHP furnished with GE Jenbacher cogeneration equipment. The designed heat loads are the same as for the Option IV.

Table 6.3 presents the key techno-economic features for aforementioned five heating options, each of which is considered with two sub-options: (a) heat supply for only heating purpose and (b) heat supply for both heating and domestic hot water supply.[38] The apartment-level investments and heat tariffs for four options excluding CHP are presented in **Figure 6.1**.[39] The following conclusions on heat supply options can be derived from Table 6.3 and Figure 6.1:

1. The heat supply option with individual boiler house (Option I) has the highest heat tariffs for all values of IRR.
2. The enlargement of centralized heat supply systems (from Option II to Option III) brings to heat load drop, which is not being compensated with cut in investments and has negative impact on heat tariffs.
3. The option with central boiler house for county of micro-districts (Option IV) has the lowest level of investments and heat tariffs for almost all values of IRR.
4. The option with CHP (Option V) has the lowest heat tariff level in case of low values of IRR, which is linked to the CHP electricity feed-in tariff set by the PSRC.

Table 6.3. Comparison of Options According to Apartment- Level Investments and Heat Tariffs

Option*	Heat Load Density, kW/m	Investments per Apartment, USD	Tariffs Calculated for Different Values of IRR			
			10%	12%	14%	16%
Option I (a)	N/A**	36-apt: 687 40-apt: 788	10,433 10,163	10,832 10,548	11,247 10,949	11,677 11,365
Option I (b)	N/A**	36-apt: 641 40-apt: 710	10,402 10,086	10,735 10,406	11,084 10,740	11,433 11,085
Option II (a)	4.82 3.40	MD 1: 483 MD 6: 540	7,631 8,057	7,903 8,368	8,187 8,692	8,482 9,027
Option II (b)	6.30 4.42	MD 1: 537 MD 6: 600	7,449 7,808	7,671 8,061	7,902 8,323	8,141 8,596
Option III (a)	2.70 3.16	Group 1: 580 Group 2: 531	8,282 7,957	8,623 8,267	8,976 8,589	9,342 8,924
Option III (b)	3.50 4.10	Group 1: 640 Group 2: 580	7,856 7,632	8,127 7,883	8,409 8,144	8,701 8,414
Option IV (a)	3.24	County of MDs: 503	7,691	7,984	8,288	8,603
Option IV (b)	4.20	County of MDs: 542	7,349	7,581	7,823	8,073
Option V (a)	3.24	N/A***	7,270	8,663	10,113	11,617
Option V (b)	4.20	N/A***	6,081	7,115	8,186	9,294

Source: Heat Supply Scheme for Sevan - USAID/RHP

**(a) denotes heat supply for heating only and (b) denotes heat supply for both heating and domestic hot water supply.*

*** The concept of heat load density is not applicable for the option with individual, building level boiler house.*

****Capital investments per apartment for the option with CHP are provisional and can not be used as a decisive factor for comparison, because it is difficult to identify the share of investments for electricity and thermal energy.*

[38] Heat Supply Scheme for Sevan - USAID/RHP

[39] Heat Supply Scheme for Sevan - USAID/RHP

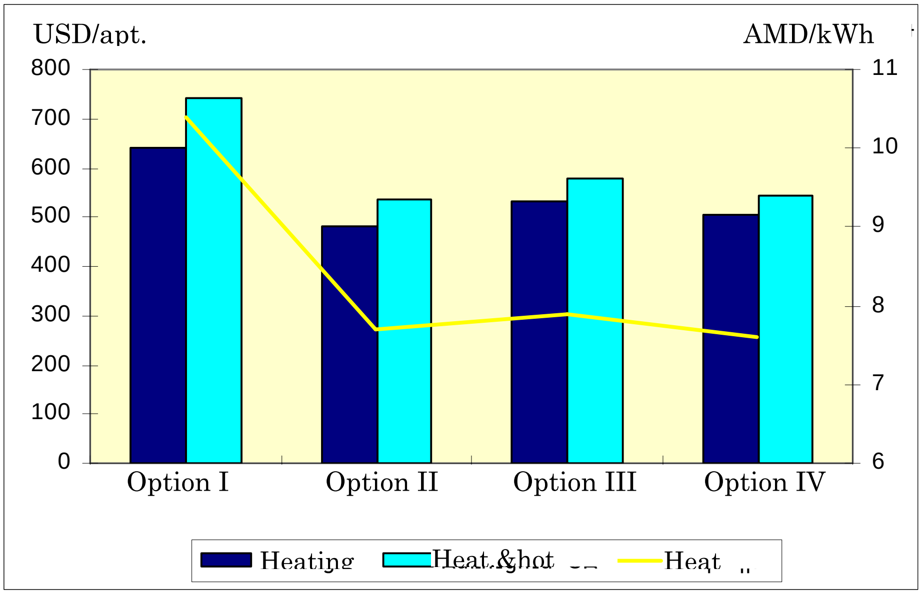

Figure 6.1. Comparison of Heating Options According to Investment per Apartment and Heat Tariffs

It is worth analyzing the options with central boiler house and CHP to identify the feasibility of options for different values of IRR.

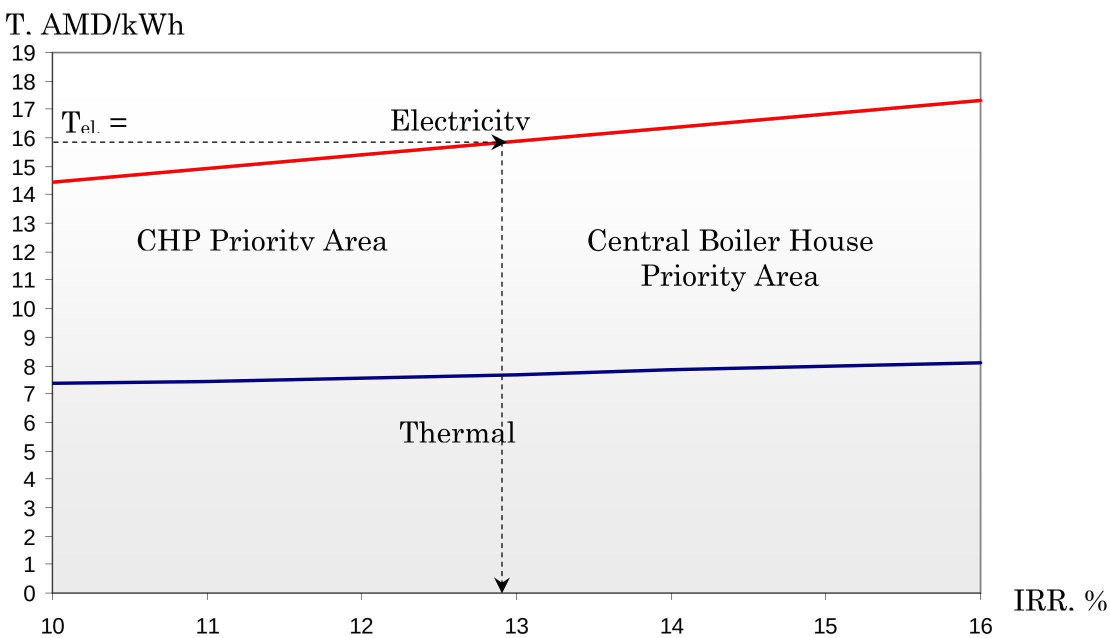

Figure 6.2. The comparison of CHP and Central Boiler House

Figure 6.2[40] allows to identify the IRR value, which guarantees the cap tariff (15.917AMD/kWh equivalent to that of Hrazdan TPP according to the Govt. Decree No.509-N) for CHP generated electricity and the same level of thermal energy tariff for both options (CHP and central boiler house). As it is evident from the graph, that feed-in tariff allows for IRR value of 12.9%, the CHP as well as central boiler house assure the same level

40 Heat Supply Scheme for Sevan - USAID/RHP

of thermal energy tariffs. If the IRR is less than 12.9%, the Option 5 (CHP) is less feasible than Option 4 (central boiler house). This occurs because the CHP is much more capital intensive and the investments can be return through the comparably high value of IRR only. [41]

6.3 INDIVIDUAL (APARTMENT-LEVEL) HEAT SUPPLY

The intensive gasification of residential buildings during the recent years leads to a fast dissemination of apartment-level gas heating. Individual apartment heating is the fiercest competitor of DH even in countries with highly cost-effective DH systems. In Armenia, where DH has predominantly collapsed, and new centralized heating alternatives are lapsing, the majority of the population opts for individual heating options, which are easier to install, do not depend on other members of the community, and do not have institutional and organizational problems. Furthermore, individual heating allows residents to regulate heat consumption and to save funds even through sacrificing their comfort level, which is particularly important for low-income families.

The individual natural gas heat supply option presumes the installation of gas heaters or boilers and gas water-heaters in each apartment together with the gas pipelines, and individual gas meters for each apartment, in the hallways. In the case of apartment boilers, an internal two-pipe network is also necessary for heat and hot water circulation.

Apartment-level gas heaters (stoves) are five to ten times cheaper than an apartment-level heating and hot water supply system with gas-fired apartment-level boilers. In most cases, gas stoves do not heat the apartments evenly: the temperature varies in different rooms, resulting in the condensation of water vapor (a gas burning by-product in addition to regular indoor humidity). This condensate ruins walls and carpentry in colder rooms.

Unlike gas stoves, apartment-level gas boilers guarantee an appropriate and even heating and hot water supply. The investment required for a heat supply system designed for an apartment with an area of 70 to 130m^2 is between about US$1500 and 2500 depending on the quality, type and price of the installed equipment. Since these systems usually have over 85% efficiency, the average household gas bills range from US$30 to US$70, which is 15% to 20% less than that in the case of a gas stove.[42] In addition to higher efficiency and comfort, the boilers also supply domestic hot water.

Currently there are many companies in the Armenian market that manufacture and/or import and supply individual gas boilers: Italian-manufactured Baxi, Ecoflam, Biasi, Lamborghini, Beretta, Ferolli, Riello, Sime, Ariston and Fondital; German manufactured Buderus, Vaillant and Viessmann; Spanish-manufactured Roca; Czech-manufactured Mora; Swedish CTC and Osby Parca; Chinese-manufactured Mercury; and Korean Kiturami and Lotte boilers with open and closed combustion chambers.[43] Aside from more imports of equipment, to meet the vast demand for this heating option, over the past three to four years many construction and engineering companies have started offering installation services for apartment-level heating systems.

[41] Heat Supply Scheme for Sevan - USAID/RHP

[42] Heat Energy Market Assessment Report - USAID/RHP

[43] Heat Energy Market Assessment Report - USAID/RHP

These individual gas boilers are used mostly in single-family houses and in multi-apartment buildings no more than 3 stories high that are equipped with smoke outlets and ventilation facilities. However, this option has limited application in multi-apartment buildings due to the serious, sometimes irresolvable problems related to the organized ventilation of smoke gases. Exhaust chimneys have appeared in the walls of multi-apartment buildings creating a construction safety and environmental hazard. In this regard, Temporary Regulations for Restoring (Reconstructing) Gas Supply Systems of Multi-Apartment Buildings were established by GoA Order No. 2024-N on 5 December 2002, regulating existing multi-apartment building gas supply system rehabilitation (reconstruction) works, prior to the implementation of heat supply activities specified in Order No. 1384-N of GoA adopted 5 September 2002.[44] Further safety issues on this heat supply option are discussed in the Chapter 5.6.

However, the individual (apartment level) heating option is less attractive than centralized heating options discussed in the previous chapter from an economic as well as safety perspective. The investments required for installation of apartment-level gas boilers are two to five times higher than that for the centralized heat supply systems and the market niche for this heating option is limited to more affluent households. And although heat supply systems with apartment-level gas stoves are cheaper than centralized heat supply systems, they are less comfortable, less safe (with over 50 fatalities registered during the 2005-06 heating season), and have a shorter lifespan and major health implications. These factors cause the quality of heat supply service between apartment-level gas stoves and centralized heating systems very different, making any direct comparison between them impossible.

6.4 HEATING PILOT PROJECT IMPLEMENTED IN ARMENIA AND THEIR TECHNO-ECONOMIC FEATURES

There have been over a dozen decentralized heating pilot projects implemented in Armenia aimed at testing and illustrating technical, institutional and economic solutions. The review of these projects allow an analysis of the results received, barriers faced, and lessons learned, and reveal replicable models for application in future heating projects. This section presents three tables where the technical, economic, organizational characteristics of these pilot projects are summarized. In addition, the section summarizes the findings of a customer satisfaction survey conducted by the Alliance in the pilot communities, the beneficiaries of the projects. The list and technical solutions tested under the Armenian circumstances are presented in **Table 6.4**.[45]

The reviewed projects implemented over the past few years have involved 34 multi-apartment buildings and 33 private homes. Heating was rehabilitated in 1,486 apartments with total area of 66,000 m^2. A total of US$665,167 was invested in these residential heating pilot projects, which have an aggregate heat generation capacity of about 9 MW. More details on the individual project details can be found in the Alliance Decentralized Residential Heating Pilot Project Review (the electronic version is available at http://www.munee.org/go.idecs?i=593).[46]

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[44] Possibilities for Reconstructing and Improving EE Heating & HWS – UNDP/GEF

[45] DRH Review – ASE

[46] DRH Review – ASE

Table 6.4. Summary of Technical and Organizational Solutions Piloted in Various Decentralized Residential Heat Supply Projects

Technical Solution	Organizational Solution	Funding Scheme & Ownership of Boiler House	Sites
Introduction of metering and controls on existing DH-supplied building (installation of heat meters, heat allocators, hot water meter and thermostatic valves)	Service contract between condominium association & district heating company. Heat demand regulation and metering by the condominium; payment per consumed heat.	*Condominium Ownership* – Joint World Bank/ UNDP/GEF USAID Grant.	**Yerevan** ▪ 7 Rubinyan St ▪ 1 Avanesov St. ▪ Gumri ▪ 11 P. Sevak St
Installation of heat meters, allocators and thermostatic valves	The building is heated by the “Heating company” SCJSC. Billing based on the readings of the heat meters and allocators.	*Condominium Ownership* – Loan borrowed by the condominium	**Yerevan** 1,2,3,11a and 11b Surenyan St.
Local heat-only boiler house built in the leased old heat distribution point. Installation of modern boilers and auxiliary equipment. Repair of internal and external heating networks, installation of heat meters, allocators, and regulation valves.	Heat supply and billing based on contractual arrangement between the private heat service provider and the condominium.	*ESCO Ownership* – Dutch grant-funded, with investment from Ar&Ar ESCO	**Yerevan, Jrashat condominium** ▪ 92 Jrashat St. ▪ 92/1 Jrashat St. ▪ 1 Baghramyan Dr ▪ 190 Antarayin St
	Heat supply and billing based on contractual arrangement between the private heat service provider and the apartment owners.	*ESCO Ownership* – USAID grant, with investment from SouthTherm ESCO	**Yerevan** 33 Sayat-Nova St.
	Boiler operation, heat supply and billing and collections carried out by “YerFrez” OJSC ESCO.	*ESCO Ownership* – Loan held by ESCO and condominium	**Yerevan** 70/2 A.Avetisyan St.
Construction of small capacity individual heat-only boiler houses, including gas supply and external heat network setup, repairs of internal heat networks.	Boiler operation, heat supply and billing and collections carried out by the condominium management with assistance from municipality. Billing	*Condominium ownership* – Government grant, with investment from municipality.	**Aparan** Buildings 6, 8, 10, 12, 14, 19, 23, 25, 46a and 46b Baghramyan St.

	based on operation costs.		
Construction of a boiler house on land adjunct to kindergarten for heating additional 4 buildings, including construction of external heat network and connections of the buildings' internal networks. Full repair of internal heating network of the kindergarten.	Construction was completed at the end of the 2003/2004 heating season. It is planned that the municipality will operate the boiler house with the help of the condominiums.	*Municipal ownership* – Nor-Nork Municipality grant.	**Yerevan** 3rd New Nork district, buildings 5,6,7,8 Baghyan St. and kindergarten #10.
Construction of boiler house on the roof of the building with replacement of vertical heat distribution with horizontal, including gas supply setup, replacement of heating batteries and pipes, installation of individual, apartment-level meters.	Boiler house operated by condominium. Billing based on operation costs, distributed in accordance with the heat meters' readings.	*Condominium ownership* – JMF grant	**Gumri** 157a Yerevanyan Rte
Construction of boiler house on the roof of the building, gas supply setup, repair of internal heating networks, with vertical heat distribution and heat cost allocators.	Boiler house operated by condominium. Billing based on operation costs distributed through HCAs	*Condominium ownership* – Loan borrowed by the condominium.	**Yerevan** 106 P.Sevak St.,
Installation of Individual Gas Heaters	Apartment level heating. Payment per individual gas consumption.	USAID Grant. *Private household ownership*	**Yerevan** ▪ 29 Papazyan St., ▪ 27/1 Papazyan St. ▪ 21 Atoyan St., New Aresh dist.
Individual gas heaters' installation combined with weatherization	Condominium-managed building. Apartment level heating. Payment per individual gas consumption contracts with gas company.	USAID Grant. *Private household ownership*	**Gumri** 155 Yerevanyan Rte.

Table 6.5. Economic Features of Reviewed Heating Pilot Projects

Pilot Project Name		Heated /Living space	Capital investment costs*				Tariffs		
		m²	USD	USD/ m²	USD/ kW	USD/apt	AMD/ kWh	AMD/ Gcal	AMD/ m²
1		2	3	4	5	6	7	8	9
Boiler house construction/reconstruction									
1	33 Sayat-Nova Ave.	3,600 / 6,000	78,060	13.10	65.00	976	12.50	14,538	1,700
2	Jrashat Condo proj.	5,080 / 10,698	125,000	11.70	156.20	1,097	14.50	16,863	-
3	Nor-Nork municipal PP	16,000 / 9,600	55,000	3.40	44.00	230 + kindergarten**	-	-	-
4	Aparan municipal PP	27,000 / 20,000	72,000	2.60	25.30	257	5.70	6,630	-
5	Erfrez OJSC	5,767 / 2,645	51,713	8.97	87.60	808			
Roof boiler house construction									
10	157a Yerevanyan	2,780 / 1,590	50,000	18.00	167.00	1042	Tariffs based on the operation costs		
7	106 P.Sevak St.	6,419 / 3,251	51,645	15.88	87.53	717	Tariffs based on the operation costs		
Metering and regulating equipment installation*									
4	7 Rubinyan St.	3300/1553	10,505	3.20	-	292	7.60	8,800	1100+ municipal subsidy
5	11 P. Sevak St.	-/645	5,100	7.90	-	340	3.84	4,470	1,100
6	1 Avanesov St.	3265/1872	10,686	3.30	-	237	-	-	900
9	1,2,3,11a,11b Surenyan St.	7870/20366	32,538	1.60	-	139	12.00	13,956	-
Gas heater installation									
11	155 Yerevanyan	3800/2300	61,269	16.10	163.40	1,021	Tariff for natural gas consumption		
12	Fuel Substitution	11200/7000	61,651	5.50	62.90	411	Tariff for natural gas consumption		

Source: DRH Review – ASE
* *The capital investments are provided by total/heated area.*
** *Includes the cost of heating networks' rehabilitation at the kindergarten.*
*** *The estimates do not include the project monitoring cost, which comprised $11,570.*

The economic features including the investments per square meter of residential space, installed unit capacity, as well as tariffs for different pilot projects are summarized in **Table 6.5**. The cost and price estimates presented in Table 6.5 are predominantly expressed in USD, where appropriate, particularly because of the drastic fluctuations in the exchanges rates between USD and Armenian Dram (AMD).[47]

As can be seen in Table 6.5, the investment size and structure varies between projects, since each of them have various starting conditions, different states of physical deterioration in the existing systems, and different installed capacity requirements and auxiliary equipment selection. The major variable was the investment in metering and regulation equipment. Depending on the objectives of the project, some projects placed a great deal of focus on the transparency of the billing and collection process and the opportunities for demand-side regulation. Others, however, focused on maximizing the installed capacity of assets for further expansion, with metering and control devices either not installed or installed insufficiently. It is noteworthy that a greater focus was placed on metering and regulation in condominium-driven projects, whereas when an ESCO provides financing and operation of the boiler house, lack of transparency in billing is in their best interest, so they prefer billing based on apartment space rather than consumption.

The share of investments in billing and regulation equipment in the reviewed projects varies between 12% and 25%, which corresponds to additional investments of between $1.50 and $4.00 per covered area. Annex IV, with tariff analysis for autonomous heating systems' operation and maintenance costs, presents the projection and calculation methodology of operation and maintenance costs for independent heating systems, as well as tariff analysis, taken from the analytic memorandum developed by the Public Service Regulatory Commission.

To evaluate the effectiveness of the heating projects and to reveal the satisfaction level of the project beneficiaries, the Alliance conducted a survey of the participating multi-apartment building management bodies (the condominium managers). The interviewees graded the level of comfort in the heated building after the project completion on a scale of 1 to 5 points, with 1 being extreme discomfort and 5 being a high level of comfort. The general effectiveness of a project was evaluated on a scale of 1 to 10, with 1 being the lowest effectiveness and 10 the highest effectiveness. The findings of the survey are summarized in **Table 6.6**.[48]

The survey revealed that the rehabilitation of building level heat supply has significantly increased the relative level of comfort compared to status quo, however in some cases maximal comfort level and optimal effectiveness was not reached due to financial constraints or technical nuances.

Another noteworthy heating project was implemented by Technokom Ltd. funded by a USAID grant, combined with the residents' own contribution. The heat supply system—with a capacity of 59.5 kW constructed in the framework of this project—provides heat to only one entrance (#4) of the multi-apartment building at #24 on Khachatryan Street in Yerevan. The investment costs were about 40,000 USD, 10% of which was co-financed by the residents of the project site and the other 90% by USAID. The system is being operated by the residents, based on mutual agreement.

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[47] *For reference, the official exchange rate on 18 October 2004 was 506AMD for 1USD. Furthermore, the exchange rate has dropped up to 389 AMD for 1USD according to official exchange rate in September 2006.*

[48] DRH Review – ASE

Table 6.6. Project Effectiveness by Multi-Apartment Building Management

Project Site	Comfort Level after Project		Project Effec-tiveness	Explanation
	Before	After		
	Scale of 1 to 5		Scale of 1 - 10	
Boiler house construction/reconstruction				
33 Sayat-Nova Ave, Yerevan	2	4	9	No condominium association; the project was implemented and operated by a private entity. No transparency of billing, but sufficient heat quality and adequate customer satisfaction.
Jrashat condo-minium, Yerevan	2	4	9	Not all valves are in working order and no valves installed on radiator exits. Mechanical valves (instead of TRVs) installed for thermal regulation do not allow fine tuning—can just be used for turning on or off. Not all parts of the old system were replaced, including main heat pipes, which are so old they create clogging and accident risk.
Roof boiler house construction				
157a Yere-vanyan Rte, Gumri	1	4	8	Budget constraints did not allow thermostatic regulating valves to be installing in apartments, so no individual heat control. But as a 1-building condominium, temperature is regulated based on condominium member opinions. Heat network does not include balancing valves, so the heat is distributed unevenly between apartments. Indi-vidual ultrasonic heat metering devices installed were not used so billing is based on heated space.
Gas heater installation				
155 Yere-vanyan Rte, Gumri	2	3	8	There are two reasons for the low level of comfort: 1. A single heat source (the gas heater) could not provide equal heat supply to all of the rooms; 2. The heaters drastically increased indoor air humidity and condensate in non-heated rooms. However, the residents did not have safety concerns since high-quality Czech heaters were installed, while many Iranian and Turkish heaters installed elsewhere in Gumri have resulted in accidents.
Metering and regulating equipment installation				
7 Rubin-yan St., Yerevan	3	5	9	Due to budget constraints, only a small part of the heating system was repaired, which resulted in uneven distribution of generated heat energy. There is still a need to replace or clean clogged areas in the main heat pipes and risers, and the convector radiators need to be replaced by cast-iron radiators.

11 P. Sevak St., Yerevan	3	3	8	The low assessment of comfort level is because of the insufficient quality of heat from the "Mayisyan" district boiler station both before and after the project implementation, which failed to supply sufficient quality of heat due to large system losses.
1 Avan-esov blind-alley, Yerevan	2	3	4.5	Only a building-level heat meter was installed, the thermostatic valves are limited, and no allocators are installed. Not only is the heat quality is low, the residents are not satisfied with the regulation possibilities of the system.

This project was not discussed in the tables above and can not be considered as a replicable project because its operation is based more on the agreement between the residents than on the legal documentation. There are no contracts and no individual metering devices; the single gas meter installed in the roof-top boiler house provides the reading of gas consumption for the building, with the residents sharing the gas bill according to apartment space. Nevertheless, the system operates successfully due to the well-organized community leadership.

Another USAID-funded pilot project underway is installing apartment-level boilers in a multi-apartment building of Yerevan. Many apartments in multi-apartment buildings have already chosen this option, particularly with the expansion of the gas supply network, wide availability of installation services as well as vendor financing for these systems. This solution is certainly convenient because it eliminates the need to hold numerous meetings with all building residents to achieve consensus on the technical solution, metering and regulation requirements and arrive at a joint decision on the financing and sophistication of the system. However, such a system is not affordable for lower middle class and low-income households because the capital investments required range from $2000 to $2500. In addition, such a system requires disconnection from the existing central heating network, and the installation of an autonomous heating and hot water supply internal network.

6.5 LESSONS LEARNED: CRITICAL FACTORS AFFECTING THE SUCCESS OF HEAT SUPPLY IMPROVEMENTS

The primary lesson from these pilot projects is that energy efficiency is key. In cases with poor insulation/weatherization of common areas (such as basements, entrances, staircase windows and roofs) energy distribution was inefficient and operation costs were high. As could have been predicted, buildings with higher efficiency due to new heating facilities and networks saw a more dramatic drop in household heating bills. Systems with higher efficiency installations demonstrated a resulting market reduction in average monthly heating expenses and their share in household income. This section outlines the major lessons learned from the analysis of past efficiency projects and those critical measures that can guarantee smooth operation of service, and that when poorly implemented or not implemented at all, result in cumbersome system operation, low customer satisfaction, and failure to recover costs.

Lesson Learned #1: *Although higher efficiency equipment and loss reduction measures increase up-front capital investments, the service quality and smaller heating bills result in customer satisfaction, high collection rates and significant savings.*

PROPER CONDITION OF INTERNAL HEATING NETWORKS: The level of customer satisfaction strongly depended on the repair and/or replacement of radiators and risers before starting heat supply. When was done and done properly, low losses, high service quality and customer satisfaction are guarantee. In apartments with old, clogged risers and radiators, the living space is incompletely heated, resulting in unhappy customers and low collections. In cases when full rehabilitation of internal networks was carried out before starting the heat supply, but no continued maintenance and ongoing repairs were implemented, the service quality becomes unsatisfactory.

Lesson Learned #2: *Even under budgetary limitations, proper condition of the internal networks must be ensured for service quality and customer satisfaction, not only after the work is completed but during the system's continued operation.*

DEMAND SIDE MANAGEMENT/REGULATION NOT WIDELY USED: In the successful projects, the majority of apartments were equipped with thermostatic and/or mechanical valves for regulating their consumption of heat. Even when only a small share of households actually used them, there was still a level of customer satisfaction and trust of price-setting practices, metering and billing. The worst thing a heating project could do is install metering devices without regulatory valves, thus introducing an incentive for EE, but no instrument for EE. There were also cases where the building's internal heating network was not well balanced and consumption was very uneven the building, resulting in major concerns about large differences in heat bills among households.

Lesson Learned #3: *Do not install regulating devices until the following four conditions have been met: 1) the benefits of metering and demand regulation tools have been explained to residents, 2) the residents understand and specifically request them, 3) the building heating network is well balanced, and 4) the additional investment will pay for itself through savings. And since regulating devices balance comfort with affordability through demand management, their cost should be covered by residents.*

HEAT METERING EQUIPMENT/ALLOCATORS: High quality heat metering and cost allocation devices are a critical factor affecting consumers trust towards heat billing and collection practices, regardless of the particular tariff mechanism (AMD/m^2 or AMD/kWh).

Lesson Learned #4: *Commercialization, transparency and full cost-recovery of heating costs is significantly facilitated by heat cost allocators.*

TRANSPARENCY OF PRICE-SETTING AND BILLING PRACTICES: Lack of awareness of the components making up the heating fee resulted in absolute mistrust towards the fee calculation mechanism.

Lesson Learned #5: *The heat service operator and/or the condominium should provide in-depth information, printed leaflets and on-call information on the price-setting and billing mechanism and formula to the customers to build transparency and trust with consequent bill collections.*

TRUSTWORTHY MANAGEMENT: Incidents of suspected dishonesty by one-person service operators can result in low collections and little trust towards the billing practices. This results in a subjective desire to change the pricing system, while no pricing mechanism can guarantee transparency if monetary transactions are not transparent.

Lesson Learned #6: *In each system operation, there is need to assign an unbiased inspector of the billing and collection procedures to avoid suspicion and conflict.*

In conclusion, it is important to note that the above measures should be applied in combination to guarantee efficient, affordable, transparent and cost-effective heat supply service.

7 Future Directions: Summary of Recommendations

To summarize the most important findings of the analysis of the recent developments, reform efforts and pilot projects in the Armenian urban heating sector, this section will recap the key conclusions and recommendations for addressing current and anticipated future needs related to the country's heating sector, as well as recommendations for further interventions.

7.1 Major Problem Areas

Over the past decade, the numerous government initiatives, donor efforts, public initiatives and analytical exercises have revealed the major problem areas slowing down the acceleration of the heat market. These include but are not limited to the following major barriers:

- High capital investment costs due to the high prices of imported equipment and heating system component parts, and complications of laying heating networks in densely populated areas and inside furnished and occupied apartments;
- There is still little awareness by consumers of modern central heating technologies and their financing mechanisms, or of the advantages and disadvantages of various heating options.
- Most consumers, housing associations and policymakers are not familiar with the basic concepts of weatherization, contemporary heating equipment and services, heat meters and allocators, and project finance, leaving building residents to pay too much of their limited income for infrequent, unsustainable and poor quality service with potential health hazards and safety threats.
- Weak financial capacity and credibility of home-owner associations/condominiums to borrow for heating projects.
- Legal gaps and lack of awareness and willingness of ESCOs to apply performance contracting financing to heating projects, especially when there is continuing grant procurement and contractual arrangements that involve no financial investment from the ESCO, and given the strong aversion of ESCOs in Armenia to financial risk.
- Weak institutional capacity and inadequate business management experience of home-owner associations and ESCOs in managing heat supply service on a commercial basis.
- Lack of legislative incentives for establishing new and retrofitted heating systems, or for developing ESCO services and efficient and safe heating technologies.

- Lack of holistic social safety policies, which is hampering heat supply even in areas where modern heating assets are in place.
- Lack of state initiative for planned reinforcement and retrofitting of existing district heating assets throughout the country, or for a state mandate to preserve those heating assets in places where they can still provide heating.
- Legal gaps for ensuring the commercialization of heating services: with due contractual arrangements, intervention tools in cases of non-payment, disconnection, and guarantees of consumer satisfaction with the quality and reliability of service.

7.2 LESSONS LEARNED

Based on the analysis, the following are the most main useful lessons gleaned from the reviewed pilot projects:

- Individual, apartment gas heaters provide a quick and cheap solution for the space heating problem, but they are rife with problems impacting comfort, health, safety and property damage. Moreover, due to the short lifespan of such heaters, households must replace them at least three times in the space of 18 to 20 years, which is the average lifespan of a boiler. Surveys show that users of such heaters will gladly switch to central heat supply if it is available.
- In buildings with uneven income levels, individual apartment gas boilers are usually installed, however the apartments with lower income level can not afford it. The apartments, which use apartment level gas-fired boilers, are not usually inclined to switch back to a district heating system due to higher efficiency, lower operation cost, independence and easier regulation of the individual gas boilers. This deprives the rest of the building of an effective heat load density, thus hampering the rehabilitation of an organized, central heat supply to the whole building.
- The presence and participation of condominium associations plays an important role in the implementation and further operation of heating projects, and the regulation of boiler regime and billing procedures.
- The decision of the Public Service Regulatory Authority to exclude heating systems with less than 5.8 MW capacity from regulation, and the consequent elimination of many approval and licensing procedures, contributed to the development of decentralized heating systems.
- Soft loans promote the implementation of heating projects, improving the internal rate of return and reducing the investment needed from residents.
- Placing the boiler on the roof avoids the need for an external heating network, which minimizing heat losses in transmission. It also eliminates the need for leasing boiler house space. On the other hand, there are certain barriers that need to be overcome in the construction phase. The identified drawbacks of this scheme are as follows:
    - In the cases of accidental water spills there is threat of flooding in the top floors of the residential building;
    - The setup of the boiler house is complicated, yet impossible to expand to add new consumers.
- In some projects, the installed heat meters and allocators established a transparent and effective billing and collections system, which allowed a transfer from heat billing as a service to one where the payment is for a consumed product. The consumer has

the technical capability to regulate heat consumption in accordance with their ability to pay.

- Some of the projects have ceased operation due to problems, such as mistrust towards non-transparent billing or low heat quality in some apartments due to uneven heat distribution, resulting in non-payment from some households. To avoid disconnections in a newly started heat supply, transparency and trust are just as important as quality of service.
- The heat supply system should be designed at a sufficiently high professionally level to ensure an appropriate heat supply quality. Budget constraints should not be an excuse for leaving technical flaws in the heating system. Cutting corners on the system results in poor heat quality, low collection, and customer dissatisfaction.
- In the growing market for residential heating service provision, there is a gradually outlining need for consumer rights' protection in the field of contractual arrangements between the private heat supplier companies and condominium associations and/or individual heat consumers.

From these lessons it can be concluded that the main keys to success in implementing and operating a heating project are:

- ✓ an appropriate level of heat supply quality,
- ✓ well organized residents,
- ✓ strong building management,
- ✓ the ability to regulate heat consumption at the apartment-level, and
- ✓ transparency in pricing and trust in the mechanism for calculating the heating fee.

7.3 POLICY RECOMMENDATIONS

The heat supply sector in Armenia is plagues by conditions of limited funding, low creditworthiness of potential consumers, and the low level of development of the local ESCO industry. The following steps are recommended to eliminate the key barriers to rehabilitating residential heat supply in Armenian communities:

1) ***Strengthen Condominium Associations.*** Continue strengthening the capacity of condominium associations to carry out budget planning, financial management, accounting, project development and fund-raising. The condominiums should be capable of sound management and financial stability, which can be accredited by independent institutions to assure banks of the condominium creditworthiness.
2) ***Improve the Legal Environment for Condominium Associations.*** Eliminate legal gaps making condominium associations unreliable borrowers; subsidize transaction costs required for signing individual contracts with each household to minimize the risk of non-payment; and simplify the conflict resolution procedures.
3) ***Strengthen the ESCO Industry***. Train energy service companies on the technicalities, benefits and successful examples of ESCO financing schemes applied to heat and hot water services in Armenia. Help them arrange joint ventures with western ESCOs to make them creditworthy borrowers to allow them to obtain financing. Encourage ESCOs to seek long-term involvement in residential heat supply, with ESCO or third-party financing and continued operation and maintenance aimed at providing long-term return on investments and commercial profit.

4) ***Strengthen Consumer Organizations*** for providing broad outreach and protection to heat service and equipment users on critical information such as the advantages and drawbacks of each service and equipment purchased; and the health, safety and environmental implications of operating individual heating facilities, heaters and burners indoors.

5) ***Strengthen District Heating Companies.*** The State and the donor community can significantly advance the rehabilitation of residential heat supply in Armenia by contributing to the implementation of the Urban Heating Strategy and building capacity in the existing district companies to improve their coverage, service quality, operational efficiency, and commercial viability.

6) ***Increase Municipal Financing.*** In the absence of credible borrowers, the role of local government/municipalities should be expanded to attract the municipal funds, as well as their borrowing capacity to draw the financial resources into the residential heating sector. Moreover, establishing municipal loan funds to finance condominium projects could help eliminate the financing vacuum and build general confidence about lending to condominiums;

7) ***Make Consumption-Based Billing Mandatory.*** Consumption-based metering and billing should be mandatory to create incentives for payment and the rational use of heat energy. The level of sophistication of the individual metering and regulating devices should be determined by the consumers themselves to allow them to tailor the capital investment costs to their financial capabilities.

8) ***Regulate the Installation of Gas Heaters and Boilers.*** To preserve the effective heat load density in buildings subject to central heat supply, installation of gas heaters and boilers should be regulated by the Government.

9) ***Have an Adequate Social Safety Net.*** In the rush to bring heat to apartments, policymakers and investors often forget that even if complete grant funding is made available for heating all buildings, the current social-economic status of the population still leaves a major area for reform and assistance in developing a social safety net that supports low-income households in paying heat bills, which with central/district heat and the current prices and salary levels is not affordable.

10) ***Educate the Public on What It Takes for Affordable, High Quality Heating.*** A national outreach campaign should be developed and implemented to educate the public on technical and institutional aspects of the available residential heating options and the keys to successful heating projects and their potential bottlenecks. Highlight case studies of projects implemented in other residential buildings, including their costs, effectiveness and benefits. The public needs to understand the fundamentals involved with sustainable, high quality heating, such as technical and economic issues, financial-organizational arrangements, management, billing, accounting, demand-side management and energy efficiency measures, and ownership structure.

11) ***Heating Providers Need to Connect with Their Clientele.*** Heat sector businesses such as service and equipment providers, distributors and representatives of state-of-the-art heat supply and measurement equipment producers, should reach out to the potential consumers. They need to present their product and service packages, prices, applications, previous sites and clientele, where their products and services were provided, and the range of engineering and mounting services provided. Moreover, businesses should offer financing with their product and service packages.

12) ***Promote the Domestic Heating Supply Industry.*** Where possible, domestic production of heating equipment and component parts should be promoted, diversifying

the locally offered product line to eliminate the heavy reliance on expensive, imported products and to strengthen the local economy.

13) ***Standardize and Certify Heating Service and Equipment.*** The legislative framework for standardization and certification of service and equipment should be developed to facilitate and educate consumer choice.

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ANNEX I: Techno-Economic Characteristics of Armenian Heating Systems with Heat-Only-Boilers

Table 1. Technical Parameters of the District Heating Assets in the Cities of Yerevan and Gumri

Heat-Only-Boiler Houses	Installed Thermal Capacity (MW)	Connected Load (MW)		Number of Central Thermal Substations	Number of Connected Buildings	
		Heating	Hot Water		Resi-dential	Public
Yerevan #1 Terian	104,7	59,2	12,7	17	216	80
Yerevan #2 Charents	174,5	82,5	18,0	26	245	88
Yerevan #3 Davitashen	232,6	56,4	12,3	15	174	20
Yerevan #4 Nor Nork -1	139,6	83,7	17,2	13	258	48
Yerevan #5 Nor Nork -2	174,5	106,8	22,7	18	314	35
Yerevan #7a South-Western District	232,6	132,6	28,1	31	487	62
Yerevan #8 Ajapniak	232,6	126,5	26,8	26	374	60
Yerevan #11 Avan	174,5	80,7	16,9	18	260	46
Gumri-Majisjan	314	46,0	11,0	12	258	
Total	1779,6	774,4	165,7	172	2586	439

Source: Heat Energy Market Assessment Report, USAID/Residential Heating Project, 2006

Table 2. Initial Cost and Residual Values of the Assets at Large Heat-Only Boiler Houses in Yerevan

Heat-Only-Boiler House	Commis sioning Year	Last Year of Operation	Initial cost (1000 USD)	Depreciation (%)	Residual Value (1000 USD)
Yerevan #1 Terian	1977	2002-2003	4500	65%	1575
Yerevan #2 Charents	1979	1991-1992	7500	80%	600
Yerevan #3 Davitashen	1987	2002-2003	10000	50%	5000
Yerevan #4 Nor Nork–1	1971	2002-2003	6000	80%	1200
Yerevan #5 Nor Nork -2	1985	2000-2001	7500	50%	3750
Yerevan #7a South-Western District	1991	2002-2003	10000	80%	2000
Yerevan #8 Ajapnial	1980	1991-1992	10000	80%	800
Yerevan #11 Avan	1978	2002-2003	7500	80%	1500

Source: Heat Energy Market Assessment Report, USAID/Residential Heating Project, 2006

ANNEX II: Current Status of the Heat Supply Systems in Different Regions of Armenia

Marz	Area	Population, thousand people*		Centralized Heat Supply Systems			Characteristics of multi-apartment buildings		
		De jure	De facto	Before 1992	Operated until	As of 01.01.06	Number	Building gasification level,%	Apt. gasification level.%
1	2	3	4	5	6	7	8	9	10
Aragatsotn	Aparan	6,61	5,71	1 system, 10,5 MW		disposed	26	93	50-60
	Ashtarak	21,47	19,68	4 systems, 17,5 MW		disposed	57	80	60
	Talin	5,61	4,98						
Ararat	Ararat	20,48	19,57	2 systems, 13 MW		disposed	90	15	65
	Artashat	25,06	22,57	8 systems, 56 MW	1995/1996	disposed	126	98	70
	Masis	21,38	19,05	5 systems, 54 MW		disposed	62	40	80
	Vedi	12,96	12,28	1 system, 12 MW	2001/2002	disposed	39	90	60
Armavir	Armavir	32,03	28,73	8 systems, 95 MW	1998/1999	disposed	154	100	45
	Echmiadzin	56,39	51,28	11 systems, 100 MW		disposed	160	100	50
	Metsamor	9,87	8,85	1 system, 70 MW	1998/1999	disposed		Gasification newly begun	0
Gegharkunik	Sevan	21,42	18,78	10 systems, 136 MW	2001/2002	bankrupt and disposed	178	98	30-35
	Gavar	26,62	23,30	17 systems, 80 MW		Dismantles and disposed	55	20	30
	Martuni	11,76	11,12	4 systems, 68 MW	1991/1992	disposed	31	98	25-30
	Vardenis	12,73	11,46						
1	2	3	4	5	6	7	8	9	10

Kotaik	Abovian	44,57	38,88	1 system 116MW, 10 systems 55MW	2002/2003	Disposed including the central heating systems	250	around 95	
	Charentsavan	25,04	19,71	5 systems, 42 MW		Disposed 10x50kW TACIS boiler house	162	67	45
	Hrazdan	52,81	43,93	Hrazdan TPP 650MW, 5 systems, 58 MW	2004/2005	Boiler houses and networks disposed	165 systems in the district of Micro	In process in Micro and Center districts	
	Nor Hajn	10,17	9,46	0			67	100	70
	Tsaghadzor								
	Yeghvard								
Lori	Vanadzor	107,39	93,82	Vanadzor TPP 470MW, 12 systems 82 MW		Vanadzor TPP does not operate 4 small capacity boiler houses	970	To be completed in 2006	
	Alaverdi	16,64	14,85	8 systems, 71 MW	1998/1999	ûï³ñí³Í	158	50	50
	Spitak	14,98	13,59			1 new, 6 MW unit			1800 apartments
	Stepanavan	16,30	13,93	7 systems, 33 MW	1992/1993	disposed, 2 still existing			
	Tashir	9,54	7,86						
Shirak	Gumri	150,92	140,32	1 system 315MW, 63 systems 418 MW	2003/2004 boiler houses were ruined	1 system, 300 kW		95	
	Artik	17,56	15,98						
	Maralik	5,78	4,99						
	Ashotsk	2,38	2,18	1 system, 15 MW	1993/1994	dysfunctional	31, wooden	0	0
	Amasia	1,88	1,69						
	Akhurian	9,70	7,73						

Siunik	Kapan	45,71	34,66	6 systems, 195 MW	1998/1999	dysfunctional	252	40	45
	Sisian	16,84	15,02	6 systems, 120 MW		disposed	76	70	45
	Goris	23,26	20,84	12systems, 75 MW		10 still existing but not in operation	110	40	40
	Kajaran	8,44	7,98						
	Meghri	4,81	4,51						
	Agarak	4,80	4,74						
Tavoush	Ijevan	20,2	15, 37	7 systems, 23 MW		Still existing but not in operation	101	100	60
	Dilijan	16,2	14.8	15 systems, 80 MW	1998/1999	disposed	117	80	60
	Nojemberian	5,8	5,1						
	Berd	8.8	8.4						
Vajots Dzor	Jermuk	5,39	5,17	5 systems, 82 MW	2000/2001	Disposed private	48	98	
	Vaik	6,02	5,46	1 system, 37 MW		dysfunctional	30	100	
	Yeghegnadzor	8,19	7,72	1 system, 16 MW		Disposed sports center	36	100	80

* Figures with the regards to the number of population are represented per the results of the 2001 census in RA.

Source: Heat Energy Market Assessment Report, USAID/Residential Heating Project, 2006

ANNEX III: Summary Matrix of the Main Donor-Funded Heat Related Projects/Programs

Donor agency	**USAID**					**GoA & WB**		**UNDP/GEF**	
Institution	**Urban Institute**	**Alliance to Save Energy (ASE)**	**Advanced Engineering Association International**	**PA Consulting**	**Chemonics & consortium**	**R2E2 Fund**	**Urban Heating PIU**	**UNDP/GEF/ARM/98/G41/A/1G/99**	**UNDP/GEF/00035799**
Program Name	Armenia Local Government Project	Municipal Network on Energy Efficiency	Armenia Energy Efficiency, Demand-Side Management & Renewable Energy Program	Non-Heat Energy Efficiency and Renewable Energy Pilot Projects	Residential Heating Project	Urban Heating Program (UHP)		"Armenia - Improving the Energy Efficiency of Municipal Heating and Hot Water Supply"	
Program aim	Strengthening local government and condominium associations.	To design and implement innovative energy efficiency policies and identify barriers to their successful adoption; and to strengthen the capacity of regional and municipal stakeholders to develop, and attract financing for, energy efficiency projects in the countries of Central and Southeastern Europe, the	To expand knowledge and experience in Armenia of the benefits and technologies available to increase the energy efficiency invarious sectors of the Armenian economy.	To help manage and use Armenia's scarce energy resources with greater EE and in an environmentally sustainable way by renewable energy resource development, enhancing the sustainability of Armenia's private sector energy service companies (ESCOs); pursuing economically	Capacity building for institutions, development of a heat energy market and implementing heat projects	With the purpose of preparing broad projects for rehabilitation-reconstruction of urban multi-apartment buildings heating systems, finance necessary costs for testing safe and environmentally friendly heating options with available technical and institutional solutions in order to increase number of urban households having access to heating services and identify advantages and		The objective of the project is to reduce greenhouse gas (GHG) emissions resulting from the current heat and hot water supply practices in Armenian cities by laying the foundation for the sustainable development of heat and hot water supply services in these cities while taking into account global environmental impacts.	

		Balkans, the Central Asian Republics, Russia, and the former Soviet Union.		feasible opportunities for fuel diversification.		barriers of technical, economic and institutional mechanisms that might appear while rehabilitation of multi-apartment buildings heating systems.	
TASKS ON SPECIFIC PROBLEMS / ISSUES							
Policy Frameworks –							
Lack of clear legislation for heat supply sector in Armenia	Technical assistance in development of the Condominium and Multi-Apartment Management laws	✓ Technical assistance in energy saving and renewable energy law development, ✓ Development/adaptation of building codes, EE standards			Ø Standards and their enforcement for heat energy industry Ø Update of the national UHS and implementation plan		1. Reviewing and proposing appropriate changes to the existing legal and regulatory framework for associations of residents of multi-apartment buildings to make those associations more effective
Lack of institutional capacity at the state & local levels	Condominium and municipal trainings in business planning, accounting, fund-raising, etc	✓ Training municipal and HOA officials in energy planning, project development and energy management; ✓ Strengthening the Municipal Energy Efficiency Network in Armenia/outreach to cities; ✓ Developed and published advice booklets;			✓ Development of municipal heat energy strategies and implementation plans ✓ Strengthening local authorities including condominium associations ✓ Supporting	✓ Institutions development. Creating a qualified heat supply industry ✓ Heating and Related Building Infrastructure	✓ 1. Strengthen the role of condominiums in collectively organizing and managing heat and hot water supply services at the building level; ✓ Establishment of Advisory Centers.
Heating Infrastructure							
Generation capacity inadequate, destroyed municipal			Building and commissioning new boiler houses for residential and		Identifying generation operational capacities scattered	Lending to leasers of municipal boiler houses and heat distribution points for modernization	Rehabilitating heat supply from old DH stations through upgrading and/or conversion into CHP

heat supply system (feasible heating options are needed)			public buildings, in cooperation with ESCOs		throughout the country and available for recommission-ing	and service rehabilitation	
Heat affordability						✓ Development of mechanisms for income support to low-income households; ✓ Updating the Social Assessment data.	
No active and working ESCOs			✓ Continued support for developing local ESCOs and energy industry through pilot projects implementation ✓ Establishment and development of ESCO Association of Armenia				✓ support the restructuring and capacity building of the existing district companies to improve both their service quality and operational efficiency; ✓ support the new decentralized service providers to commercially run, market and diversify their businesses, in order to promote the use of alternative environmentally clean and energy efficient technologies and to structure financing for the required investments in areas that do not sustain the centralized district heating services;
Country dependence on imported fuel for heat generation		Assistance for the development and discussions on the National Program for the Promotion of Energy Saving and the development of enforcement mechanisms for ES&RE Law.	Implementation of EE, DSM and RE pilot projects in the sectors of high energy demand, including residential, municipal-governmental, commercial, industrial and agricultural.	Examine, develop and assist in the implementatio n of micro-hydro projects.		R2E2: Combining heating with renewable energy development projects, feasibility studies and lending through participating financial institutions	utilize the results, experiences and lessons learned for advancing the sustainable development of the heat and hot water services in Armenia with a specific emphasis on the GHG emission reduction aspects, as well as develop norms and enforcement mechanisms for supporting sustainable use of forest resources and implementation of the objective of the Climate Change Convention
Finance & Investment							
Lack of		Strengthening	✓ To demonstrate			Through R2E2	

market conditions for the commercial provision of heat supply		condominiums to become credit-worthy for heat and EE project lending	the potential for the use of EE technologies through pilot projects implementation ✓ To promote replication of EE projects through pilot projects implementation			Board of Trustees propose and promote elimination of barriers for commercial provision of heat supply	
Financing mechanisms * unavailable or too expensive						Make available a financing resource (IDA Loan) disbursed through local banks on attractive terms.	
Lack of "bankable projects"		Identify and help develop bankable projects	Enhanced market of energy services in Armenia	Work with identifiable energy service companies, business associations and other stakeholders to identify a broad range of feasible projects.	Identify bankable projects	Identify bankable projects	Identify and help develop bankable projects
Heat supply companies not creditworthy			✓ Training of ESCOs; ✓ Organizationally strong and financially sustainable ESCO Association of Armenia able to advocate on behalf of its members and leverage resources for implementation of joint projects				
End-Use Efficiency							
Lack of consumer		✓ Assistance to condominiums	✓ Increased awareness of the	✓ Design and implement		✓ Community	Grant assistance for DSM

awareness and involvement in EE heating issues		and local government for EE and heating in municipal and residential buildings, ✓ Education and awareness campaign, ✓ Publishing and disseminatin g analytic materials on successful pilot projects, heat market, energy efficiency opportunities , etc.	Armenian public on EE and energy conservation issues ✓ Public outreach activities supporting the project specific objectives and public awareness building on energy efficiency and energy conservation issues. ✓ More competent local ESCOs able to provide more diversified and high quality services to consumers	between 25 and 50 pilot demonstration projects. ✓ Engage the "associate project managers" (APMs) to work on each project under the guidance of a PA specialist to design the statements of work, assist with the tender evaluation, oversee project completion and monitor project results.		Mobilization and Development; ✓ Development of public information and education campaign, identifying ✓ Training and Workshops	equipment: HCA, TRVs, balancing valves, etc.
No incentives for end-use EE		Establishing interest-free micro-loan revolving fund for building energy efficiency					

ANNEX IV: Autonomous Heating Systems' Operation and Maintenance Costs, Tariff Analysis

This Annex presents the projection and calculation methodology of operation and maintenance costs for independent heating systems, as well as tariff analysis, taken from the analytic memo developed by the Public Service Regulatory Commission.[49]

The estimates of operation and maintenance (O&M) costs for the reviewed autonomous heating systems (AHSs) can be bade based on the implemented and presently operating normative indicators.

The O&M costs include fuel, electricity, water use and all the other components accounted for in the tariff. Since the energy carriers, water and other costs directly derive from the heat energy demand, the demand size calculation has the fist emphasis.

Heat Energy Demand Forecast

The formula for heat energy demand calculation for heated space is the following:

$$\mathbf{Q_{heat} = V_{ext.} \times q_0 (t_{indoor} - t_{avg}) n \times 24 \times 10^{-6}}$$

Q_{heat} - the quantity of heat energy required for the heating system, GJ

V_{ext} - Construction external volume of the heated building, m^3

q_0 - the net heating parameter, which depends on the building volume, designation, and outdoor air temperature, kJ/(m^3 x h x ^oC). May vary depending on the building type and location (wind speed in an open or closed site). See Box 1.

T_{indoor} - Averaged calculated indoor temperature ($t_{calc.}$) in the heated space, ^oC. In residential and institutional buildings, constructed in areas with t ≥ -31^oC, the t_{indoor} is assumed 18ûC, and when t_{calc} < - 31ûC is assumed 20ûC (see Box 2¤;

T_{avg} - average outdoor air temperature during the heating season, ^oC;

n - Heating season duration, days.

Box 1.

***Table 1**: The heating parameters (q_o) for buildings constructed during 1930-1958 and after 1959*

kJ / (m^3 x h x ^{o} C) [kCal/ (m^3 x h x ^{o}C)]

Building external volume (m^3)	Building Heating Parameters (q_0) under the outdoor temperature of -30 ^{o} C	
	1930 -1958.	After 1959
500	2.44 (0.58)	-
600	2.35 (0.56)	-
700	2.27 (0.54)	-
800	2.23 (0.53)	-
900	2.18 (0.52)	-
1000	2.14 (0.51)	2.73 (0.65)
1100	2.1 (0.5)	2.6 (0.62)
1200	2.06 (0.49)	2.52 (0.6)
1300	2.02 (0.48)	2.48 (0.59)
1400	1.97 (0.47)	2.44 (0.58)
1500	1.97 (0.47)	2.43 (0.57)
1700	1.93 (0.46)	2.31 (0.55)
2000	1.88 (0.45)	2.26 (0.53)
2500	1.85 (0.44)	2.18 (0.52)
3000	1.81 (0.43)	2.1 (0.5)
3500	1.76 (0.42)	2.05 (0.48)
4000	1.68 (0.4)	1.97 (0.47)
4500	1.64 (0.39)	1.93 (0.46)
5000	1.59 (0.38)	1.93 (0.45)
6000	1.55 (0.37)	1.81 (0.43)
7000	1.51 (0.36)	1.8 (0.42)
8000	1.47 (0.35)	1.72 (0.41)
9000	1.43 (0.34)	1.68 (0.4)
10000	1.38 (0.33)	1.67 (0.39)
11000	1.34 (0.32)	1.6 (0.38)
12000	1.3 (0.31)	1.6 (0.38)
13000	1.26 (0.3)	1.55 (0.37)
14000	1.26 (0.3)	1.55 (0.37)
15000	1.21 (0.29)	1.55 (0.37)
20000 and over	1.17 (0.28)	1.55 (0.37)

[49] DRH Review – ASE

In cases when the calculated temperature is different than $t_{calc.}$= -30°C for outdoor temperature, the α parameter attributed to q_0 is applied.

Application of the α parameter attributed to q_0 for cases when the calculated temperature is different than $t_{calc.}$= -30°C for outdoor temperature.

t°C	0	-5	-10	-15	-20	-25	-35	-40	-45	-50	-55
α	2.05	1.67	1.45	1.29	1.17	1.08	0.95	0.9	0.85	0.82	0.8

Receiving the calculated heat energy demand, adding the unavoidable technical losses of heat energy in the networks ($Q_{n.loss}$) and the heat energy required for own use in the boiler house ($Q_{own\ use}$), which are estimated through testing data. The sum is equal to the total heat energy required for production in the boiler house.

Box 2.
Table 2: *Average indoor air temperature values (t_{indoor}) values for various building types*

Buildings	**Indoor Air temperature °C**
Hotels, dormitories, adminitrative buildings	18-20
Higher and middle professional educational institutiones, schools, boarding schools, laboratories, public food enterprises, cultural centers, clubs.	16
Theaters, stores, laundromats	15
Movie-theatres	14
Garages	10
Kindergartens, cliniques, hospitals, health care centers	20
Saunas	25

$Q_{total} = Q_{heat} + (Q_{n.loss} + Q_{own\ use})$, GJ

Projection of Fuel Use

Given the design of factory efficiency parameters of the boiler, we can determine the conditional fuel use required to produce one unit of heat energy.

$$(34.12 \times 100)/\eta_{br} \quad \text{kg c.f./GJ}$$

where

η_{br} - is the *brutto* boiler efficiency based on the factory passport data of the boiler;

b - net conditional fuel use

To transfer form conditional fuel to natural gas, the Э equivalency coefficient of the latter.

For natural gas it is as follows: Э n.g.=1,14 kg c.f./nm3;

For mazut (residual oil) Э m =1,37 kg c.f./kg.

The required amount of fuel for heating energy generation equals:

$$B = b \times Q_{total} \times 10^{-3}, \quad \text{t c.f./year.}$$

Projection of Electricity Use

The electricity required for heat energy generation, transportation and distribution can be conditionally devided into:

1. Electricity used for technological needs (power equipment, electric valve transmissions, metering – control equipment etc);
2. Electricity used for other production needs (light, appliances, etc).

$$\mathbf{P_{total} = P_{power} + P_{other}}$$

$P_{power} = N_1 \times n_1 + N_2 \times n_2 + \cdots N_i \times n_i$, where

$N_1, N_2, \cdots N_i$ - the capacity of electricity consuming equipment, kW;

$n_1, n_2, \cdots n_i$ - number of hours of appliance/equipment operation during the heating season, hours.

$$\mathbf{P_{other} = N_{other} \times \tau}$$

N_{other} - lamps and residential appliances overall capacity, kW

τ - hours in heating season when lamps and residential appliances are in use, hours.

When calculating the electricity used, the efficiency of installed equipment should be considered.

The electricity use in heat energy generation and transmission of autonomous heating systems under 5GCal/h (5.8MW) can be evaluated by the normative indicators of Table 3 below.

Table 3: *Marginal norms of electricity use for autonomous systems*

MW (Gcal/h)	kWh/kJ	kWh/Gcal
upto 0.58 (under 0.5)	4.8	20
0.59-1.16 (0.51-1)	4.8	20
1.17-2.32 (1.01-2)	4.5	19
2.33-3.48 (2.01-3)	4.3	18
3.49-5.8 (3.01-5)	4.3	18
5.81-11.6 (5.01-10)	4.3	18

Projection of Water Use

The amount of water required for boiler input and output, as well as to fil the network pipelines and internal radiators, is considered the constant quantity of water. Taking into account that during the realization of the heat energy water losses occur in the network, it isnecessary to resupply water from an external source, which should be approved by its technoeconomic evaluation. This water use is considered variable.

Thus, the total amount of water required for the autonomous heating system during the heating system is as follows:

$$G_{total} = (G_{boiler} + G_{ext.net.} + G_{heat.equip})x\ n_{É} + G_{loss} \qquad m^3/year,$$

where

G_{boiler}, $G_{ext.net}$, $G_{heat.equip.}$ – are the volumes of water required for a single filling of respectively the boiler, external network and internal heating network, m^3,

$n_{É}$ - number of refills in the heating system during the season, can be assumed $n_{É}=3$,

G_{loss}- Heat carrier losses from the system during the heating season, m^3/year.

The volume of water required for the single-time filling of the boiler is determined by the equipment passport data. The external network volume is determined as follows:

$G_{ext.net.} = L\ x\ Vnet.$

L - length of external networks, m.

V_{net} - water volume in 1m of network pipeline, m.

Depending on the ***d*** curcumference of the external networks, the V_{net} can be determined by Table 4.

Table 4: *Water refill volumes for heating networks*

External Circumference, mm	Internal Circumference, mm	Wall thickness, mm	Water Volume, l/m
48	41	3,5	1.32
57	50	3,5	1.963
76	69	3,5	3.739
89	81	4	5.153
108	100	4	7.854
133	125	4	12.21
159	150	4,5	17.67
219	203	8	32.36
273	257	8	51.9
273	255	9	51.07
325	309	8	74.99
325	307	9	74.02

The external network water volume can be determined with the help of the following formula:

$$G_{heat.\ equip.} = V_{heat.\ equip.} x\ Q$$

Where:

$G_{heat.\ equip.}$ - amount of water in the heating equipment, depending on the heat capacity and temperature fluctuations of direct and backward pipelines;

Q - System heat capacity, GJ/h or MW;

$V_{heat.\ equip.}$ - volume of water in the heating equipment - m^3/GJ/h; The autonomous heating systems generally use 95/70°C degree schedule, for which the $V_{heat.\ equip.}$ can be determined by Table 5.

Table 5: *Net water volume requirements for heating systems*

Heating Equipment Description	**m^3/GJ/h; (m^3/GCal/h)**	**l/kW**
Heating Equipment , height 500 mm	4.66 (19.5)	16.77
Heating Equipment , heaight 1000 mm	7.4 (31)	26.64
Heating Equipment with ribbed piping	3.39 (14.2)	12.20
Heating Equipment with plynth convectors	1.34 (5.6)	4.82
Heating Equipment with flat heating pipelines.	8.84 (37)	31.82

Considering that the accepted norm for hourly water loss is 0.25% of the general system volume of the autonomous heating systems accept, we shall have.

$$G_{loss} = \frac{(G_{boiler} + G_{ext.net} + G_{heat.equip})\,x\,0.25\,x\,n}{100}$$

n - number of hours in the heating season.

Depreciation of Main Assets

The deprectiation is usually calculated linearly from the initial purchase (or construction) value of the main assets, based on the period of operation/use.

The operation lifetime of equipment in heating systems is assumed 25 years, for the production buildings and constructions – 40 years.

The following formulae allow calculating the depreciation of main assets for buildings and constructions:

$C_{build\&constr.} = K \text{ x } n_{cost}$ x depreciation norm thousand AMD/year

N_{cost} -- cost share attributed to the buildings and constructions;

The equipment depreciation depends on the level of technical operation, number of hours worked during the year, overall operaiton period and fuel type. The depreciation for equipment is calculated by the following formula:

$C_{equip.} = K\ (n_{equip} + n_{mount.})$ **x** depreciation norm thousand AMD/year

The depreciation value for all main assets will be:

$C_{deprec.} = C_{build\&constr} + C_{equip}$ thousand AMD/year

Ongoing maintenance costs are presumed as 20% of the depreciation costs:

$C_{maint.} = 0.2 \times C_{deprec}$

The personnel wages are determined based on the average monthly salaries in the heating sector, in the factor of 1.2 with the considering of social security fee.

Other expenses are assumed as 3-5 of O&M costs:

$C_{other} = (0.03+0.05)\Sigma \cdot C_{heat}$

Total heating costs are calculated as follows:

$\Sigma C_{heat} = C_{deprec} + C_{maint} + C_{wage} + C_{soc} + C_{fuel} + C_{electr} + C_{water} + C_{materials}$

$C_{fuel} = B_{year} \cdot \hat{e}_{fuel}$

$C_{electr} = \Sigma \acute{Y}_{year} \cdot \hat{e}_{electr}$

$C_{water} = G_{water} \cdot \hat{e}_{water}$

<u>Analysis of Operation Costs and Heat Energy Tariff</u>

The O&M costs of an autonomous heating system boiler of 1.2 MW installed capacity and 1.0 MW calculated heat generation are presented in Table 6 for 90 and 139 days heating season (including energy carriers and water):

Table 6: *1.2 MW capacity autonomous heating system O&M cost structure*

Cost Articles	Structure, %		Note
	90 days	139 days	
1. Fuel (natural gas)	50.7	55.5	f = 1.14 U = 18.2 AMD/kWh
2. Electricity	3.7	4.1	
3. Water	0.4	0.5	
4. Wages and Social Payments	8.2	9.5	
5. Maintenance (repairs)	5.5	4.6	
6. Other costs	4.0	4.2	
7. Depreciation	27.5	21.6	K = 100 $ /kW α_{mo}=4%

Hence, the constant operation and maintenance costs are approximately 40-45% and the variable costs about 50-55% of the total O&M costs.

The heat energy tariffs depend on the structure of investments and conditions of borrowed capita involved. Particularly, if investments ate only made in main assets, various heat tariffs guarantee different rates of return (see Figure1).

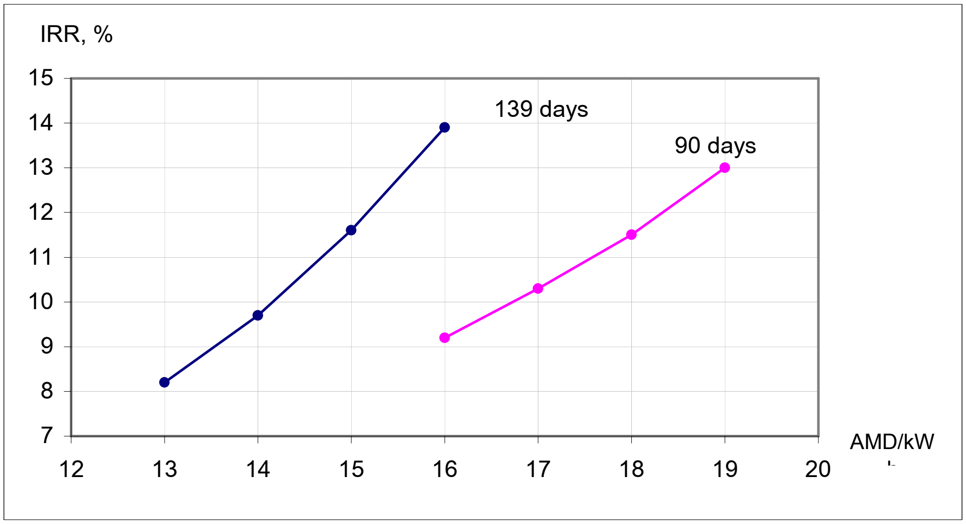

Figure 1: *Internal rate of return under main asset investments*

<u>Conclusion:</u> Tariffs attractive for consumers do not guarantee the investor the necessary rate of return.

The same issues can be considered under different terms of borrowed capital (5%). Figure 2 presents the results:

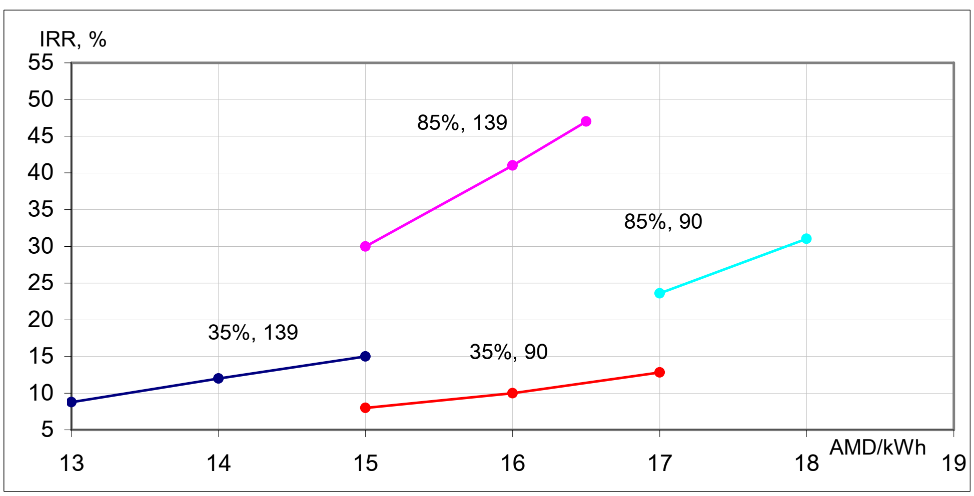

Figure 2: *Internal rate of return under 35% and 85% borrowed capital*

<u>Conclusion:</u> Under relatively soft conditions of borrowed capital, the construction and operation of autonomous heating systems is more attractive than electric heating.

ANNEX V: Methodology for Calculation of Tariff for Thermal Energy Used for Heating Purposes

Annex 7 of the decree N1-N of Public Service Regulatory Commission (PSRC) adopted on 01.13.2003 regarding the tariff setting and review in the Energy Sector of Armenia

1. General Provisions

The following methodology sets the basis for calculation of tariff for thermal energy used for heating purposes for heat providing entity that has licenses for generation, transportation and distribution of thermal energy. This methodology applies for centralized heating systems (CHS) with boiler house (BH) or thermal power plants (TPP) with a capacity of equal or higher than **5.8 MW**.

The basis for calculation of thermal energy tariff lays in securing a required profit (RP), which should be enough to cover the following expenses incurred by the heat supply entity:

1. operational and maintenance (O&M) costs associated with reliable and safe generation, transportation and distribution of thermal energy,
2. amortization (A) of assets used during the generation, transportation and distribution of thermal energy
3. ensuring reasonable profit (P) from using the operating assets for generation, transportation and distribution of thermal energy

The required income (I) is calculated using the following equation

$$I = O\,\&\,M + A + P \text{ (AMD)}$$

The tariff for thermal energy is calculated using the following equation

$$T = \frac{I}{Q_{heat}} \text{ (AMD/GJ)},$$

where

Q_{heat} – thermal energy supplied to the consumers for heating purposes (GJ) – thermal energy demand for heating.

2. Initial Data

The heat supply entity shoul dprovide the PSRC with the following initial data:

1. Total area od residential buildings
2. Living space area of residential buildings
3. Total volume of the residential building according to the construction sizes,
4. The area of non-residential buildings (stores, municipal building, fabric, etc.),

5. The average outdoor air temperature during the heating season (the data can be acquired from reference books, based on a document provided by the meteorological service, or based on readings of a certified termometers, etc.),

6. Duration of heating season (according to an application f certified entity),

7. The efficiency of the boiler house, or the efficiency of thermal energy production at the TPP, which takes into account the own energy consumption during the generation of electric-thermal energy (design or experimental/practical data),

8. Inevitable thermal energy losses incurred in heat networks, which are due to the losses of heat carrier.

3. Classification of Operation and Maintenance (O&M) Costs

During the tariff calculation it is necessary to take into account all the expenses occuring during the generation, transportation and distribution of thermal energy for heating purposes.

The following parameters are used for calculations:

1. fuel expenses (C_{fuel})
2. cost of purchased electric energy (C_{el})
3. cost of purchased water (C_{water})
4. salary expenses for the staff (C_{salary})
5. payments to the social security fund (C_{soc})
6. cost of materials used during the operation (C_{mat})
7. cost of maintenance and repair (C_{repair})
8. costs associated with the utilization of thermal energy (C_{ut})
9. administrative-general expenses (C_{admin})
10. other expenses included in energy tariff according to provisions of the Law on Energy of RA (C_{other}).

Other expenses not related to the provision of thermal energy are not considered during the thermal energy tariff calculation and are not regulated by the PSRC.

The components of O&M and the amortization costs are determined according to the calculation mechanisms, presented in the tables included in the annex to this document and the analysis of the actual expenses included in reports to the PSRC.

4. Calculation of Components of O&M Expenses

4.1. Calculation of Fuel Component

The fuel component is calculated based on the demand for thermal energy. The design thermal capacity of the heating system (Q_{des}) and demand for thermal energy (Q_{heat}) are calculated using the following equations:

$$Q_{des} = V_{ext} \times q_0 \times \alpha \times (t_{in} - t_{out}^{des}) \times 10^{-6} \text{ (GJ/h)},$$

$$Q_{heat} = Q_{des} \times \frac{t_{in} - t_{out}^{av}}{t_{in} - t_{out}^{des}} \times n \times 24 \text{ (GJ)},$$

where

V_{ext} - the external construction size of the building, m^3,

q_0 - specific heat coefficient, depending on the volume of building, the purpose of building, and the design external air temperature (kJ/m^3h^oC). For a separate building the q_0 is determinned from the Table 1 for the heated are, depending on the average construction density indicator,

α - coefficient, which equals to α=1 in case if $t_{out}^{des} = -30^oC$, and is determinned according to Table 2 in all other cases,

$t_{out}^{des}, t_{out}^{av}$ - design and average outdoor temperatures during the heating season, (^oC),

t_{in} - average design temperature of indoor air (^oC). For residential buildings built in regions with $t_{out}^{des} \geq -31^oC$ the $t_{in} = 18^oC$, and for regions with $t_{out}^{des} < -31^oC$ the $t_{in} = 20^oC$. For non-residential buildngs the average design indoor air temperature is determined according to Table 3. The $t_{in} = 18^oC$ for calculation of heat demand during the heating season.

n - duration of heating season (days).

When adding the demand for thermal energy for heating purposes to the inevitable thermal energy technological losses in heating network the total quantity of thermal energy supplied from the CHS is obtained:

$$Q_{total} = Q_{heat} + Q_{loss} \text{ (GJ).}$$

The specific consumption of conditional fuel for thermal energy production and transfer is determined the following way:

a) CHS with boiler houses:

$$b = (34{,}12/\ \eta_n)x100\%, \qquad \text{(kg cond fuel/GJ)},$$

where

η_n – net efficiency of the boiler.

b) CHS with TPP's:

$$b = (34{,}12/\ \eta^T_n)x100\%, \qquad \text{(kg cond fuel/GJ)},$$

where

η^T_n – net efficiency of thermal energy production by the TPP.

The amount of natural fuel necessary to produce thermal energy for heating purposes is calculated accroding to the following equation:

$$B = \frac{b \times Q_{total} \times 29310}{Q_{LHV}} \text{ (nm}^3\text{), (kg),}$$

where

Q_{LHV} - the low heating value of fuel sources imported to the Republic of Armenia (kJ/nm^3), (kJ/kg).

The fuel consumption is determined according to the following equation:

$$C_{fuel} = B \times T_{fuel} \text{ (AMD)},$$

where

T_{fuel} – the cost of fuel delivered to the boiler house (AMD/nm^3), (AMD/kg) (without VAT).

4.2. Calculation of Electricity Purchase Eexpenses

In CHS with boiler houses the electric energy necessary for generation, transportation and distribution of thermal energy is entirely due for purchase and is conditionally divided to:

1. $E_{tech(BH)}$ - electric energy used for technological purposes (power equipment: pumps, fans, smoke exhausters, electric valve drives, measurement equipment, etc.).
2. $E_{other(BH)}$ - electric energy used during general production process and for other purposes (lighting, domestic appliances),

$$E_{total(BH)} = E_{tech(BH)} + E_{other(BH)} \text{ (kWh)}.$$

The amount of electric energy used for technological processes is calculated using the following equation:

$$E_{tech(BH)} = N_1\tau_1 + N_2\tau_2 + ...N_i\tau_i,$$

where

$N_1, N_2, \cdots N_i$ - the capacity of electric equipment (kW),

$\tau_1, \tau_2, \cdots \tau_i$ - number of hours in use during the heating season (h).

The amount of electric energy used during general production process and for other purposes is calculated using the following equation:

$$E_{other(BH)} = N_{other}\tau$$

N_{other} - total capacity of lighting fixtures and domestic appliances (kW),

τ - number of operation hours of lighting fixtures and domestic appliances during the heating season.

In CHS where the heat source is a TPP the energy used for own purposes and by the technological equipment for generation and supply of thermal energy is accounted in the η^T_n efficiency.Only electric energy used for transportation and distribution of thermal energy for utility purposes within the TPP are due for purchase.

$$E_{total(TPP)} = E_{utility(TPP)} + E_{tech(TPP)} + E_{other(TPP)} \text{ (kWh)}$$

where

$E_{utility(TPP)}$ - consumption of electric energy for generation of thermal energy for heating purposes for utility needs,

$E_{tech(TPP)}$ - consumption of electric energy for technological purposes in the thermal energy transportation and distribution networks (pumps in centralized heating systems, electric valve drives, measurement equipment, etc.),

$E_{other(TPP)}$ - consumed electric energy for general production needs in thermal energy transportation and distribution systems and other needs (lighting, domestic appliances, etc.).

Expenses associated with the purchased electric energy are calculated using the following equation:

$$C_{el} = E_{total(BH/TPP)} \times T_{el} \text{ (AMD/year)},$$

where

T_{el} - tariff for purchased electric energy without VAT (AMD/kWh).

4.3. Calculation of Water Purchase Expenses

The amount of water necessary for boilers, heat exchangers of a TPP, and for internal and network pipelines of a boiler house is considered a permanent demand for water. During the utilization of thermal energy water losses occur in heating netwrok, which should be compensated from an external water source. The amount of compensated water is considered variable and depending on the amouint of supplied thermal energy.

Thus the total amount of water necessary for a heating season is determined the following way:

$$W_{total} = W_{system} \times n_1 + W_{loss} \quad (\text{m}^3),$$

$$W_{system} = W_{boiler} + W_{ext.net} + W_{\text{int}.net} \quad (\text{m}^3),$$

where

W_{system} - water used for one-time filling of the heating system - boiler (W_{boiler}), external network ($W_{ext.net}$) and internal network ($W_{\text{int}.net}$),

n_1 - frequency of filling of the heating system during the heating season, usually taken $n_1 = 3$

W_{loss} - water losses durng the heating season (m^3).

The amount of water (W_{boiler}) required for a one-time filling of the heat exchangers of a boiler or a TPP is calculated using the passport data of the equipment.

The amount of water required for filling the external network is calculated the following way:

$$W_{ext.net} = L \times V_{net}$$

where

L - lenght of pipeline in external network (m),

V_{net} - the volume of wtaer in 1 meter of the pipeline (m^3/m).

Depending on the diameter d of the pipes in external network, the V_{net} can be determined from the Table 4.

The amount of water necessary for filling the heating equipment is calculated using the following equation:

$$W_{heat.equip} = V_{heat.equip} \times Q_{des},$$

where

$V_{heat.equip}$ - specific water volume of the heating equipment, which depends on the temperature difference in forward and backward heat pipelines and the types of heaters (m^3/GJ/h). The 95/70 ^oC schedule is usually used in TPPs, and the $V_{heat.equip}$ can be determined from the Table 5.

Taking into account that the hourly rate of water loss in CHS is 0.25%, the losses from the total water volume in the system wil be:

$$W_{loss} = \frac{(W_{boiler} + W_{ext.net} + W_{\text{int}.net}) \times 0.25 \times n \times 24}{100}.$$

Expenses associated with the purchase of water are calculated using the following equation:

$$C_w = W_{total} \times T_w \text{ (AMD)},$$

where

T_w - tariff for purchased water (AMD/m^3).

4.4. Calculation of Expenses Associated with the Maintenance and Operation of the System, Salaries, and OtherEexpenses

Maintenance expenses can not exceed 3.5% of the initial (construction) cost of main assets in operation:

$$C_{ma\,\text{int}.} \le 0.035 \times C_{initial}$$

where

$K_{initial}$ - initial cost of main assets in operation.

Salaries for main industrial staff are determined based on the average salary level in the heat supply sector. The number of employees should be agreed with the PSRC.

The operational expenses including materials, sales, administrative and general, as well as other expenses are calculated based on analysis of actual expenses included in the reports submitted to the PSRC. The aforementioned expenses can not exceed 20% of the O&M expenses.

5. Depreciation of Main Assets

The depreciation is calculated based on the purchase costs of main assets using a linear approach, taking into account the effective operation period.

The operation period for equipment used in heating system is set at 30 years, and for industrial buildings and constructions – 65 years.

6. Profit Calculation

The reasonable profit included in the required income is calculated using the following equation:

$$P = \text{Profit calculation baseline} \times \text{Profitability level}$$

The profit calculation baseline is the net value of assets (NVA):

$$NVA = CFA - AD + WK,$$

where

CFA - the cost of floating assets accepted as useful and operational by the PSRC,

AD – accumulated depreciation,

WC – amount of working capital allowed by the PSRC.

The allowed profitability level of net assets is set by the PSRC.

Table 1. Specific characteristics of building heating for 1930-1958 and since 1959, kJ/(m³ ·h·ºc), or kcal/(m³·h·ºc).

External volume of building, m³	Specific characteristics of building heating (q_o), for $t_{ext.}$= -30 º C	
	1930 - 1958	Since 1959
500	2.44 (0.58)	-
600	2.35 (0.56)	-
700	2.27 (0.54)	-
800	2.23 (0.53)	-
900	2.18 (0.52)	-
1000	2.14 (0.51)	2.73 (0.65)
1100	2.10 (0.50)	2.60 (0.62)
1200	2.06 (0.49)	2.52 (0.60)
1300	2.02 (0.48)	2.48 (0.59)
1400	1.97 (0.47)	2.44 (0.58)
1500	1.97 (0.47)	2.43 (0.57)
1700	1.93 (0.46)	2.31 (0.55)
2000	1.88 (0.45)	2.26 (0.53)
2500	1.85 (0.44)	2.18 (0.52)
3000	1.81 (0.43)	2.10 (0.50)
3500	1.76 (0.42)	2.05 (0.48)
4000	1.68 (0.40)	1.97 (0.47)
4500	1.64 (0.39)	1.93 (0.46)
5000	1.59 (0.38)	1.93 (0.45)
6000	1.55 (0.37)	1.81 (0.43)
7000	1.51 (0.36)	1.80 (0.42)
8000	1.47 (0.35)	1.72 (0.41)
9000	1.43 (0.34)	1.68 (0.40)
10000	1.38 (0.33)	1.67 (0.39)
11000	1.34 (0.32)	1.60 (0.38)
12000	1.30 (0.31)	1.60 (0.38)
13000	1.26 (0.30)	1.55 (0.37)
14000	1.26 (0.30)	1.55 (0.37)
15000	1.21 (0.29)	1.55 (0.37)
20000 and more	1.17 (0.28)	1.55 (0.37)

Table 2. Values of α coefficient

t^oC	0	-5	-10	-15	-20	-25	-30	-35
α	2.05	1.67	1.45	1.29	1.17	1.08	1.0	0.95

Table 3. Design temperature of internal air in heated premises

BUILDINGS	Internal air temperature, ^oC
Hotels, hostels, administrative buildings	18-20
Higher and specialized secondary education facilities schools, foster-homes, laboratories, public catering facilities, cultural centers, clubs	16
Theatres, shops, laundry facilities	15
Movie theatres	14
Garages	10
Kindergartens, policlinics, hospitals, ambulatory facilities	20
Bathing facilities	25

Table 4. Specific volume of water required for filling of heat system pipline

Eternal diameter, mm	**Internal diameter, mm**	**Wall thickness, mm**	**Water volume V_{net}, (l/m), ($x10^{-3}$ m^3/m)**
48	41	3,5	1,32
57	50	3,5	1,963
76	69	3,5	3,739
89	81	4	5,153
108	100	4	7,854
133	125	4	12,21
159	150	4,5	17,67
219	203	8	32,36
273	257	8	51,9
273	255	9	51,07
325	309	8	74,99
325	307	9	74,02

Table 5. Specific water volume of heating system

Characteristics of heating equipment	Vheat.equip, (m3/GJ/h), (m3/GCal/h)	l/kW
Height of heating equipment equal to 500 mm	4,66 (19.5)	16,77
Height of heating equipment equal to 1000 mm	7.4 (31)	26,64
Heating equipment with finned pipline	3,39 (14,2)	12,20
Heating equipment with plinth converters	1,34 (5,6)	4,82
Heating equipment with flat heating pipeline	8,84 (37)	31,82

ANNEX VI: SUCCESS STORY:

Case Study - Restoration of the Heating System of Residential Building #106 on Paruyr Sevak St.; Yerevan; Armenia

[Restoration of the Heating System of Residential Building #106 on Paruyr Sevak St.;Yerevan; Armenia]

PROJECT HIGHLIGHTS

- The building #106 on Paruyr Sevak (P. Sevak) St. in Yerevan, which was not connected to the centralized heating network before, at present, receives heat from a top-roof boiler house.
- The loan-funded heating project was implemented by "Thermosupply Programs" Project Implementation Unit State Institution (PIU SI) with World Bank (WB) Urban Heating revolving fund in 2003 to provide qualitative, affordable and metered heat supply services.
- The heat supply system is being operated by "P. Sevak 106" condominium.
- 61 apartments from 72 are connected to the heating system and currently 49 apartments receive heat from the system.
- All the apartments connected to the heating system have heat metering equipment; about 75-80% have regulatory equipment though only half of them regulate heat consumption in their apartments.
- More than 60% of households are satisfied with their heat control and metering systems, and they trust to their heating fee calculation.
- Almost all connected to the heating system apartments were heated partially before the project implementation; still currently most of the households heat their apartments totally; and the comfort level was significantly increased.
- The project contributes to the affordable heating of the multi-apartment building due to the significant reduction of the average share of heating expenses in the family budget from 41% to 25%.
- Before implementation of the project the residents were using electricity and firewood to heat their apartments. And although the share of heating expanses in family budgets were high (about 40%), the heating quality was not sufficient and most of the apartments were heated partially.

Key Results

- Total Energy Cost Savings (for residents): 25% per year
- Measures introduced: small scale centralized heating system (with a top-roof boiler house) was constructed; apartment level heat meters were installed in all apartments connected to the heating system; regulatory devices were installed in about 75-80% of apartments.
- Affordability indicator: the average share of heating expenses in the family budget was dropped from 41% to 25%.
- Project financing: total project cost was 51,645 USD, including:
  - 45,681 USD - loan from World Bank (WB) Urban Heating revolving fund;
  - 5,964 USD - co-financed share of the "P. Sevak 106" condominium.

PROJECT APPROACH

- The "Thermosupply Programs" Project Implementation Unit State Institution (PIU SI) implemented the loan-funded heating project for this residential building in 2003.
- A roof-top boiler house is designed with two boilers: Lamborghini with 290kW capacity and Ferroli with 300kW capacity. The system has already been operating for three years (heating seasons of 2003-2004, 2004-2005 and 2005-2006).

- Individual regulators (such as mechanical valves on the radiator feeders) were installed, which enabled the customers to regulate the heat consumption at their own discretion. Also allocators were installed on the radiators in each apartment, which enabled to calculate the actual heat consumption.
- Window glazing and doors were installed in areas of general use of the building.
- The "P. Sevak 106" condominium borrowed 88% of the actual project cost from World Bank (WB) Urban Heating revolving fund.
- The loans agreements set a payment period of 10 years starting in the 3rd year after the loan receipt; and a 5% annual interest would be charged based on the amount of the unpaid loan. Note: consulting services, technical inspections, drafting and design of project-related documents were provided by Heating PIU free of charge.
- The "P. Sevak 106" condominium operates the heating system and has contract with each apartment owner, who pays for heat consumption and loan service payments.
- There were few closed door apartments in the building, which were disconnected from the system.
- The part of the loan of recently sold apartments of the building was included in the costs of the apartments, and the given to the building manager.
- The main objective of this project was to demonstrate the possibilities of having efficient and affordable heating through implementation of loan based mechanism and joint efforts of the residents.
- The loan based mechanism for heating for multi-apartment management bodies was a new approach for Armenia after the collapse of the district heating networks and privatization of the housing stock.
- This approach assures that well organized and purposeful community/residents can have affordable and qualitative heating at their homes.

RESULTS

- The actual project cost was 51,645 USD, including 45,681 USD of the loan and 5,964 USD of the co-financed share.
- The benefits of the project are:
  - 25% energy costs savings per year,
  - Reduction of the share of heating expenses in the family budget from 41% up to 25%.
  - Increase of comfort level,
  - Possibilities of heat consumption regulation.
- Although the energy consumption was increased due to the project implementation by about 50%, it does not suppose a drop in efficiency of energy use, because the comfort level was significantly increased, an average indoor temperature was increased from 12^0C to 18^0C. Before the project implementation the comfort level was inappropriate, because the apartments were mostly heated by electricity, which is an expansive energy source for heating. And only insignificant part of the apartments was heated by firewood stoves.
- The heat energy costs savings and energy consumption increase were calculated according to presented in the table key data gathered through the survey:

Apt.	Pre-project average heat expenses per apartment [AMD/month]		Post-project average heat expenses (using small scale centralized heating) per apartment [AMD/month]
	Using electricity	Using firewood	
1-room	15,000	-	12,300
2-room	21,500	13,800	16,500
3-room	24,667	13,800	15,763
4-room	25,500	13,800	20,143

- In the beginning of the heating season the building manager collects prepayments, and semimonthly informs residents about their consumed amount of thermal energy and collects the fees for heat supply, which is calculated with the tariff of 7.5 AMD per kWh.

The top-roof boiler house of the building #106 on P. Sevak st.

Lessons Learned

This heating project is considered as a successful and replicable project. And the keys to the success are the following:

- Soft loans were available;
- The residents were organized and the building management was strong;
- Heat consumption apartment-level regulation possibility;
- Awareness of the price elements and also trust towards the fee calculation mechanism (due to allocators' installation) which resulted in overall satisfaction with the heating system.

Approaches for Helping Vulnerable Households Meet Energy Needs into the Future

As in almost every multi apartment building of Armenia, in the building # 106 on P. Sevak street there are low-income families. And these apartments had/have difficulties in paying the investment, heat consumption and loan repayment costs. And neither government nor donor organizations assisted low-income households in that.

The Government of Armenia does not provide any utility-related subsidy to the population. Currently there is only one subsidy provided to the residents of Armenia – the Family Poverty Benefit. Only one family of the building #106 P. Sevak connected to the heating system is included in the Program of Family Poverty Benefit, but it makes its payments (consumed heat and loan repayment fees).

It is noteworthy mentioning that not every low-income family is included in the mentioned above poverty program, the involvement of the families in the mentioned program is calculated based on the grades that the family gets according to the current legislation.

There is one such low-income family on #106 P. Sevak, which is currently not able to start repayment of its part of the loan, but pays for received heat regularly.

This issue is not much critical, as in this case only one family have a problem of temporary delay of the loan repayment.

Suggestion: for further implementation of loan based heating project where the problem of low-income families will be a big issue, auxiliary approaches should be implemented. The involvement of municipality and/or other donor organizations in assisting low income families will be another key to success of the implemented project.

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For More Information:

Contact Name
Contact Email
Location of Contact

Last Update: [June 2006]

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This work was funded by the United States Agency for International Development

ANNEX VII: FAILURE EXAMPLE:

Case Study - Restoration of Heat Supply in Residential Buildings of Jrashat Condominium, Yerevan, Armenia

[Restoration of Heat Supply in Residential Buildings of Jrashat Condominium; Yerevan; Armenia]

ALLIANCE TO SAVE ENERGY
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PROJECT HIGHLIGHTS

- A small scale centralized heating system for four residential buildings of Jrashat condominium was constructed/ rehabilitated. The system was operated in February 2002 (10-15 days testing period) and following 2003/2004 and 2004/2005 heating seasons in full capacity. The project was failed and the system did not provide heat during the 2005/2006 season.
- The heating project was implemented by Eco-Engineering Ltd in 2002 aimed at starting efficient and commercial heat-supply in residential buildings.

"Jrashat 92" boiler house

- The heat supply system was operated by Eco-Engineering, which had a contract with "Jrashat" condominium.
- 100 apartments from 113 were receiving heat from the system.
- The comfort level of the apartments with no technical defects in their part of internal network was increased during the system operation period.
- However, the project was failed in 2005.
- And on request of Jrashat condominium, the UNDP/GEF "Armenia – Improving the Energy Efficiency of Municipal Heating and Hot Water Supply" (EE Heating and HWS) Project specialists analyzed the results of the system previous year operation aimed at finding the reasons of the project fail and restarting the heat supply for the heating season of 2005/2006.
- According to the analysis the project did not succeed for the following main reasons:
    - An expensive system with overestimated capacity was constructed.
    - A wrong method was implemented for the consumed heat distribution by apartments.
    - The system was operated on professionally inappropriate level.
    - The condominium was not institutionally strong.
    - Ar&Ar Ltd was not interested in operation of the heating system.
    - The gasification of apartments promoted the installation of individual (apartment level) gas fired boilers/stoves for heating.

Key Results

- Measures introduced: small scale centralized heating system was constructed; mechanical regulating valves and allocators were installed in apartments.
- Project benefits: increase of comfort level and energy saving possibilities; commercial heat supply experience.
- Project financing: total project cost was 125,000 USD.
- The project failure: professional and institutional problems.

PROJECT APPROACH

- Eco-Engineering Ltd implemented the heating project for this residential building in 2002. The Eco-Engineering is a joint venture established for that purpose in 2002 by Ar&Ar Engineering and the Dutch EcoFys.

  Note: Ar&Ar Engineering is an Armenian company which has been operating in the heating market in Armenia for over 10 years, not only designing and constructing heating systems, but also manufacturing boilers.

  EcoFys is an international consulting and business development organization, which operates in the field of energy efficiency and renewable energy.
- The goal of the project was to start and conduct efficient and commercial heat supply in residential buildings.
- And for the above mentioned purpose the boiler house of the 92 Jrashat street building was completely renovated and refurnished with three boilers (Logano GE 515 with 300kW capacity and KB-03 (condensation) and KB-02 with 300kW and 200kW capacities accordingly), pumps, meters and other equipment.

  The external heat network was installed using factory-manufactured insulated pipes, and heat flow meters were installed at the heat entrances of the buildings.

Boilers installed at "Jrashat 92" boiler house

  Inside the buildings some of the risers and radiators were replaced, and mechanical regulating valves and allocators were installed.
- The heating system was designed and constructed for four residential buildings of Jrashat condominium with total of 113 apartments: #92 Jrashat Street, #92/1 Jrashat Street, #1 Baghramyan Avenue Alley 1 and #190 Antarayin Street with 40, 11, 38 and 24 apartments accordingly. About 88% of apartments (100 apartments) were receiving heat from the system.
- The heating system had testing period of 10-15 days in February 2002 for residential buildings of #92 and 92/1 Jrashat street. And during that season residents were not charged for the heat supply.
- Further, the system was operated during the following 2003/2004 and 2004/2005 heating seasons providing heat to the all four residential buildings of Jrashat condominium.
- The heating system was operated by Eco-Engineering Ltd.
- The fees for the consumed heat energy were collected based on the heat flow-meter's indications and the readings of the allocators installed in the apartments. Jrashat condominium conducted the fee collection. During the 2003/2004 heating season the condominium was charged a retail price of 13.5AMD/kWh for the heat energy, and then, in turn, charged the residents 14.5AMD/kWh.
- Two-tier tariff with fixed and variable components was established for the heating season of 2004/2005.
- According to the new "heat supplier - condominium" renting agreement, Jrashat condominium

should have pay fixed costs (deprecation expenses, boiler house rent, maintenance costs) of 900 thousand drams per month and costs for consumed gas, electricity and water. And according to the agreement between the condominium and consumers, the heating fees were collected by the condominium according to proportions of actual consumed and meters' fixed indications during the heating season of 2004/2005.

- The heating system was operated for 45 days in the heating season of 2004/2005, and stopped due to the non-payment for gas supply. As a result the condominium owes the heat supply company (Eco-Engineering Ltd) 720 thousand drams (of which: 270 thousand drams for consumed gas; and 450 thousand drams for renting), and Eco-Engineering owes gas supply company (ArmRusGasprom CJSC) 270 thousand drams. For this and many other (which will be discussed below) reasons the system operation was stopped.
- On request of Jrashat condominium, the UNDP/GEF "Armenia – Improving the Energy Efficiency of Municipal Heating and Hot Water Supply" (EE Heating and HWS) Project specialists analyzed the results of the system previous year operation aimed at restarting the heat supply for the heating season of 2005/2006.
- During the analysis, the heat tariff components were studied, and series of meetings, negotiations and discussions were held with condominium /residents, Eco-Engineering Ltd, Ar&Ar Engineering Ltd, Yerevan municipality, "EE Heating and HWS" Project and other interested international organizations/ programs.
- In the first stage of the analysis, the heat tariff was calculated as 18.2AMD/kWh according to the actual heat demand of 2003/2004 (300MWh) and the designed capital costs. Analysis showed that the fixed part of the heat tariff, which includes depreciation expenses, was high due to the overestimation of designed capital costs, as initially, the project was designed to provide not only heat but also hot water. This issue was discussed with Ar&Ar and Eco-Engineering authorities, the overestimated initial costs were decreased to more realistic amount, according to which a new heat tariff was calculated as 17AMD/kWh, and only 58 apartments from 113 were agreed to receive heat with that tariff, this fact supposed the decrease of annual heat demand from up to 172.2MWh, which resulted to the heat tariff increase from 17 to 27.3kWh which was even higher than electricity tariff.
  However, due to negotiations organized by "EE Heating and HWS" project, the president of Ar&Ar agreed to cut the depreciation costs and profit, thanks to which the heat tariff was reduced up to 14.6AMD/kWh. 76 households agreed to this option; considering the fact that the last mentioned tariff was calculated according to the actual heat demand of 300MWh/year (for 100 apartments) and the demand is less than 300MWh/year for 76 apartments, the tariff was recalculated as 16AMD/kWh.
- The heat tariff calculations are summarized below:

Annual Heat Demand [MWh]	Calculated heat tariff [AMD/kWh]	Number of Households Agreed
300	18.2	negotiations
300	17	58
172.2	27.3	negotiations
300	14.6	76
less than 300	16	76

- After series of meetings and explanatory works with residents, 76 households were agreed to receive heat from the system and 37 - were not, and the following are the reasons for refusal:
  1. There are internal heating system defects and plugging – *7 apartments*;
  2. Heat consumption regulatory valves are missing – *1 apartment*;
  3. Apartment level (individual) gas fired boilers and stoves are being used for heating after gasification of the buildings – *7 apartments*;
  4. Heat tariff is high – *5 apartments*;
  5. There are closed door apartments – *11 apartments*;
  6. There are no radiators at the apartments (they do not want to receive heat from centralized heating system) – *6 apartments*.

  The first mentioned reason could have been mitigated by conducting renovation woks in internal heating system.
- Following investments were necessary to start up the system and operate it more efficiently and safely:
  - o 0.35mln AMD – for the renovation of internal heating system;
  - o 1.45mln AMD – for regulatory and maintenance works to start up the system.

  Thus 1.8mln AMD prepayment was required.
- However, the heating system have not been operated during 2005/2006 heating season, because the condominium was able to collect only 1.2mln AMD, which was less than the amount required for the system start up and Eco-Engineering refused signing a heat supply contract with the condominium.

RESULTS

- The project designed cost was 125,000 USD, including the portion that goes to the beneficiaries: 80% Ecofys and 20% Ar&Ar Engineering Ltd.
- Due to the new heating system the comfort level was improved during the heating seasons of 2003/2004 and 2004/2005, as before the project implementation most of the households were using electricity for heating, which is an expensive energy source for that purpose, therefore most of the apartments were heated partially. However, many apartments were also heated partially after the project implementation for two main reasons:
  - o defective technical resolutions,
  - o bill cut motivation of the households through the less heat consumption.
- Under the condition of the same level of comfort, the energy costs savings were possible due to implementation of the project, as the energy price decreased from 20-25 AMD per kWh to 14.5 AMD per kWh for the households (with no consideration of the efficiencies of heating appliances/equipment).
- However, the possibilities of the mentioned benefits were decreased/ disappeared for the heating season of 2005/2006 due to the project fail, the main reasons of

which are summarized under the next headline.

LESSONS LEARNED

This heating project is considered as a failed project, and the following are the main reasons of the project fail:

- An expensive system was designed/constructed due to overestimation of the system capacity (the system never has been operated with its full capacity), which increased the depreciation expenses and heat tariff.
- A wrong method was implemented for the consumed heat distribution by apartments, as the distribution was made based on the heating costs instead of heat consumption recorded on allocators installed in each apartment (few allocators were out of order).
- The system was operated on professionally inappropriate level during the previous years, because of lack of appropriate cadres at Eco-Engineering Ltd.
- The condominium was not institutionally strong.
- Ar&Ar Ltd was not interested in operation of the heating system.
- The gasification of apartments promoted the installation of individual (apartment level) gas fired boilers/stoves for heating.

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For More Information:

Contact Name
Contact Email
Location of Contact

Last Update: [July 2006]

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This work was funded by the United States Agency for International Development