LESSONS LEARNED FROM THE UNDP-GEF PROJECT IN ARMENIA

Improving Energy Efficiency of Municipal Heating and Hot Water Supply

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Lessons Learned from the UNDP-GEF Project in Armenia:
"Improving Energy Efficiency of Municipal Heating and Hot Water Supply"

Executing Agency:	Ministry of Nature Protection of the Republic of Armenia
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Authors:	Robert Kharazyan, PhD (Lead Author) Diana Harutyunyan, PhD (Project Coordinator) Eduard Keryan Marina Sargsyan, PhD Mikhail Vermishev, PhD Svetlana Galoyan
Editor:	Tara Bray

Empowered lives.
Resilient nations.

This publication is prepared as a part of the project "Armenia - Improving Energy Efficiency of Municipal Heating and Hot Water Supply" UNDP-GEF/00035799, funded by the Global Environment Facility. The project objective was to investigate and promote solutions for an energy efficient municipal heating and hot water supply for Armenian cities paying special attention to the GHG emissions reduction aspect and the application of new high energy efficiency technologies.

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Executive Summary

In June 2005, the United Nations Development Programme and the Government of Armenia began the implementation of a project entitled "Armenia – Improving the Energy Efficiency of the Municipal Heating and Hot Water Supply". The project is scheduled for completion in February 2013.*

Prior to the commencement of project activities, municipal heat supply services for cities throughout Armenia were non-existent. Additionally, the Government strategy to address the emergency heat supply situation did not result in any changes in regard to the restoration of the district heating system as a whole as the strategy had neither financial backing nor defined implementation measures. Thus, the objective of the project was to investigate and promote solutions for an energy efficient municipal heating and hot water supply for Armenian cities.

The project findings provided valuable input for the initiation and implementation of Armenia's first large-scale district heating restoration project. The restored system provides heat from a 'greenfield' autonomous energy centre, utilising cogeneration technology, via fully reconstructed heat networks. Apartment-level metering and regulation have also been put in place to ensure the operation of an effective consumption-based payment system. By developing a holistic approach aimed at reducing commercial risk, while ensuring a competitive and affordable level of heat energy cost for consumers, the project was able to attract private investment for the restoration of district heating systems.

The success of the project was mainly due to the approach applied to pricing the heat and electricity produced by the cogeneration units. The rationale of this approach was such that the Government adopted a Decision guaranteeing the purchase of electricity produced from the cogeneration units of the district heating restoration demonstration project and assuring a favourable purchase price for this electricity. This created investor confidence that an adequate return on investment was realisable. Equally, the demand side regulation and consumption-based payment system created incentives for energy saving, and the application of a multi-part tariff system for heat energy mitigated the risk for the supply company from a reduction in heat consumption.

The project findings also substantiated the need for a public-private support scheme, which was ensured by the Government's decision to transfer the heat supply infrastructure of the demonstration project to the newly established heat supply company.

As a direct outcome of the project's technical assistance and efforts aimed at ensuring a favourable economic and administrative environment, more than USD 9 million in foreign direct private investment was used to finance the restoration of the district heating system of the Avan residential area in Yerevan.

Furthermore, the project approach to the pricing of the electricity and heat produced from cogeneration units aimed at promoting district heating restoration was the cornerstone for the regulatory framework drafted by the project and approved by the Public Services Regulatory Commission (PSRC) of Armenia. This regulation focused mainly on reducing commercial risk to a level that would stimulate private investment in district heating. The introduction of this regu-

* UNDP-GEF/00035799

lation proved to be an incentive, as several new cogeneration based heat supply projects were initiated following its adoption.

However, given the lack of experience in the construction and operation of cogeneration-based district heating systems, the PSRC cancelled the promotional regulation in 2010, postponing further decision-making until the Avan district heating restoration project had been fully completed. The success of the Avan project may prove to be the key to unlocking the application of cogeneration technology in the heat supply sector of Armenia and to providing the evidence that district heating restoration projects only become feasible and attractive for private investors when support schemes are available.

The project also successfully contributed to the application of advanced energy efficient technologies and renewable energy resources in the heat supply sector by implementing over 20 small-scale pilot projects, and by building the capacity of the associated energy service companies, thereby replicating the experiences gained from the pilot projects and increasing the market penetration of these technologies.

As a direct consequence of the technical assistance provided, the project was able to leverage USD 16.4 million in private investment for the heat supply sector, USD 10.7 million of which had already been invested by 2012. The remainder will be invested by 2014 in accordance with the approved investment plan of the district heating company.

This Lessons Learned Report was prepared in order to capture the experiences gained and observations made during the project's implementation, to summarise the achievements of the project, and to make recommendations concerning the future development of the heat supply market in Armenia. As the project tackled the barriers hindering the development of an energy efficient heat supply market, which is often a common problem for countries with economies in transition, the findings can be considered useful for addressing similar issues elsewhere.

The experience gained and lessons learned from the implementation of the project are summarised in the key recommendations to (i) the Government of Armenia and (ii) donors, as follows:

(i) *In light of the existing and forecasted prices for natural gas, cogeneration-based district heating is the most feasible way to further develop a centralised heat supply market in Armenia. Therefore, the Government's perception of the real benefits of a centralised heat supply for compact urban areas and the willingness to support it are key elements to the successful restoration of district heating systems. Thus, both a regulatory framework for promoting cogeneration-based district heating, and a supportive administrative environment at the municipal level, need to be in place to attract private investment in such restoration projects.*

(ii) *To ensure an energy efficient, sustainable and affordable heat supply in countries in transition, donor assistance needs to promote the use of cogeneration for district heating, thus contributing to emissions reduction and mitigating the impact of natural gas price increases on heat energy. To this end, efforts should focus on ensuring that a supportive regulatory framework exists, along with corresponding public private partnerships, to reduce the commercial risk for private investment. This approach should ensure substantial environmental, economic and social benefits.*

The Report is structured in ten sections:

Section 1 provides general information about the country and a brief note on the Energy Sector, highlighting the background of heat supply in Armenia;

Section 2 examines the barriers to the sustainable development of a heat supply

market and presents a brief summary on the challenges faced during the project's development and inception phase;

Thereafter, the sections present the project activities in terms of how the project contributed to the sustainable development of the heat supply market and to improving the energy efficiency of the sector, in particular:

Section 3 presents the activities on improving the legal and regulatory framework;

Section 4 describes the private investments made in connection with the implementation of the first cogeneration-based district heating projects;

Section 5 is devoted to the introduction of energy efficient advanced technologies and renewable energy sources in the heat supply sector;

Section 6 describes the joint activities with municipalities aimed at energy efficiency (EE) and energy savings improvement;

Section 7 is devoted to capacity building, awareness raising and replication of experience.

Section 8 presents an assessment of the GHG emission reductions resulting from project implementation;

Section 9 looks at the lessons learned during project implementation and presents recommendations aimed at providing further support to the development of a sustainable energy efficient heat supply market in Armenia. The lessons are considered in terms of removing barriers and the project's successes and failures in reaching the project goals.

Section 10 highlights the main achievements of the project.

Abbreviations

AMD	Armenian dram
CCGT	Combined cycle gas turbine
CDM	Clean Development Mechanism
CIS	Commonwealth of Independent States
CJSC	Closed joint stock company
DH	District heating
EE	Energy efficiency
ES	Energy saving
FIT	Feed-in-tariff
FDI	Foreign direct investments
FS	Feasibility study
Gcal	Giga Calorie (10^9 cal)
GDP	Gross domestic product
GEF	Global Environment Facility
GHG	Greenhouse gas
GoA	Government of Armenia
GW	Gigawatt (10^9 W)
GWh	Gigawatt hour (10^9 Wh)
HPP	Hydropower plants
HW	Hot water
kW	Kilowatt (10^3 W)
kWh	Kilowatt hour (10^3 Wh)
kWe	Kilowatt (10^3 W) electrical energy
kWt	Kilowatt (10^3 W) thermal energy
LTD	Limited liability company
MENR RA	Ministry of energy and natural resources
MNP RA	Ministry of nature protection of the Republic of Armenia
MUD RA	Ministry of urban development
MW	Megawatt (10^6 W)
MWh	Megawatt hour (10^6 Wh)
m^3	Cubic meter
NEEAP	National Energy Efficiency Action Plan
NGO	Non-governmental organization

ANPP	Armenian Nuclear Power Plant
O&M	Operation and maintenance
OECD	Organization for Economic Cooperation and Development
PIU	Project implementation unit
PPP	Purchasing Power Parity
PSRC	Public Services Regulatory Commission of the RA
RA	Republic of Armenia
RES	Renewable energy sources
RF	Russian Federation
R2E2	Renewable Resources and Energy Efficiency Fund
SNC	Second National Communication on Climate Change of Armenia
SHPP	Small scale hydropower plant
TPES	Total primary energy supply
TPP	Thermal power plant
t	Ton
toe	Ton oil equivalent
UHS	Urban Heating Strategy
UNDP	United Nations Development Programme
USAID	United States Agency of International Development
USD	United States dollar
WB	World Bank

1. Introduction

1.1 Republic of Armenia: Basic Data

The Republic of Armenia is located in the north east of the Armenian Highlands, bordering Georgia to the north, Azerbaijan to the east, Turkey to the west and southwest, and Iran to the south.

Figure 1.1. *Map of the Republic of Armenia (source: www.lonelyplanet.com)*

Armenia is a mountainous landlocked country covering 29,800 km^2 and with 76.5% of its territory at altitudes of 1,000m to 2,500m above sea level.

Armenia is a country of climatic contrasts. Substantial changes in climate can be seen, even between short distances, because of the complex terrain. The country's climate ranges from arid subtropical to cold, high mountainous. The average temperature in January is -6.7 °C and in July the average is 16.7 °C. The lowest temperature ever recorded was -42 °C.

The population of the Republic of Armenia is nearly 3.3 million (as of 2010) with 64% of the population settled in urban areas; the average population density is 110 person/km^2. Yerevan is the capital city.

The collapse of the Soviet Union and the disruption of economic relations with the Soviet republics, followed by a severe energy crisis, led to the economic downturn of 1991-1994. Thereafter, Armenia managed to overcome the difficulties of the transition period and to ensure economic stability and rapid growth. During 1995-2000, Armenia's Gross Domestic Product (GDP) increased annually by 5.4%, and between 2001-2006 the average annual GDP growth amounted to 12.4%. This annual growth slowed to 2.2%, on average, during 2007-2010 due to the worldwide financial crisis.

In 2010, the Armenian GDP reached USD 9.37 billion or USD 16.56 billion GDP (PPP) with the following structure: 16.4% from industry, 19.4% from agriculture, 19.0% from construction and 45.4% from services. At the same time GDP (PPP) per capita amounted to USD 5,711.

Armenia has trade relations with 66 foreign countries, including nine from the Commonwealth of Independent States (CIS). The main trading partners are the Russian Federation, Germany and the USA. CIS countries account for more than half the turnover.

Figure 1.2. *A view of Yerevan, the capital city of Armenia*

The Republic of Armenia is a member of the CIS, the Council of Europe and the World Trade Organization, and maintains diplomatic relations with 153 countries. The country is ranked 86 in the UNDP Human Development Index (2011).

1.2. Energy sector of the Republic of Armenia

Primary energy resources. Armenia has no domestic fossil fuel resources and strongly depends on imported primary energy resources to meet its energy demand. Domestic primary

energy resources, namely hydro resources, provide only 8.1% of Armenia's energy demand. Armenia is dependent on the import of hydrocarbons for transport, all gas used for heating, cooking, and the generation of electricity (roughly one-third of the country's generating capacity), and all of the uranium needed for the Metsamor nuclear power plant.[1] Energy efficiency and utilising alternative sources of energy are therefore top priorities.

In 2010, Armenia's total primary energy supply (TPES) amounted to 2,570 ktoe with the major share being natural gas (52.8%) (Figure 1.3).

The main consumers of fossil fuel are the power industry (24%), the housing and public sector (23%) and transport (20%).

2010 energy consumption per capita was 0.79 toe and the energy intensity of GDP was 0.274 kg o.e./USD or 0.16 kg o.e./USD (PPP). For comparison, the 2007 energy intensity of GDP (PPP) was 0.17 kg o.e./USD in Armenia, while worldwide it was 0.20, 0.17 for OECD countries, and 0.41 in CIS countries.[2]

Electricity. Electricity is generated by thermal, nuclear and hydro power plants and small plants (small hydro, wind power, cogeneration and biogas). About 40% of the installed power generating capacity has been in operation for more than 35 years, and only 70% of its capacity is available.

Therefore, modernising and replacing this generating capacity is essential. The Government of Armenia has already taken steps towards improving the situation, including the rapid development of small HPPs; the commissioning of a new combined cycle unit (240 MW capacity) at the Yerevan TPP and a 440 MW gas turbine unit at the Hrazdan TPP. The first wind power plant and a number of small cogeneration plants have also been put into operation (15.51 MW in total).

In 2010, total power generation amounted to 6,491.2 million kWh, with 38.4% generated by the nuclear power plant, 21.7% by TPPs, 33% by HPPs and 6.9% by small plants (Figure 1.4).

The major consumers of electricity are the residential sector and industry, using 35.7% and 23.2% respectively.

Armenia has intersystem connections with all its neighbouring countries, but an operational power interchange exists only with Iran and Georgia.

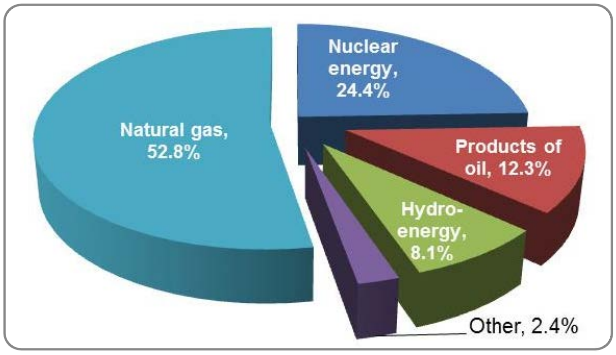


Figure 1.3. *Structure of primary energy resources in 2010 with "other" including firewood, manure, and coal (source: "ArmRusGasProm" CJSC, "Settlement Centre" CJSC of RA MENR, surveys done by WB, FLEG, UNDP)*

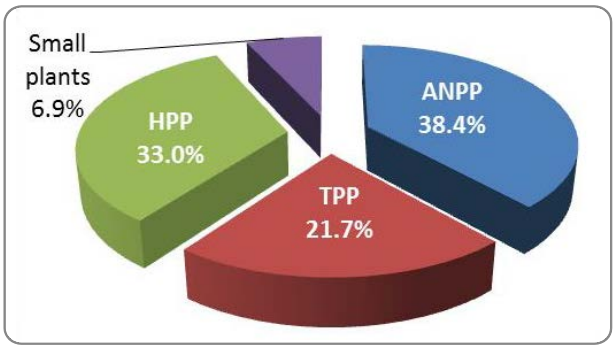


Figure 1.4. *Structure of power generation in 2010 (source: "Settlement Centre" CJSC of the RA MENR)*

Gas Supply System. Armenia imports natural gas from Russia, via Georgia, and from Iran. The gas transportation system includes a main high-pressure pipeline and an underground gas storage facility. The gas distribution system has expanded rapidly in recent years and the number of consumers has now reached 620,000 (Figure 1.5), which exceeds that of the Soviet period. Annual gas consumption is in the range of 1.8-2.2 billion m^3.

[1] "Charged Decisions: Difficult Choices in Armenia's Energy Sector", the World Bank, 2011.
[2] International Energy Agency, 2009.

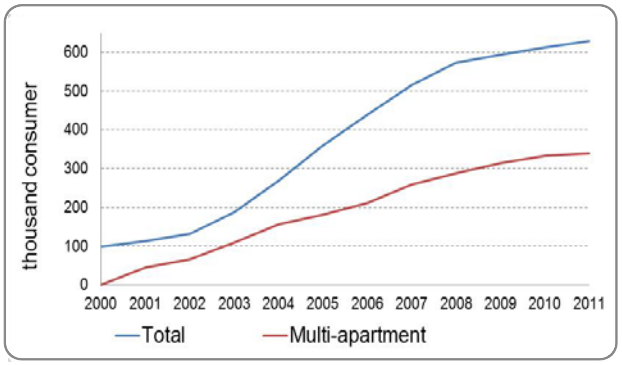


Figure 1.5. *Expansion of the natural gas network in the residential sector (source: the RA National Statistical Service)*

1.3. Heat Supply Sub-Sector History

Until the economic and energy crisis of the 1990s, the district heating system in Armenia supplied nearly all heating and hot water to residential and public buildings: 35% of the housing stock, and 90% of residential and public buildings in the country were supplied from district heating systems, operating on natural gas and with mazut (reduced crude) as a reserve fuel. Heat supply for the housing sector was provided by both large heat sources, TPPs and heat plants (35%), and by medium- and small-scale heat plants (65%).

The first phase of the development of the heat supply in Armenia started in the 1950s, when there was a rapid increase in the construction of residential apartment buildings and the natural gas network was extended to ensure their coverage. In this phase, heat was supplied to residential areas from medium- and small-scale heat plants.

The second phase of the development began in the early 1970s and ended in the 1980s. It involved the construction of large district heating systems supplied from TPPs in Yerevan, Hrazdan and Vanadzor, as well as heat plants with a 120-150 MW capacity. The existing small-scale boiler houses were converted to central heat substations (CHS), thus incorporating the existing distribution networks into larger systems.

Thus, by the end of the 1980s the existing district heating systems were supplying heat and hot water to 55 settlements in Armenia (9,400 residential apartment buildings and 3,800 public buildings in total).

With the closure of the nuclear power plant in 1989 and the regular interruptions of Russian gas imports through neighbouring countries, Armenia became almost entirely dependent on its hydropower resources for electricity generation purposes. Heat production fell sharply in 1992 and most of the district heating systems discontinued operation soon after. As a consequence, residents were forced to rely on individual heating solutions and use expensive electricity, wood, kerosene or any other available means. This resulted in (i) widespread harvesting of trees and consequent environmental damage; (ii) indoor air quality problems; (iii) power distribution system overload; and (iv) the shrinking of already small family budgets, particularly for those using electricity for heating.

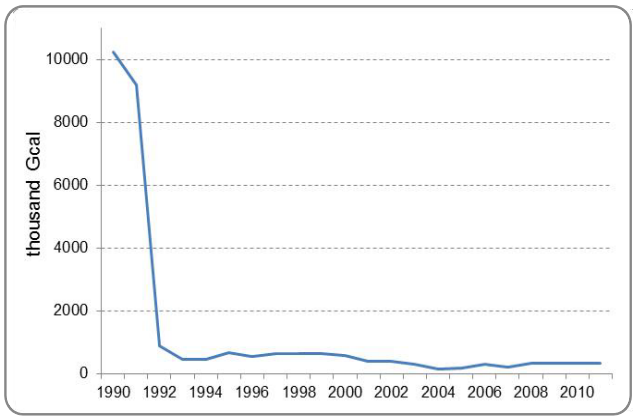


Figure 1.6. *Heat production by district heating systems in the RA (source: MENR for 1992 to 2002 and "ArmRusGasProm" CJSC for 2003 to 2011)*

Since 1996, despite the restoration of the gas and electricity supply, district heating services continued to decline because of the liberalisation of primary energy prices and the worsening social and economic conditions of the population. A number of operational shortcomings also became apparent: low reliability, significant heat losses, a lack of regulating and measuring equipment, and extremely low collection rates.

In 2002, the Government adopted the Urban Heating Strategy (UHS) to address the emer-

gency heat supply situation and to ensure the future provision of efficient, safe, affordable and clean heating services. The Strategy was composed of three implementation phases: i) survival: keeping the existing centralised heating systems operational with minimal investment and implementing measures to offer affordable heat supply (two years); ii) recovery: developing and implementing sustainable heating options (three to five years); and iii) growth: attracting investment for the rehabilitation of a centralised heat supply and promoting the large-scale utilisation of decentralised systems.

The Strategy focussed on the commercialisation of the heat supply, the provision of social support schemes, regulatory controls, technical measures and public awareness campaigns. The Strategy also promoted decentralised and individual supply for less densely built urban areas.

Unfortunately, the adoption of the Strategy did not result in any significant changes in the heat supply sector and the population continued to rely on individual solutions to cover their heating needs. By 2011, natural gas was being supplied to 79% of residential buildings, with the residents relying predominantly on gas for heating with the majority using gas space heaters. Due to the relatively low price of natural gas, compared with electricity[3], the share of households using natural gas for their heating increased dramatically. However, this increased reliance on individual heating solutions created additional problems, such as safety risks in both individual apartments and the buildings themselves; air quality issues, both indoors and outdoors; and had a negative impact on the structural integrity of the buildings.

The remaining district heating systems that supplied space heating discontinued operation before the end of the Strategy's planned two-year timeframe for the 'survival' phase. This was due to poor management, non-existent metering and control systems, the illegal release of hot water from the radiators of the internal heating networks (because of the discontinuance of the hot water supply), a low collection rate and consequent financial shortages, resulting in poor system maintenance and a lack of system modernisation. The few systems that supplied space heating finally collapsed in 2004 following the Government's decision to abolish natural gas subsidies.

Thus, when the UNDP-GEF project began in 2005, the situation in the heat supply sector in Armenia was as follows:

- The district heating system had actually collapsed: heat generation by district heating systems in 2005 fell to about 2.5% of that in 1990 (Figure 1.6).
- There was no political will for the development, management and regulation of the sector: i.e. no regulations or authorised body designated responsibility for the sector, no targeted social support and no financial support schemes.
- Public reliance on individual heating solutions for heating and hot water increased;
- The gas supply system was expanded and safety requirements were relaxed for using natural gas for heating purposes in multi-storey residential buildings.

[3] In 2007, 1 kWh of electrical energy cost 21.7 AMD, while 1 kWh of heat energy from gas-fired heaters with open combustion chamber cost 15.7 AMD and 16.8 AMD from those with close combustion chamber.

2. The Project and its Development Context

2.1. Development Context

The heat supply sub-sector is one of the biggest consumers of energy resources in Armenia and correspondingly one of the country's largest GHG emitters. By 2006, its consumption rate had reached 20%, while its GHG emissions were about 20% of those from the energy sector and 14% of the country's total emissions.[4] According to the National Program on Energy Saving and Renewable Energy (2005), improving the energy efficiency in buildings has the energy saving potential of 331 ktoe - 33% of the total energy saving potential of Armenia. Thus providing a low-cost, reliable, energy efficient and environmentally friendly heat supply is of primary importance and the technical, environmental and economic feasibility of high-efficiency district heating systems should be explored for densely-built urban areas.

The following key barriers to the sustainable development of heat and hot water supply services were identified during the development phase of the UNDP-GEF project:

- Weak institutional, legal and regulatory framework:
  - Lack of short- and long-term planning for the development of feasible, energy efficient, environmentally friendly heat supply systems;
  - Lack of a favourable business environment for attracting private investment in the heat supply sector;
  - Lack of a clear assignment of responsibilities and accountability among government and local authorities for making key decisions on heat supply issues;
  - Lack of a regulatory framework for ensuring appropriate working relations between apartment owners in multi-storey buildings after privatisation, in terms of common rules and responsibilities;
  - Lack of social support schemes for essential heating needs;
  - Lack of an appropriate tariff policy promoting an energy efficient and environmentally friendly heat supply.
- Lack of incentives and an implementation plan for restructuring and commercialisation/privatisation of existing district heating companies;
- Lack of capacity, experience and appropriate skills within local authorities and of multi-apartment building management bodies to manage existing small-scale heat supply systems.

2.2. Project Objective and Project Components

The project was designed to address the above-mentioned barriers and took into full consideration national and sectoral policies and priorities.

The project objective was to reduce the GHG emissions resulting from the heat and hot water supply services in Armenian cities and to lay the foundation for the sustainable development of these services.

Project activities were grouped into four main components:

- strengthening the role of condominium associations in collectively organising and managing the heat and hot water supply services at the building level;
- supporting the restructuring and capacity building of existing district heating companies to improve both their service quality and operational efficiency;

[4] The Second National Communication of Armenia under UNFCCC, 2010

- supporting the new decentralised service providers and developing a structured financial framework to encourage the required investments; and
- utilising the results, experiences and lessons learned to advance the sustainable development of heat and hot water services in Armenia with an emphasis on GHG emissions reduction.

2.3. Project Duration and Financing

Financed by a GEF grant of USD 2.95 million the project was implemented by UNDP with the Ministry of Nature Protection of the Republic of Armenia as its national executing partner. The project began in June 2005 and was due to close in January 2009, however following the recommendations from the Mid-Term Evaluation, the Project Steering Committee extended the project until February 2013.

The project's activities were designed to complement the activities of various other donor-funded initiatives also supporting the development of the heat supply sector in Armenia. Specifically: the World Bank/IDA-funded Urban Heating Project (USD 10 million, credit), the USAID activity [5] (USD 7 million, grant) and the Government of Netherlands-funded Development of the District Heating Industry Project (USD 0.57 million, grant).

2.4. Project Inception Phase

During the inception phase, project implementation arrangements were continually assessed and adapted to reflect the changing status of the heat supply market. These findings were then reflected when planning the project activities to ensure that project components remained appropriate, viable and implementable, in light of Armenia's rapidly changing market conditions and the time delay from project approval to actual start date.

Thus, the outputs under the second component of the project were revised (Table 2.1) due to the collapse of the remaining district heating systems between 2003, when the project was approved, and 2005, when the project actually commenced, and the subsequent leasing by municipal authorities of the heating substations and small boiler houses to the private sector.

The project objective and interventions were formulated in line with the Urban Heating Strategy of RA (2002) and subsequent legislation including:

- Energy Saving and Renewable Energy Law (2004);
- Energy Sector Development Strategy in the Context of Economic Development in Armenia (2005);
- GoA Decision on "Transfer of Heat Supply Assets to Yerevan Municipality" (2003);
- GoA Decision on "Leasing of Heat Supply Facilities" (2003);
- GoA Decision on "Amendments to GoA Decision on Leasing of Heat Supply Facilities" (2004).

Additionally, the following activities were implemented: co-ordination and operational modalities were established with national partners (in particular, a Memorandum of Understanding was signed with the Municipality of Yerevan in 2005 to co-ordinate activities aimed at heat supply restoration); co-ordination between donor-funded projects for co-financing specific activities was established to avoid duplication of effort (all donors structured their projects around the UHS to support different aspects of its implementation); continuous liaison between the UNDP country office and the project executing partner, Ministry of Nature Protection, as well as the partner ministries, Ministry of Energy and Ministry of Urban Development, to ensure stronger engagement of these key partners; engagement of a professional and respected project team.

[5] The USAID project operated only one year with approximate budget of USD one million; cancelled in 2008.

2.5. Project Implementation

As mentioned in Section 2.4, the project had to maintain an adaptive management approach to reflect the changed conditions and the emerging needs of the market. Throughout implementation the project outputs and planned activities reflected this approach.

Accordingly, Output 4.2 - "Adopt norms and enforcement mechanisms for preventing the unsustainable use of forest wood as fuel" - became less relevant following the restoration and expansion of the gas supply system, as the use of firewood for heating purposes was significantly reduced. As such, following the recommendations of the Mid-Term Evaluation in 2009, activities associated with forest management standards were cancelled.

Another project activity that was adjusted related to policy work for condominium associations. Although condominium associations could play an important role in the management of heat supply at the building level (e.g. collection of payments for centralised heating), once the central heating collapsed this management role became less relevant. Thus, following the Mid-Term Evaluation, activities with condominium associations were reduced from 2008 onwards.

The main activities of the project therefore focussed on establishing a framework for implementing and managing heat supply services at the municipal level; improving the regulatory framework to promote an energy efficient and environmentally friendly heat supply; creating a favourable business environment for attracting private investments; commercialising heat supply services; introducing advanced energy efficient technologies and renewable energy sources in the heat supply sector; and facilitating awareness raising, knowledge sharing and replication of experience.

Table 2.1: Revisions to Component 2 Project Outputs

#	*Outputs according to the Project Document under Component 2*	*Revised Outputs*	*Rationale for Amendment*
2.1	Finalise an implementation strategy for improving the energy efficiency of existing district heating companies.	Develop municipal strategies to improve heat and hot water supply services to the population	Collapse of district heating systems and bankruptcy of the former district heating companies. Designation of Yerevan City Municipality as the authorised body to manage heat supply assets with permission to lease them to private operators based on corresponding business plans.
2.2	Improve the legal and regulatory framework to encourage and support the improved energy efficiency of existing district heating services and the commercial operation of the remaining district heating companies.	Improve the legal and regulatory framework for increasing the energy efficiency of heat supply systems	
2.3	Adopt a consumption-based metering and billing system for use by the remaining district heating companies.	N/A	Incorporated in other outputs, as integral part of business plans for restoration of district heating systems.
2.4	Strengthen the capacity of the management and the operating personnel of the district heating companies to improve their efficiency.	Strengthen the capacity of municipalities to manage district heating assets and facilitate the further development of heat and hot water supply services.	See Rationale for Amendment to Components 2.1 and 2.2

3. Improving the Legal and Regulatory Framework

3.1. Creating a regulatory framework for the promotion of cogeneration-based district heating

As mentioned in Section 2.1, in 2006 the supply of heat and hot water to residential and public buildings accounted for approximately 20% of primary energy resources. The efficient use of these resources is therefore essential for reducing Armenia's dependence on imported fuel, enhancing the country's energy security and limiting GHG emissions from the energy sector.

An assessment conducted by UNDP-GEF project experts in 2006 confirmed that in terms of the existing and forecasted prices for natural gas, a district heating system based on heat-only boilers was not competitive when compared to individual heat supply solutions and consequently not attractive for private investors.

At gas import price of USD 110/1000 Nm^3, the cost of heat energy from centralised small-scale heat supply systems based on heat-only boilers amounted to AMD 24.8/kWh. However, the cost from gas-fired apartment level space heaters with an open combustion chamber and a closed combustion chamber amounted to AMD 15.7 per kWh and AMD 16.8 per kWh respectively.

Therefore, the project team undertook a feasibility study for district heating restoration in two high heat density residential areas in Yerevan (Avan and Davidashen), comparing two restoration alternatives: i) heat-only boilers; and ii) cogeneration.

Directive 2004/8/EC of the European Parliament and of the Council of Europe on the promotion of useful heat demand based cogeneration outlines the framework for promoting cogeneration. The support scheme for cogeneration developed by the project team was in line with this Directive, taking into consideration the specifics of the internal markets for electricity and heat.

With the underlying goal of providing an environmentally friendly and reliable heat supply at low rates and reducing commercial risk to a level that stimulates investment in cogeneration-based district heating restoration, the following pricing approach was applied in the feasibility study. Firstly, a competitive and affordable heat energy tariff was determined based on the market research. Thus, the revenue from heat sales was first taken into account and then the electricity tariff was calculated as the "left over" costs associated with running the cogeneration system and ensuring the required return on the investment.

According to the feasibility study for the Avan project, using a gas import price of USD 110/1000 Nm^3, the heat energy tariff from cogeneration amounted to AMD 14.6/kWh, whereas the cost from the conventional district heating system (based on boiler houses) amounted to AMD 22.7/kWh.

With this approach, the tariff for electricity produced from cogeneration units was close to the calculated one-part tariff of the marginal TPP of the Armenian power system.

Based on these findings and the preliminary assessment, the Government of Armenia adopted a Decision that guaranteed the purchase of the electricity produced from the cogeneration units of the Avan and Davidashen district heating restoration projects at a favourable price (see Section 4.) This GoA Decision was the first of its kind in supporting the promotion of cogeneration-based district heating restoration.

As private investor interest in cogeneration-based district heating restoration increased, it became necessary to issue regulations that supported cogeneration-based district heating restoration and that defined a tariff policy in this area.

In this regard, two documents were prepared in compliance with the principles and approaches

of EU Directive 2004/8/EC and submitted to the Public Services Regulatory Commission of RA (PSRC). In 2007, the PSRC adopted two resolutions: No.168-L "Principles of Tariffs Calculation for Cogeneration based on Useful Heat Demand" and No.206-N "Methodology for Calculating the Tariffs for Heat and Power from Cogeneration based on Useful Heat Demand".

To stimulate a favourable economic environment for investment in new cogeneration installations, resolution No.206-N stipulated a five-year grace period, during which all electricity generated was considered "electricity from cogeneration" and therefore should be purchased at a favourable price. In the same year, the PSRC adopted a further document, which defined the methodology for determining reference values to calculate the efficiency of cogeneration.

The UNDP-GEF project's consistent advocacy for the adoption of the above-mentioned regulations provided essential support for the EU/Armenia Action Plan for 2007.

As the development of new cogeneration-based district heating systems was initiated, it became evident that the methodology for calculating the tariffs would require certain amendments. However, rather than approving the individual amendments drafted by the project experts, the PRSC decided to replace the existing methodology with a new one which would incorporate all the required amendments. This new document has yet to be approved.

3.2. Proposal on revising the natural gas tariff system

The existing single-part tariff system for natural gas in Armenia was adopted in 1997 and is obsolete in the current economic environment. In contrast to the situation in 1997, a wide range of consumer type now exists, along with significant differences in consumption patterns and volumes (monthly and annual). In addition to the known disadvantages of a single-part tariff system, substantial differences exist in the tariffs' value, which depends on the monthly consumption threshold of 10,000 Nm³. The main shortcomings of the existing system were analysed by the project team and identified as follows:

- The suppliers' cost structure is not taken into account and tariffs are not split into fixed and variable parts. The supply company tries to sell as much gas as possible in order to recover its fixed costs; therefore there is no incentive for it to encourage energy savings by end users. Moreover, it may incur significant losses as a result of a decrease in gas consumption.
- Tariffs do not reflect the costs incurred by the supply company from different groups of consumers. Each consumer varies by the gas distribution network they require connection to (based on their demand for high, medium or low pressure gas) and consequently the losses and operating and maintenance costs caused by these consumers vary.
- The existing tariff system cannot be used for encouraging the economic development of selected sectors because it applies only to monthly consumption-based differentiation.
- The monthly consumption-based tariff system increases costs for small and medium businesses: 35% higher tariff for a monthly consumption of less than the threshold of 10,000 Nm^3 versus the tariff for a monthly consumption equal to and above 10,000 Nm^3 (USD 330 versus 243 per 1000 Nm^3). Thus, the same consumer may see a significant difference in monthly payments as their consumption varies above or below the 10,000 Nm^3 threshold. This makes it difficult for businesses to remain competitive.
- Under the current tariff system, in some cases it is cheaper for smaller consumers to use more rather than less gas (e.g. consumption of 9,900 Nm^3 per month costs

USD 3,267, whereas monthly consumption of 10,000 Nm^3 costs USD 2,430). This promotes energy wastage rather than energy savings.

- The last two points are particularly relevant for small boiler houses (supplying schools, kindergartens, hospitals), which in 2010 totalled approximately 900 throughout the country.

The project team recommended that tariffs should be differentiated by consumer type rather than monthly consumption threshold. As such, the following consumer groups were suggested: i) "industry", including the energy sector; ii) "trade and services", including agriculture, organisations funded by the State budget, commerce; and iii) "residential sector". These recommendations were discussed with key decision makers.

As a result of the project team's analysis, findings and recommendations, measures to revise the natural gas tariff system were included in the National Energy Efficiency Action Plan adopted by the GoA in 2010.

3.3. Revision of Standards and Technical Regulations

The current technical regulations in Armenia are mainly based on the norms, standards and methodologies used in the former USSR. They are based on out-of-date climatic data, do not take into account the requirements for improving energy efficiency or using new technology and do not reflect today's economic environment.

In 2004, Armenia was invited to enter into intensified political, security, economic and cultural relations with the European Union in the framework of the European Neighbourhood Policy. To this end a new European Neighbourhood and Partnership Instrument (ENPI) was drawn up and an Action Plan was developed to bring Armenia's legislation, norms and standards in line with those of the EU.

The UNDP-GEF project provided support to the implementation of the priority measures of the Action Plan, which also reflected project objectives, namely energy efficiency-related standards and technical regulations.

3.3.1. Revising and updating the "Construction Climatology" building code

The "Construction Climatology" building code forms the basis for calculating the heat energy demand and thermal protection of buildings and is applied in urban planning and construction, design, etc. The existing building code was based on climatic data from the 1960s and therefore required urgent revision using the latest climatic data (up to 2010) in order to take into account the existing climate change trends and further expand the climatic indicators and parameters used.

The project team were requested to undertake this activity by several key stakeholders, including the Ministry of Urban Development. Relevant data from 52 operational hydro-meteorological stations in Armenia was collected and processed; based on this information the climatic parameters were elaborated.

The revised "Construction Climatology" building code was approved by the Ministry of Urban Development and entered into force in 2011. The adoption of the revised "Construction Climatology" building code will improve the calculations of the thermal protection requirements and heat energy demand of buildings, resulting in a more accurate estimation of the investment required for the construction of buildings and their engineering systems.

3.3.2. Introducing energy efficiency standards for residential and public buildings

Multi-apartment buildings in Armenia (totalling 25 million m^2 in residential floor area) are typically in poor condition, with poor thermal characteristics and defective sealing. Improving

the energy performance of these buildings is therefore an important measure for reducing Armenia's energy dependency and GHG emissions. As this activity was in line with the project objectives, the Ministry of Energy and Natural Resources requested project assistance to introduce seven International and European standards regarding the energy efficiency of buildings, energy performance of buildings, heating systems in buildings and heat meters.

The new standards were translated, discussed with relevant agencies and ministries and adopted between 2010 and 2012.

3.3.3. Energy efficiency labelling of energy-consuming household appliances

As noted earlier, the collapse of district heating led to the widespread use of individual solutions for heating and hot water provision, which was promoted by the easy availability of gas-fired household appliances and encouraged by private sector marketing and advertising.

International experience has demonstrated that introducing energy efficiency labelling on household appliances is among the most efficient and cost-effective way of promoting energy efficiency.

An initial study, carried out by the project during 2008-2009, identified a huge potential in energy savings through the transformation of the market for gas-consuming household appliances. Project activities initially focused on the introduction of energy efficiency labelling systems for household gas-fired appliances. However, the scope of the study was then extended to building regulations, thus introducing an energy efficiency labelling system for energy consuming appliances in general (e.g. gas-fired and electric mains operated appliances).

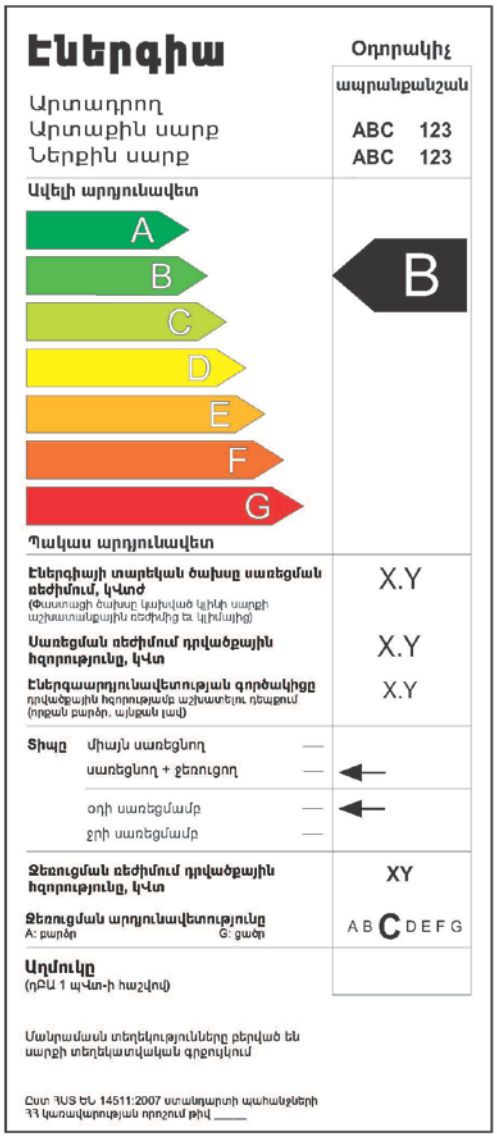
Using the provisions of the EC Directives as the basis for defining labelling requirements, in 2010 the project team conducted a study to find the best approach for introducing an energy efficiency labelling system for energy consuming household appliances in Armenia. As a result of this study, a draft Government Decision and energy labelling regulation were developed. Since this was the first time a labelling regulation had been applied in Armenia, a phased approach was proposed, with only a limited number of household appliances subject to labelling in the first phase. The list of appliances subject to labelling would then be gradually enlarged. To this aim, the corresponding international and European (CEN) standards on testing the energy performance of selected energy-consuming household appliances were translated and adopted.

The project team prepared a draft Government Decision and energy labelling regulation, which were both submitted to the Ministry of Energy and Natural Resources for adoption. Approval is expected in 2013.

3.3.4. Methodology for calculating hazardous emissions from solid, liquid and gaseous fuel fired boiler houses (installed capacity up to 5.8 MW)

The current methodology used to calculate hazardous emissions from boiler houses is out of date. As substantial changes have occurred in the performance specifications of modern equipment, hazardous emissions have decreased significantly and the concentration of hazardous substances in emissions has also changed. Therefore current regulations need revising in order to reduce the barriers for the application of new technologies, as well as to address the measures included in the EU-Armenia ENPI Action Plan for 2009-2011.

The methodology developed by the project calculates hazardous emissions from solid, liquid and gas-fired boiler houses of up to 5.8 MW of installed capacity and should be used for:



a. Sample energy label of an air conditioner

b. Sample energy label of a gas boiler

Figure 3.1. *Sample energy labels for selected domestic appliances*

- preparing statistical reports on atmosphere protection;
- developing maximum permissible concentration (MPC) reports and obtaining emission permits;
- promoting the implementation of measures for reducing emissions.

The methodology is applicable for municipal and industrial heat sources, including steam boilers, water boilers and cogeneration plants. The emission factors proposed were developed based on the experience of European countries and the best available technologies for heat energy production, as described in the joint EMEP/EEA Air Pollutant Emission Inventory Guide Book, 2009.

Within the methodology, boilers are grouped by their heat generating capacities and by the type of fuel being burned. For these groups the emission factors of different substances were selected based on the available heat capacity or amount of heat energy produced.

The draft methodology was discussed with key stakeholders, approved by the Ministry of Nature Protection and entered into force in October, 2012.

3.4. Proposals on building energy audits and passport applications

Both residential and public buildings have a high potential for cost-effective energy efficiency investment and GHG emission reduction. However, no established energy audit procedures for buildings exist in Armenia.

Given the urgency of implementing energy saving measures in buildings, the project undertook a study on the possibilities of implementing energy audits and introducing energy passports for multi-apartment buildings in Armenia, given the current legislative basis and based on European and international experience. The study was therefore conducted by an international expert, in close collaboration with the local company responsible for

developing the building passport form and energy audit procedure, and for piloting the new practices in five multi-apartment buildings. The study produced the following results:

- problem areas and barriers were identified and analysed;
- recommendations on necessary changes for improving the institutional, legal and regulatory frameworks for implementing building energy audits and developing energy passports were provided;
- barriers and possible bottlenecks to introducing building energy audits and passports were identified and recommendations on ways to overcome them were developed;
- recommendations on the building passport exemplary form were elaborated;
- procedure for building energy audit and passport development/application in multi-apartment buildings in Armenia was developed.

The results of the study were presented and discussed with interested parties and beneficiaries, including representatives from multi-apartment building management bodies and relevant state authorities. The study and subsequent stakeholder discussion to identify existing barriers and bottlenecks in this area substantiated the need to implement a project aimed at improving energy efficiency in buildings.

4. Attracting private investment for district heating restoration

4.1. District heating restoration in the Avan district of Yerevan

Background

The Master Plan of Yerevan for 2005-2020 envisaged district heating restoration in six residential districts of the city. However, despite the adoption of the Urban Heating Strategy in 2002, no district heating restoration actually took place.

As mentioned in Section 3.1, in 2006 the UNDP-GEF project conducted feasibility studies to identify alternatives for restoring district heating in two of the high heat-density districts included in the Master Plan.

The feasibility studies considered two alternatives: i) heat only boilers and ii) cogeneration. Both alternatives had to provide a reliable and good quality heat and hot water supply, the possibility of apartment level metering and regulation, and ensure affordable heat tariffs.

In light of the existing situation in the heat supply sector, it became clear that restoring district heating in the selected residential areas could only be achieved with the involvement of the private sector. The key to this was to create investor confidence by ensuring an adequate return on investment. Therefore, when developing the feasibility study, the project focused on reducing commercial risk and ensuring a competitive and affordable level of heat energy for consumers.

The cogeneration-based alternative proved to be the most feasible and environmentally-friendly solution for the selected areas (Avan and Davidashen), with its affordable heat tariff and higher GHG emissions mitigation potential.

Brief description of the project

The feasibility study for the restoration of the Avan district heating system included the construction of a 'greenfield' autonomous energy centre, equipped with cogeneration units and heat only boilers for peak heat loads, the full reconstruction of primary and distribution networks, the redesign of the internal distribution system of buildings (from vertical to horizontal), the installation of new internal heating and hot water supply networks and radiators equipped with regulators, and the installation of heat and hot water meters in preparation for the introduction of a consumption-based payment system.

The Avan residential district was built in the mid-1970s. It is a large residential area (150 ha) in the north-east of Yerevan. It has a population of 32,000 (218 high-rise apartment buildings) and is 1,200m-1,300m above sea level. The former district heating system began operation in the mid-1970s and provided heat and hot water to consumers in the area. From 1994 to 2003 it limited its operations to space heating only and was finally shut down in 2003. According to a study by the French company BCEOM (1996), the efficiency of the system was approximately 50%.

The Russian company "Bazoviy Element" had expressed interest in the district heating restoration in Armenia as early as February 2006. The project team therefore held several meetings with company representatives and government officials, while developing the feasibility study, to explain the applied approaches and respective potential benefits.

Project assistance in the implementation of the Avan district heating restoration project. Project assistance included: i) development of the feasibility study; ii) development of a regulatory framework to reduce commercial risk, by establishing public-private partnerships and establishing preferential tariffs for electricity generated from cogeneration units and two-part tariffs for supplied heat; iii) assistance in negotiations between private sector and national authorities – Government, Regulator and Yerevan Municipality - during the initiation and implementation of the pilot project; iv) organisation of consultations with the Avan district community

and condominium management; v) surveys of public opinion in the pilot area; vi) provision of international consultants, particularly Ramboll A/D and organisation of study tours for national decision-makers; vii) provision of apartment level heat and hot water metering equipment; viii) monitoring system operation.

The tariffs. The tariff setting approach for cogeneration based district heating, developed by the project team, was designed to provide affordable heat to residents and to reduce the commercial risk for investors. The approach used to determine the tariffs (see Section 3.1) was as follows: firstly, a competitive heat tariff was determined based on market research (comparing the heat costs from household appliances). The revenue from heat sales was first taken into account and then the electricity tariff was calculated as the "left over" costs associated with running the cogeneration system and ensuring the required rate of return on the investment. Using this approach the purchase tariff for electricity produced from cogeneration units was close to the calculated one-part tariff of the marginal TPP of the Armenian power system.

Using these calculations as a basis, on 13 April, 2006, GoA Decision No.509-N was adopted, which set a favourable purchase price (not exceeding the calculated one-part tariff of the marginal TPP) for electricity produced from the Avan CHP plant.

Setting a favourable price for the purchase of electricity from cogeneration based on useful heat demand is a well-known CHP promotion instrument in international practice; however this is the first example of public support for the promotion of cogeneration based on useful heat demand in Armenia.

The adoption of the GoA Decision reduced the commercial risk for investors by providing:

- a guaranteed revenue from electricity sold to the grid at the favourable tariff;
- a competitive and affordable heat tariff thus ensuring a high connection rate by the residents and consequently a high revenue from heat sales.

During the 2011-2012 heating season, the heat tariff for Avan district heating system was 16 AMD/kWh, while the cost of heat produced by apartment-level boilers was about 23 AMD/kWh (investment and operation costs), and for closed chamber gas-fired heaters only the gas costs amounted to 17 AMD/kWh.

Public-private partnership. Following the justification and introduction of the project's public-private partnership scheme, on 3 August, 2006, GoA protocol decision No.30 was adopted. In this regard, the Yerevan municipality was instructed to transfer the heat supply assets of Avan district to the heat supply company which would be set up to provide district heating for Avan residential area.

The adoption of these GoA Decisions reduced commercial risk and created a favourable economic and administrative environment for attracting private investment for the Avan district heating restoration project. It specifically influenced the investment decision of a Russian investor and in August 2006, a heat supply company, "ArmRusCogeneration" CJSC, was founded with the majority of shares owned by one Russian investor and the minority held by the Municipality of Yerevan.

Stage-by-stage implementation of the Avan project was envisaged - the first stage included 76 buildings to be supplied from the new Autonomous Thermal Power Plant ("ATPP-1") equipped with two cogeneration units of 2 000 kW_e and 2 180 kW_t capacity each and two peak heat only boilers with a capacity of 7.56 MW each.

The Autonomous Thermal Power Plant was commissioned on 15 December 2009. As of 2012, one CHP unit and one peak boiler had been installed to supply 30 apartment buildings, one school and two kindergartens. By 2012, approximately USD 9 million had been invested in the Avan district heating restoration project.

Figure 4.1. *Autonomous energy centre*

The demand side regulation and consumption-based billing system advocated by the project for the Avan district heating project was a first for Armenia. The payment system created incentives for saving heat energy and fostered economic relations between the supply company and consumers. The project also provided apartment-level ultrasonic heat meters and hot water meters to support the new billing system.

A multi-part tariff system for heat and hot water was also advocated by the project to reduce the risks associated with a reduction in heat consumption. The system creates incentives for demand-side energy savings, while simultaneously ensuring that the heat supply company recovers its fixed costs regardless of the consumption level.

Figure 4.2. *Cogeneration unit*

Financing the construction of internal networks in the apartments. With the aim of attracting consumers to the district heating system, the project proposed that the supply company finance the construction of internal networks in the apartments. Considered as a soft loan to the house owners, the cost would be recovered by a separate tariff rate.

This arrangement has been working successfully for the last two years and is an example of how to reduce commercial risk while expanding the market and ensuring utmost revenue from heat sales.

Heat supply contract forms. To regulate both the new tariff and supplier/consumer arrangements, contract forms were developed, agreed by all parties and the PSRC and applied by the company.

Explanation and awareness raising activity. As many Avan residents were sceptical about the benefits of the pilot project, based on their negative experience with the previous centralised heating service, the project conducted awareness-raising activities, explaining the consumer benefits of the new system and assuring residents that the associated lower tariff for heat energy would continue in the future. This activity was important because it developed consumer confidence and buy-in for the new system and thus expanded the market and consequently reduced commercial risk.

The GHG emissions reduction assessment for the Avan district heating restoration project compared the project emissions with the baseline scenario of 75% of households using natural gas-fired and 25% using electric appliances for both their heat and hot water needs. The annual GHG emissions reduction of the first phase of the project (76 buildings) amounted to 10,200 t CO_{2eq}.

Lessons learned:

1. The project provided technical assistance from initiation and throughout the implementation of the Avan cogeneration based district heating restoration project. This proved critical for reducing commercial risk and prompted investor confidence, resulting in financing for the follow-up phase (connecting the remaining 46 buildings of 76 under the first phase of the project).

2. The price support mechanism developed by the project proved attractive for private investment in cogeneration based district heating restoration projects, whilst concurrently kept heat tariffs at an affordable level for consumers.

3. Since the adoption of the preferential regulation for cogeneration-based district heating in 2006, debate has continued regarding the suitability of the support scheme developed within it. In 2010, the PSRC cancelled the preferential regulation, yet under a special GoA Decision, the Avan project retained its preferential tariff. It is expected that the PSRC will wait until the project has been fully completed before taking a further decision. In this regard, the viability of the Avan pilot project is critical for the development and application of cogeneration technology in Armenia's heat supply sector and for providing the evidence that only with the availability of support schemes can such projects become feasible and attractive for private investors.

4. Building trust between the project team and project beneficiaries is important. The project team consisted of both national and international experts who provided professional and unbiased advice to national decision-makers, helping them to overcome regulatory and institutional barriers and to promote the application of international practices in the design and implementation of the Avan district heating restoration demonstration project.

4.2. Rehabilitation of district heating in the micro-region district of Sevan

The successful launch of the Avan project and the subsequent adoption of regulation promoting cogeneration-based district heating increased the interest of private investors. A private investor from the Russian Federation expressed interest in a district heating restoration project in the micro-region district of Sevan. The site was selected by the investor based on the advice of the project team because of its harsh natural climatic conditions and high heat density. At the request of the investor, in 2008 the project team developed a feasibility study for cogeneration-based district heating restoration for 1,646 apartments - more than 120,000 m² of floor area. Thereafter the company "Sevan Heating Networks" CJSC was established and by 2009, the private investor had already invested USD 900,000 into the new system. The project team provided support for the design of external heat networks, central heat substations and internal distribution networks.

However, due to the financial crisis of 2009, work was suspended and the investor decided to apply a phased approach to the implementation of the district heating project. Regrettably, when the PSRC cancelled its promotional regulation in 2010 the investor lost confidence on receiving an adequate return on his investment. Thus, the work never resumed.

4.3. Energy centre of Yerevan State Medical University

In 2007, a new cogeneration energy centre was constructed with private investments to supply heat and cooling for the Yerevan State Medical University. The centre was set in operation on 2 November, 2007 and supplied four buildings for two seasons.

The centre is equipped with two cogeneration units of 2 000 kW_e and 2 180 kW_t capacity each. The design load of the four University buildings is 1.80 MW (40% of the installed heat capacity).

Aiming to improve the energy efficiency of the energy centre, the University administration applied for project assistance to develop a feasibility study regarding the expansion of its centralised heat supply. Based on the results of the feasibility study the distribution network was expanded in 2010 and 2011 to supply four more hospital buildings.

Figure 4.3. *Cogeneration centre of the Medical University*

As a result of this expansion, the annual savings on natural gas, when compared to the baseline scenario of the separate production of electricity and heat, reached 9000 MWh/year and GHG emissions were reduced by approximately 1700 t CO_{2eq}/year.

Figure 4.4. *Equipment of the energy centre*

Lessons learned:

1. Despite the adoption of the UHS in 2002, no activities for restoring district heating took place until the adoption of GoA decision in 2006 in support of the Avan district heating restoration project.

Equally, after the project team advocated the introduction of a regulation to promote investment in the construction of district heating systems, on the basis of cogeneration, it stimulated private sector interest for this type of district heating and new district heating projects were initiated.

2. The implementation of the Avan district heating restoration project became possible once the GoA Decision stipulating favourable conditions and reducing commercial risk for private investment was adopted.

The construction and completion of the Yerevan State Medical University energy centre was only possible because of the PSRC's promotional regulation on cogeneration.

Attracting private investment and ensuring the continued implementation of cogeneration-based district heating projects is only possible if support mechanisms exist, including regulations issued by public authorities regarding adequate returns. This was evidenced in Sevan, when the investor stopped the construction following the cancellation of the promotional regulation by the PSRC.

3. The successful completion and reliable, cost-effective operation of the Avan demonstration project will be a critical argument for promoting the adoption of a public support scheme for restoring cogeneration-based district heating systems in densely built urban areas.

4. Projects that provide technical assistance for improving the energy efficiency of municipal infrastructures need to be designed to encompass several years. This should ensure that all the measures proposed are promoted and implemented - from regulation and establishment of support schemes to engineering works and monitoring of actual impact.

5. Promoting the use of alternative and energy efficient advanced technologies

Energy efficiency and the efficient use of alternative sources of energy is one of the main priorities of Armenia's Energy Sector Development Strategy. These issues are particularly important for Armenia as the country has no domestic fossil fuel resources and is dependent on imported natural gas. Therefore, the technical, environmental and economic feasibility of using alternative energy resources and the application of high-efficiency advanced technologies for heat supply purposes should be considered and promoted where appropriate.

5.1. Support to the introduction of solar collectors-based hot water supply systems

The Renewable Energy Roadmap for Armenia (2011) considers small hydro power plants and solar water heaters to be the most economically viable options in Armenia in the short- to medium-term.

The average annual amount of solar energy flow per square meter of horizontal surface in Armenia is about 1 720 kWh (the average in Europe is about 1 000 kWh/m^2). One fourth of the country's territory has solar energy resources of 1 850 kWh/m^2. The Lake Sevan basin is the most promising site with more than 2 800 hours of annual sunshine.

The use of solar hot water systems provides a cost-effective way of harnessing Armenia's significant solar energy potential. These systems provide both affordable hot water and contribute to the reduction of GHG emissions.

5.1.1. Private sector

Working on a co-financing basis with the private operators of a small-scale heat supply systems, the project supported the introduction of two solar hot water systems supplying residential buildings in Yerevan. The new SHW systems were integrated into the existing boiler houses, thus forming a single hybrid heat supply system.

Figure 5.1. *Solar water heaters, Avetisyan street energy centre*

One of the systems has been operating successfully since 2008, ensuring an affordable hot water supply and contributing to the sustainability of the entire heat supply system. Annual natural gas savings have amounted to 7,800 Nm^3 and the GHG emissions reduction is about 16 t annually.

The second system ceased operations in 2010, as residents refused to pay for the poor quality of heating services and the high prices being charged for them. The solar panels were dismantled and used in another UNDP hot water supply project.

5.1.2. Public sector

The Ministry of Social Affairs requested project assistance for the installation of solar hot water supply systems in several public institutions. This request was in line with project objectives, as it addressed social issues (by reducing the costs associated with hot water supply), and educated local authorities to the benefits of using renewable energy. Nine projects introducing solar hot water supply systems were implemented in different types of social institutions throughout the country. Due to the climatic

conditions, most of the systems installed were two-circuit systems with external circuits filled with non-freezing heat carrier.

The projects were implemented in close co-operation with public and local authorities on a co-financing basis. The total area of installed solar panels was 237 m², with an overall hot water storage capacity of 9,200 litres. Due to the limited market in Armenia, the cost for the two-circuit SHW systems (equipment and installation) was quite high (approximately USD 500-550 per m^2).

Figure 5.2. *Solar panels on the roof of the community kindergarten, Kajaran*

Figure 5.3. *A playroom in the community kindergarten, Kajaran*

Environmental, social, economic and institutional benefits

- Primary energy savings throughout the life cycle of the projects amount to 7,960 MWh and GHG emissions reduction for the same period will amount to 1,650 t CO_{2eq}.

- Over 2,000 people (primarily kindergarten and school children) will now enjoy reliable and quality hot water supply services. Communities will not have to spend additional money to meet hot water needs, and kindergartens will not have to increase their fees.

- The projects promote the benefits of using decentralised energy supply systems that use renewable energy.

- Following the interest generated from the installation of the solar hot water systems, positive changes were noted in the market for solar panels and their installation services

Lessons learned: The pilot projects demonstrated that with proper planning, regulated operations and availability of start-up grants or other public support schemes, SHW systems are competitive with the traditional methods of hot water provision.

5.2. Heat pump based energy supply system

During 2010-2011 the “Ayb educational hub" foundation began construction of the “Ayb” High School in Yerevan, using advanced eco-friendly technologies. In 2011, the school administration requested project assistance to assess the energy efficiency of the heating and cooling system that had been designed for the school. The system was designed to meet the space heat, hot water and forced ventilation demand with a boiler house and the cooling demand from electric air-conditioners.

Figure 5.4. *A view of “Ayb” High School, Yerevan*

The assessment revealed that the heat pumps could be used for the cooling, base load heating and forced ventilation requirements of the school and ensured a more reliable and economically feasible energy supply option, especially given the continuously increasing prices of natural gas.

Given the importance of promoting high-efficiency alternative systems, such as heat pumps, the project supported the implementation of the school project and, in particular, procured and installed two "Air to Water" heat pumps. Using the heat pumps will produce an annual savings of 37,500 Nm^3 of natural gas and an annual GHG emissions reduction of 70.5 t CO_{2eq}.

Figure 5.5. *A hall in "Ayb" High School, Yerevan*

Lessons learned: The pilot project demonstrated that using heat pumps is a feasible alternative to traditional heating/cooling systems in light of gas price increases. The majority of the operating costs for heat pumps come from the purchase of electricity (more than 60%). As such, these costs are less affected by changes in gas prices than are the conventional (heat-only boilers) heat supply systems. This is due to the structure of electricity generation in Armenia, where only about 30% of electricity is produced by gas fired thermal power plants.

These benefits, accompanied by an increased awareness of the advantages and technical merits of this type of application, generated interest from private investors.

5.3. Infrared heating system

The application of infrared heating (using gas or electricity) is economically justified for space heating in areas with high ceilings and/or where the working activity is limited throughout the day, e.g., working areas, greenhouses, warehouses, sports halls, public food and entertainment facilities, repair and mechanics workshops, etc.

Infrared systems have a number of advantages, such as: energy savings, low maintenance costs, eliminating the need for reconstruction of the internal heating system, low inertia, ensuring the necessary temperature is acquired within 20 to 30 minutes after the start of operation.

The project supported the introduction of an infrared heating system in the Arabkir Youth Centre Concert Hall in Yerevan. Five hundred children attend the Centre, which is supported and operated under the auspices of the Armenian Apostolic Church. The Centre had been repaired and had an operational heating system with the exception of the hall. The latter was heated by electrical appliances, which did not ensure indoor comfort and incurred high operating costs.

Figure 5.6. *Infrared space heating, Youth Centre of Arabkir community of Yerevan city*

To resolve the heating issue, the project supported the introduction of an infrared system for space heating in the hall, which improved the heating, reduced electrical consumption for heating by 40% (11 MWh annually) and had a

corresponding GHG emission reduction of 3.6 t CO_{2eq}.

Lessons learned: The pilot project demonstrated the feasibility of using infrared technology for space heating in areas with limited daily working activity. The project also contributed to raising awareness regarding the benefits of infrared heating technology and the related savings on energy and costs. As such it could be replicated in similar areas and, indeed, a number of new installations have been carried out by “Infrared” LLC (the company involved with the pilot project).

6. Promoting energy efficiency and energy savings

A number of pilot projects were implemented in various urban areas of the country, in close co-operation with local authorities and the management bodies of multi-apartment buildings. The objective of these projects was to build the capacity of municipalities and building management bodies to manage the remaining assets of the former heat supply systems and to encourage the use of cost-effective energy efficiency/energy saving measures.

An analysis was conducted to determine why the pilot projects had either succeeded or failed. It also identified barriers and recommended measures for overcoming them. The successful pilot projects provided the justification for using cost-effective energy efficiency and energy saving measures and could be replicated in other settlements in the country.

6.1. Pilot projects on improving energy efficiency

6.1.1. Reconstruction and commissioning of a heat supply system in Spitak

In 2001-2003, 23 multi-apartment buildings were constructed in Spitak, all supplied from a single heat plant. A boiler house and external heat supply network were built with financing from the state budget, but the system was not tested and never commenced operation.

Figure 6.1. *The road to Spitak*

The Spitak municipality requested project assistance to assess the technical condition and economic feasibility of putting the system into operation. The assessment revealed that with a moderate investment the system could become operational and would provide a reliable, low-cost heat supply. A Memorandum of Understanding was signed between UNDP Armenia and Spitak Municipality and, with UNDP-GEF project support, work commenced on commissioning the system and ensuring its energy efficient operation. The system started its operation in the 2008-2009 heating season and produced annual energy savings of 39.6 MWh and a GHG emissions reduction of 8 t CO2eq/year.

Spitak lies within the administrative borders of Lori marz and has a population of 15,000. The town is 101 km from Yerevan at an altitude of 1,552 m above sea level and has severe climatic conditions: the heating season lasts six months and the design ambient temperature is - 18°C.

Figure 6.2. *Reconstructed boiler house, Spitak*

A MoU was also signed between UNDP and the Armenian Renewable Resources and Energy Efficiency Fund (R2E2), to provide financing (approximately USD 10,000) to connect 21 poor-household apartments to the heat supply system. Under the terms of the MoU, once the work had been completed and the apartments began receiving heat, the R2E2 Fund would reimburse the investment costs. Under a separate agreement between UNDP, Spitak Munici-

pality and the system operator, the reimbursed funds were then used to implement measures to ensure the sustainable operation of the system, particularly to reduce heat losses in the distribution network and in the buildings (improved insulation of entrance doors, etc).

6.1.2. Improving the energy efficiency of the heat supply system in Spitak

The pilot project in Spitak for the heat supply of multi-apartment buildings demonstrated that proactive co-operation between UNDP and local authorities could successfully resolve the issue of how to provide a reliable and energy efficient heat supply. With this experience in mind, the Spitak Municipality applied for further project assistance to improve the energy efficiency of another small-scale heat supply system that provided heat to the community kindergarten, school and municipality. The system had been operating since 1996 and its efficiency was low (60%).

Figure 6.3. *The school supplied with heat from the reconstructed system*

With co-financing from the Municipality, the project upgraded the boiler house and the energy efficiency of the heating system was increased to 85%. Consequently, gas consumption was reduced by 23% (or 21,000 Nm^3 annually) and the electricity consumption by 57%. This resulted in a GHG emissions reduction of approximately 40 t $CO_{2eq.}$ annually.

In addition, heat consumption by the school was not financed from the community budget; therefore the costs for heating the school needed separate invoicing. To address this issue the project installed a heat consumption meter in the school, so that charges for heat could be based on actual consumption.

6.1.3. Improving the energy efficiency of the heat supply system of the child-care and protection boarding institution N1 in Yerevan

The heat supply system of the boarding institution was constructed in 1980 and had been operating for more than 30 years. The system urgently required upgrading to improve its energy efficiency. In this regard, the Ministry of Labour and Social Affairs requested project assistance to improve the energy efficiency of the boiler house on a co-financing basis.

In line with measures to increase the energy efficiency of the system, the project team also recommended the reconstruction of the internal heating network and the introduction of energy saving measures to reduce heat loss. Based on these recommendations, funds were allocated in the 2011-2012 state budget for the installation of energy saving windows and doors and the reconstruction of the internal heating network. With the high proportion of co-financing and additional leveraged funds, the project share in the implementation costs only amounted to 22%. The measures taken resulted in annual reductions of gas consumption (29,000 Nm^3), electricity consumption (20%) and GHG emissions (55 t CO_{2eq}).

This pilot project is an example of how enterprising co-operation between UNDP project teams and public authorities can successfully resolve issues regarding the provision of a reliable and energy-efficient heat supply and how informative promotion can serve to leverage funds for such purposes.

6.1.4. Rehabilitation of the centralised heat supply system of the Narcological Clinic in Yerevan

The Narcological Clinic of the "Psychological Medical Centre" (CJSC) of the Ministry of Healthcare of Armenia is the only one of its kind in Armenia and is one of the most important facilities in the social sector. It provides services to 1,300 to 1,500 patients annually and comprises a hospital and polyclinic. Until 2006, the hospital building was heated by electricity. Subsequently, a donor provided funding for a heat and hot water system; however, this only covered parts of the hospital.

Figure 6.4. *Reconstructed boiler house of the Narcological Clinic, Yerevan*

The hospital administration applied for project assistance to support the restoration of the hospital's central heating system. The work included the installation of energy efficient boilers and auxiliary equipment in the boiler house; construction of a gas supply pipeline and the installation of gas control points; and the construction of an external heat network.

The restoration not only resulted in annual reductions of electricity consumption (50%, or 130 MWh) and GHG emissions (25 t CO_{2eq}), but also contributed to the improved safety conditions and indoor comfort level of the hospital.

6.1.5. Heat supply for the 'big cats' cages in Yerevan Zoo

In 2011, several donor organisations[6] agreed to co-ordinate their technical assistance to resolve the urgent issues associated with Yerevan Zoo, including those connected with heating.

During the winter the animal cages were poorly heated by electricity, and several animals died. Based on an agreed co-operation framework, Yerevan Municipality and "ArmRusgazard" CJSC built a gas supply network, the Zoo administration developed the design documentation, and the UNDP-GEF project contributed to the installation of heating and ventilation systems for the big cats. The system has been operating since February 2012, with expected annual savings in gas consumption of 13,000 Nm^3 and GHG emissions reductions of 25 t CO_{2eq}.

6.2. Promoting energy saving

6.2.1. Implementation of energy saving measures in Aparan

The apartment buildings in Baghramyan Street in the town of Aparan were constructed in the 1970s and no repairs have been undertaken in decades. Nine of the buildings receive their heat from eight small-scale boiler houses, built in 2004, which are run by condominium associations. The connection rate is high: 240 apartments out of a total of 307 are connected to the central heating system.

To support this good example of practical cooperation between residents, condominium associations and local authorities, the UNDP-GEF project has been providing assistance since 2007 to ensure the sustainable and reliable operation of these central heating systems. Responding to a request from Aparan Municipality, the project provided gas meters,

[6] GIZ, UNDP, British Embassy, German Embassy and the Foundation for the Preservation of Wildlife and Cultural Assets (FPWC)

supported the reconstruction and operationalisation of the heating system for one multi-apartment building (No.46 on Baghramyan Street) and monitored the operational efficiency of the system. The monitoring revealed that the poor condition or, in some cases, total absence of entrance doors and windows in the buildings caused significant heat losses, resulting in increased heat consumption of approximately 20%.

Figure 6.5. *Entrance door and windows of building #19 in Aparan* ***before*** *and* ***after*** *reconstruction*

Another important issue that needed addressing was finding a solution to providing affordable heating and, consequently, ensuring the sustainable operation of the heating systems. As a matter of fact, the monthly consumption of natural gas of each boiler house was below 10,000 Nm^3. From 1 April 2010, the gas tariff for such consumers had increased by 37% compared to the previous year. As a result, heating had become unaffordable for the majority of the residents and they discontinued using the central heating services. By reconstructing the gas supply system it would be possible to switch to a lower tariff (of approximately 30%), which was applicable for large consumers (monthly consumption above 10,000 Nm^3) and would keep heating payments at about the same level as in previous years.

A Letter of Intent was signed between UNDP and Aparan Municipality and the project implemented refitting nine multi-apartment buildings with new entrance doors and windows offering better thermal protection. These measures resulted in annual savings in natural gas of approximately 36,000 Nm^3, corresponding GHG emissions reductions of 69 t CO_{2eq} and, in addition, contributed to the sustainable operation of the central heating systems.

The gas supply system of the operating boiler houses was reconstructed and gas meters were installed, thus enabling the switch to the lower gas tariff.

By reducing the overall system heating costs and application of a lower gas tariff, 1,234 residents benefited and the burden on family budgets was reduced. Indeed, monitoring of the 2010-2011 heating season revealed that residents had actually reduced their heating costs.

By successfully implementing these measures, the project demonstrated to the community the benefits of improving the energy performance of apartment buildings. The low-cost measures applied can serve as a best practice for replication elsewhere.

6.2.2. Energy saving measures in the Kajaran community kindergarten

116 children attend the Kajaran community kindergarten. The building was constructed in the late 1950s and has fallen into disrepair, with worn out entrance doors and windows causing significant heat loss.

Kajaran Municipality applied for project assistance to improve the energy performance of the kindergarten building, including the installation of a solar hot water supply system (see Subsection 5.1.2). A Letter of Intent was signed between UNDP Armenia and Kajaran Municipality regarding building renovation and energy performance enhancement. The work was completed in 2010 and included the installation of energy efficient lighting, new windows and

doors with better thermal protection, floor insulation, and the construction of a new hallway.

The total cost was USD 71,500 and was predominantly funded by the community budget; the project contribution was 28%.

The measures implemented to improve the building's energy performance, including the installation of a solar hot water system, resulted in annual savings of 3400 Nm^3 in natural gas and a GHG emissions reduction of approximately 6.4 t CO_{2eq}.

The project results again demonstrate that promoting best practices and providing clear information on their benefits produces proactive co-operation and is conducive for resource mobilisation.

Figure 6.6. *Renovated building of community kindergarten, Kajaran (new windows and renovated entrance)*

7. Capacity building and awareness raising

7.1. Development of Heat Plans

GoA Decision No.509-N dated 13 April 2006, directed the Ministers of Energy, Nature Protection, Urban Development, Finance and Economy to develop economically feasible heat plans for residential areas in Armenia, using the expertise and assistance of donor-funded programmes active in this sector.

The Master Plan of Yerevan City (2005 to 2020) envisaged the restoration of the district heating systems in six districts of the city: Avan, Davitashen, Erebuni, Shengavit, Harav-Arevmtyan and Nor Nork.

Consequently, in addition to the activities already implemented under the second component of the UNDP-GEF project (i.e. feasibility studies for district heating system restoration in Avan and Davitashen), district heating restoration plans for the other four districts of Yerevan were also developed.

The heat plans were developed taking into consideration technically and economically feasible heat supply options, using advanced, energy efficient technologies to encourage private investment. For example, the heat supply option from the combined-cycle plant at the Yerevan TPP was considered in the heat plan for the Erebuni and Shengavit areas. Although this option requires considerable investment for the construction/reconstruction of the heat supply networks, it improves the energy efficiency of the plant and will produce significant reductions in natural gas consumption and GHG emissions.

7.2. Development of feasibility studies for district heating restoration

In today's diversified and rapidly changing heat supply market, condominium associations and private investors rely on professional advice to ensure the decisions they make are both technically and economically feasible. This is particularly important in terms of advertising the availability of individual heating options and the different financial support schemes that exist. Furthermore, little information is available on the benefits of advanced energy efficient technologies and their application in district heating systems. It is therefore critically important to provide investors with sound assessments of the technical and economic feasibility of district heating systems to support them in their decision-making processes.

The UNDP-GEF project therefore developed 15 feasibility studies at the request of both local authorities and private investors. The studies analysed the economic and technical feasibility of heat supply options, including centralised heat generation and block-level boilers (connected to one or two buildings), conventional heat supply systems, and cogeneration-based systems, and undertook a comparison of the technologies available for individual solutions.

7.3. Capacity building related to commercialising services aimed at improving the energy efficiency of boiler plants

In 2004, a limited number of boiler houses were in operation in Armenia, according to a UNDP assessment conducted at that time. However, by 2008, the number had increased to 1,042, and by 2010 1,400 were in operation, most of which were equipped with water and steam boilers from former Soviet Union as well as Russia and other countries. These gas-fired heat plants provide heating to primarily health-care, educational, cultural and public buildings.

In most of these small-scale systems, there are no extensive distribution networks and thus the energy efficiency of the systems depends on the efficiency of the heat source.

Existing regulations in Armenia do not include mandatory requirements for energy performance, nor for energy audits. Therefore there is a low incentive for energy service companies to improve their technical capabilities and experience or to advertise their services.

With the aim of encouraging the use of energy efficiency related measures, the UNDP project undertook an assessment of the energy efficiency of the operating small boiler houses. In 2008, 50 boiler houses were monitored and assessed in Yerevan and other urban areas and adjustment work was undertaken to improve the energy efficiency of the lowest-rated 15. Improvements in energy efficiency and environmental indicators were subsequently recorded. Based on these results, recommendations on measures for improving the efficiency of boiler houses were developed.

Furthermore, in 2009, the project team studied the technical condition of 88 large boiler houses operating in the country. It was revealed that the majority of these boiler houses operated at low efficiency (about 5-15% less than the technical specifications). An energy audit was conducted for four of these boiler houses and, following an analysis of the results, a set of measures for improving their energy efficiency was developed. These measures ensured fuel savings of 5-7% with a relatively short payback period on the required investment.

Figure 7.1. *Presentation of the manual to "AEG Service" LLC ESCO personnel*

The results of the audit and the proposed energy efficiency measures were presented to key stakeholders (plant owners/operators) and implementation and project co-financing possibilities were discussed.

Subsequently, several energy service companies (ESCOs) applied for project support to develop a manual on conducting thermo technical testing of gas-fired boilers and assessing their energy efficiency.

Developed and published in 2012, the manual includes the performance requirements of the testing equipment, and the methodologies and reference data for undertaking thermo technical testing and for assessing the operational efficiency of gas-fired boilers.

Using the methodology presented in the manual, the largest ESCO in Armenia, AEG Service LLC, has already conducted testing and made adjustments to 18 boiler units around the country. These adjustments have significantly improved the performance indices of the boiler plants, and similar work is underway in other boiler plants.

7.4. Textbook on "Renewable Energy Sources and Technologies"

With the exception of a few booklets on solar and wind energy and monographs translated and published in the previous century, no technical literature regarding renewable energy is currently available in Armenian.

To address this shortcoming, project experts developed and published a 282-page textbook entitled "Renewable Energy Sources and Technologies" for use by students from engineering institutes, developers, designers and others interested in learning about renewable energy and the ecological impacts of the energy sector.

The textbook was gratefully received by the Yerevan State University of Architecture and Construction.

7.5. Development of software for providing calculations in small-scale heat supply systems

In accordance with GoA Decision No.785-N dated 13 May 2004, Yerevan Municipality leased 60 small heat supply facilities. This activity generated the interest of a number of private investors and condominium associations and several requested UNDP-GEF project assistance with regard to the restoration of small-scale heat supply systems.

To meet these requests, project experts developed and distributed a software package, which included both the software and a user manual. The package calculated the overall investment, the operation and maintenance (O&M) costs and the appropriate heat energy tariff for multi-apartment buildings obtaining heat and hot water from small-scale district heating systems.

7.6. Assessment of heat supply options in multi-apartment blocks in Armenia

Statistical studies and data on the status of heat supply in Armenia are limited. Comprehensive information is, however, available in a 2005 study carried out by the Economic Development and Research Centre (EDRC) for the World Bank-financed Heat Supply Project. This was followed by the 2007 and 2009 surveys, carried out for the R2E2 in the framework of the Urban Heating Project, to monitor and assess the shifts and changes in heat supply.

Given the importance of conducting such regular studies and in the framework of the providing technical assistance to the WB-financed Urban Heating Project, UNDP undertook a large-scale statistical survey entitled “Assessment of heat supply options”, which included:

a) A statistical sample survey of heat supply options in multi-apartment residential buildings in urban areas (2,000 house-holds); and

b) A survey of the beneficiaries (poor households) of the R2E2 Urban Heating Project designed to reveal their level of satisfaction with the assistance provided (500 households).

The statistical survey applied the same methodology used during the 2007 and 2009 surveys, to provide compatibility of data and findings. Thus, the survey took into consideration the recent developments in multi-apartment building heat supply, and identified the recent trends and shifts in household preferences regarding heat supply options.

8. Assessment of GHG emissions reduction as a result of project implementation

The UNDP-GEF project's impact on the energy efficiency of the municipal heat supply and the reduction of GHG emissions was assessed in accordance with the GEF Manual (2008), taking into account baseline data and the specific aspects of the projects implemented. The assessment of the overall indicators for emissions reduction and energy savings includes both pilot projects implemented by UNDP-GEF project and replicated projects, mainly in the public sector, which were financed by international organisations, Diaspora, the private sector and the Government of Armenia.

The pilot projects included the restoration of cogeneration-based district heating systems, energy efficiency improvements in small-scale heat supply systems (heat only boilers), solar hot water systems and the application of advanced energy efficient technologies (infrared and heat pump based heat supply systems).

Replicated projects included the construction of small-scale heating systems in the public sector, which replaced the individual heating solutions with low efficiency which were widely used until 2006. As a result, fuel consumption efficiency increased from 50-90%, and GHG emissions were reduced from 445-260 kg CO_{2eq}/Gcal.

For the projects implemented during the period 2006-2012 (pilot and replicated projects), the environmental and economic benefits are reflected in cumulative GHG emissions reductions of 128,300 t CO_{2eq} and fuel savings of 574 GWh. Within the economic lifetime of both the pilot and replicated projects, the estimated reduction in GHG emissions will be 885,600 t CO_{2eq} and the fuel savings will reach to 4,140 GWh.

Cumulative fuel savings and GHG emissions reductions for both the project implementation period and the economic lifetime of the projects are presented in Tables 8.1 and 8.2.

Table 8.1: Cumulative fuel savings and GHG emissions reduction during the UNDP-GEF project implementation period

Time-lines	Pilot projects		Replicated projects		Total	
	Fuel savings, MWh	GHG emissions reduction, t CO_{2eq}	Fuel savings, GWh	GHG emissions reduction, thousand t CO_{2eq}	Fuel savings, GWh	GHG emissions reduction, thousand t CO_{2eq}
2006-2009	7,702	1,898	247.7	55.1	255.4	57.0
2006-2010	16,664	3,802	342.2	76.2	358.8	80.0
2006-2011	26,400	5,763	439.8	98.3	466.1	104.1
2006-2012	37,000	7,912	537.5	120.4	574.4	128.3

Table 8.2: Estimated fuel savings and direct GHG emissions reductions during projects lifetime

Status of the projects	Fuel savings, GWh	GHG emissions reduction, thousand t CO_{2eq}
Pilot projects	1,213.0	246.5
Replicated projects	2,927.1	639.1
Total	4,140.1	885.6

9. Lessons learned and recommendations

Any lessons learned from the implementation of this project should be examined giving due consideration to the process undertaken to overcome the identified barriers for energy efficiency in the heat supply sector. In fact, the barriers identified actually became more complicated and complex than expected, as the municipal district heating systems completely discontinued operation. A set of comprehensive measures was therefore needed to eliminate these barriers. Some of the barriers identified are unique for Armenia, but others are common for countries in transition, where the heat supply sector has to adapt to new market conditions.

Measures initiated and partially implemented by the project should be continued in order to overcome the identified barriers and to establish a solid foundation for the provision of an energy efficient and environmentally-friendly heat supply. Ultimately, the main focus should be to reduce commercial risk and create a favourable economic and administrative environment for attracting private investment for the heat supply sector.

9.1. Legislative and regulatory barriers

Law on heat supply. Little incentive currently exists for decision-makers to change from the existing situation and to adopt environmentally friendly heat-supply solutions. Thus, the application of individual heating solutions continues, even in new urban areas with high heat density. Moreover, technically sound heating systems are forced to discontinue their operations, because a percentage of the population refuse to use district heating services.

There are a number of other issues that also need to be resolved, but finding the solutions is made considerably more difficult in the absence of a unified law for regulating the sub-sector.

A law on heat supply will need to be adopted to create a favourable environment for attracting private investment into a key resource-consuming sector that carries a high investment risk. The law should determine the economic and organisational relations in the sector, the responsibilities of the State Government and local self-government bodies for planning, managing, regulating and supervising the sector, and the scope of rights and responsibilities for heat supply market players.

In this regard, the project team drafted a concept paper on the Law of the Republic of Armenia on Heat Supply. However, little political interest was shown in developing the concept and to date no unified law regulating the heat supply sub-sector in Armenia exists. This indicates a lack of political will regarding the development, management and regulation of the sector.

Revision of natural gas tariffs. The existing tariff system for natural gas does not promote energy savings. On the contrary, it encourages wastefulness by some small consumers. The tariff for natural gas should vary by consumer type, based on the costs they create for the system.

Changing the methodology for setting natural gas tariffs will contribute to the efficient use of fuel, primary energy savings and the creation of fair conditions for businesses.

The analytical materials prepared in this regard by the project were used as justification for revising the natural gas tariffs setting methodology in the 2010 National Energy Efficiency Action Plan.

Heat norms. Experience gained from the pilot projects revealed that some of the norms used during Soviet times are out of date but are still being used for designing heat supply systems.

These norms do not correspond to the actual demand and need to be radically revised.

Since demand side management and a consumption-based payment system were put into practise a substantial reduction in heat consumption for residential space heating has been observed. Additionally, hot water metering revealed a daily per capita consumption of 40-45 litres compared to the normative of 100-115 litres.

The continued use of the existing normative basis when designing district heating system infrastructures results in surplus capacities (boilers, pumps, heat networks, etc.) and consequently additional, unnecessary investment. Hence, the current norms should be revised in line with existing realities.

Realistic investment planning and a certain mitigation of investment risk is possible, if current economic conditions are taken into consideration when establishing a regulatory framework for district heating system design.

9.2. Key experiences in working with external partners

Local authorities and multi-apartment building management bodies. As Armenia has no legislation to regulate the heating subsector or to designate an authority responsible for its operation, the project team had to design a special framework to establish the responsibilities and obligations of the parties involved in the implementation of the pilot projects.

The experiences gained from the pilot projects, which were implemented in co-operation with local authorities, have demonstrated that to ensure successful project implementation, the responsibilities of those involved must be clearly defined and co-financing obligations determined (ideally under an MoU) prior to the commencement of activities. Moreover, pilot projects cannot be implemented if they rely solely on donor resources.

Equally, the sustainable and reliable operation of technically and economically feasible small-scale systems is difficult to ensure unless the management bodies of multi-apartment buildings function properly.

However, it is possible to resolve heat supply issues with the active involvement and support of local authorities, despite of habitually ineffective condominium associations. The pilot projects in the Aparan and Spitak towns are the best examples of such co-operation.

Government. Securing firm political commitments by using existing co-ordinating structures, such as the Board of Trustees of the Renewable Resources and Energy Efficiency Fund and the Project Steering Committee, is critical for the success of any project activity. The best example of this is the Avan district heating restoration project, where the approaches proposed by the project were discussed and supported by the Board of Trustees and subsequently validated by GoA Decisions.

9.3. District heating market development opportunities

The studies undertaken by the project and the experience from the first cogeneration-based district heating project demonstrated that cogeneration is the most effective way to develop the district heating market in Armenia, as using cogeneration mitigates gas price increases and provides affordable heat.

This type of project could prove attractive for private investors if public authorities develop regulations that ensure adequate returns on investments, thus increasing investor confidence.

Project results demonstrated feasibility of district heating reconstruction based on co-generation for investors, affordable price of district heating solutions for apartment owners, and restored trust in good quality services of district heating solutions. The critical element in this success story was adoption of preferential feed-in tariffs for electricity produced in cogeneration and sold to the national grid. This preferential feed-in-tariff regulation was suspended by the PSRC in 2010. In current Armenian conditions investment to renovation of DH and building level schemes with cogeneration is not attractive enough for investors without preferential FITs in place (or other governmental support scheme).

Thus, the governmental support for cogeneration (FITs) is critical for its commercial replication and sustainability of reconstructed district heating schemes based on cogeneration.

Without a clear state policy supporting restoration of building level heating solutions and/or district heating (with) co-generation (subsidies, preferential FITs, ...) renovation of building level and district heating solutions is not feasible and replication of successful pilot DH projects will be minimal (emphasis added).

Jiri Zeman
International Consultant
(from Final Evaluation Report of the Project)

9.4. Support for scaling up the renewable energy and energy efficiency market

Support for the formation of the renewable energy market. The 11 solar hot water pilot projects, implemented with project support, generated significant interest among suppliers, private investors and potential users. This was reflected in the prices of solar collectors and in the change to the common opinion that SHW systems are not competitive when compared to traditional methods of hot water provision.

As was demonstrated by the successful implementation of the SHW projects, with accurate planning, optimal operating regulations and a grant component of 15-20%, or the availability of public support schemes, reasonable payback periods for investments can be ensured.

Awareness-raising and information dissemination amongst both the supply and demand side actors of a growing and changeable renewable energy market is very important and will contribute to the formation and development of the market.

Building the capacity of fledgling companies that provide energy services. To create an effective energy services market, service providers must be well-versed in the methodologies, normative documents and technical data of operating such services. To address the existing lack of information in this regard, the project developed relevant materials, and provided continuous support in the form of on-site technical experts participating in the energy audits and adjustment work undertaken by the service providers.

As a result, one of the largest energy service providers in the country, “AEG Service” CJSC, was able to conduct energy audits and make adjustments to 18 boiler units and will continue these activities as part of its new service package.

The efforts and support for creating an energy service market need to be continued and expanded, and the range of services provided by the companies involved should be widely advertised.

Awareness and information barriers

The lack of awareness regarding the possibilities and benefits of using advanced energy efficiency technologies limits their application for heat supply solutions in the public sector, even though the application of such technologies can be technically, functionally and economically more feasible compared to traditional ones.

The pilot projects on infrared space-heating systems and heat pumps demonstrated the potential benefits of these systems under certain conditions, and several new infrared space-heating systems were subsequently installed.

A certain amount of interest in heat pump application emerged among private investors as a result of a seminar, organised by the project, and an awareness campaign on the benefits of the implemented pilot project.

Since information on the intensive development and spread of energy efficient technologies is often not available to consumers or investors, or is not comprehended properly, awareness raising and impartial advertising are important for ensuring the further development and improved energy efficient operation of the sector.

10. Highlights of the Project Results

The following major achievements in developing the heat supply market and improving the energy efficiency of the municipal heat and hot water supply in Armenia were made during the course of the project, which exceeded the target level considerably and were rated as highly satisfactory in the Final Evaluation Report:

- The amount of private investment leveraged for completed/ongoing projects on the reconstruction (expansion) of heat supply systems totalled USD 16.4 million, with USD 10.7 million invested by 2012 (USD 10 million);
- 0.89 million t CO_{2eq} lifetime reductions, including 0.24 million t CO_{2eq} from pilot projects and 0.65 million t CO_{2eq} from projects supported by the GEF project and financed by the WB - IBDA and other donors (0.7 million t CO_{2eq});
- 24 pilot projects were developed, of which 20 have been implemented and 3 are under implementation, including: 8 small-scale heat supply systems (heat plants), 11 solar hot water systems, 1 infrared heating system, 1 heat pump project and 3 cogeneration-based district heating projects (10 projects); 1 pilot project - Sevan cogeneration-based district heating project was suspended.
- 5,000 citizens in residential and public buildings now have access to restored central heating and hot water supply services (2,400).

Project results are detailed below.

Public support schemes to attract private investment	Development and justification of GoA Decisions adopted in 2006 on: - setting a favourable price for electricity sales produced from the CHP plant of the Avan district heating restoration pilot project; - establishing public private partnerships: transfer of the Avan district heat supply assets to the Avan community and the new heating company, jointly owned with the investor, and now responsible for future joint actions.
Private investment attracted for the heat supply sector	USD 10.7 million leveraged, including: - Implementation of two cogeneration-based district heating projects: in Avan district and in Sevan, based on the feasibility studies developed by the project. To date, USD 9.9 million has been invested in these projects (the project in Avan is on-going); - Expansion of a cogeneration-based district heating system in Yerevan for public buildings, based on the feasibility study developed by the project (USD 570,000 invested); - Installation of two solar hot water supply systems in privately-owned boiler houses supplying multi-apartment buildings (private co-financing of USD 26,500); - Implementation of a heating and cooling project with the application of heat pump technology, (private co-financing of USD 208,600).

Improvement of legal and regulatory framework	Drafting legal acts and regulations - GoA decision and regulation on "Energy efficiency labelling of energy consuming household appliances" - in the process of adoption; - Revision of "Construction Climatology" building code - approved and put into effect by Order of RA Minister of Urban Development in 2011; - Concept of RA Law on heat supply - discussed and amended version submitted to the RA Ministry of Energy and Natural Resources;
	- Seven international and European standards on energy efficiency of buildings - adopted in 2011 and 2012; - Recommendations made on the implementation of energy performance assessments and on the Building Energy Performance Audit Report; - Methodology for the calculation of hazardous emissions from solid, liquid and gaseous fuel fired boiler houses with up to 5.8 MW installed capacity - approved and put into effect by Order of RA Minister of Nature Protection in 2012. Drafting recommendations on tariff policy improvement: - Principles of tariffs calculation for cogeneration based on useful heat demand - adopted by RA PSRC in 2007; - Methodology for calculating the tariffs for heat and power from cogeneration based on useful heat demand - adopted by RA PSRC in 2007; - Methodology for determining the reference values for calculating the efficiency of cogeneration - adopted by RA PSRC in 2007; - Recommendations on revising the principles of setting natural gas tariffs, which substantiated why the natural gas tariff system needed revision - measures were included into the National Energy Efficiency Action Plan (NEEAP), 2010.
Identification and implementation of EE and ES measures in co-operation with state authorities	Implementation of three co-financed pilot projects in Yerevan, namely: Boarding School N1, the Narcological Clinic, the Zoo (USD 292,400 total co-financing) Total number of beneficiaries: 254 Annual and cumulative energy savings: 527 MWh/year and 9.93 GWh respectively Annual and cumulative GHG emissions reduction: 107 t CO_{2eq}/year and 2,015 t CO_{2eq} respectively
Identification, implementation and consultancy on EE and ES measures in co-operation with local self-government bodies	Implementation of pilot projects to improve energy efficiency and promote energy savings in multi-apartment buildings and social institutions in Spitak, Aparan and Kajaran. The provision of continuous consultations on technical issues during system operation, support in establishing heating tariffs, and liaison with residents to provide information and explanations about the new system. Total number of beneficiaries: 2,510 Annual and cumulative energy savings amount to 837.5 MWh/year and 16.75 GWh respectively Annual and cumulative reduction of GHG emissions reach 191.4 t CO_{2eq}/year and 3828 t CO_{2eq} respectively

	Provision of apartment-level metering and regulating equipment in preparation for the introduction of consumption based payment systems: - 325 apartment-level heat and 320 hot water meters for the Avan residential area district heating project; - 80 apartment-level heat and 80 hot water meters and 8 balancing valves for the Eraz residential area district heating project in Yerevan.
	<u>Advisory Centre operation 2006-2009:</u> As requested by the project, the NGO "National Association of Condominium Owners" provides consulting services through an Advisory Centre: - Consulting services were provided to 132 beneficiaries, including apartment owners in multi-apartment buildings, management bodies of multi-apartment buildings, private heat supply companies, local authorities, NGOs; the scope of consultancy included management of multi-apartment buildings, reconstruction and operation of heat supply systems, institutional and legal issues, and taxes.
	- Four reference books containing data on 1,066 multi-apartment buildings were compiled, including 3 for administrative districts of Yerevan - Avan (218 buildings), Davitashen (173 buildings) and Shengavit (599 buildings) - and 1 for Kajaran (75 buildings). - 11 public opinion surveys (10 among residents - 920 respondents; one among management bodies of multi-apartment buildings - 45 respondents) were conducted in various urban areas of the country to assess residents' willingness to be connected to the restored heat supply systems.
	- 13 seminars and round table discussions with 400 participants in total were organised to raise the awareness of multi-apartment building residents and management bodies regarding the heat supply restoration projects under implementation and to disseminate information on the experience gained and lessons learned. Information was provided on natural gas consumption safety issues in multi-apartment buildings, on crediting mechanisms for heat supply restoration, and on the software to provide calculations in small-scale heat supply systems, etc. - Manuals, brochures, guidelines (6 in total) were developed highlighting the activities of the Advisory Centre, detailing the range of consultancy services provided, raising awareness on "heat supplier-consumer" relations, providing information on energy efficient heating in buildings, and on improving the heat insulation of buildings.
Implementation of renewable energy pilot projects	Solar water systems in two multi-apartment residential buildings: – total area of plate collectors: 78 m^2; – total number of beneficiaries: 330 residents; – annual and cumulative energy savings: 73 MWh/year and 1.46 GWh, respectively; – annual and cumulative reduction of GHG emissions: 16 t CO_{2eq}/year and 320 t CO_{2eq}, respectively.

	Solar hot water systems in nine social institutions: – total area of solar collectors: 237 m^2; – total number of beneficiaries: 2100; – annual and cumulative energy savings: 398 MWh/year and 7.97 GWh, respectively; – annual and cumulative GHG emissions reduction: 83.5 t CO_{2eq}/year and 1,670 t CO_{2eq}, respectively.
Support for the introduction of EE advanced technologies	Consultancy and investment support for implementation of pilot project on space heating with application of infrared technology: – number of beneficiaries: 500 children – annual and cumulative energy savings: 11 MWh/year and 165 MWh, respectively; – annual and cumulative GHG emissions reduction: 3.6 t CO_{2eq}/year and 54 t CO_{2eq}, respectively.
	Consultancy and investment support for implementation of heat and cold supply pilot project with heat pump application: – number of beneficiaries: 250 children; – annual and cumulative energy savings: 348 MWh/year and 5.22 GWh, respectively; – annual and cumulative GHG emissions reduction: 70.5 t CO_{2eq}/year and 1,058 t CO_{2eq}, respectively.
Heat plans and feasibility studies	Development of heat plans for eight residential areas, including six administrative districts of Yerevan, where the restoration of district heating systems is envisaged by the Master Plan of Yerevan City for 2005 to 2020.
	19 feasibility and pre-feasibility studies (nine in Yerevan) for the restoration or construction of both large- and small-scale heat supply systems, including those with cogeneration technology application, were developed at the request of condominium associations or private investors.
	The project developed a feasibility study on the restoration of the district heating system for the Avan residential area. Furthermore, it ensured follow-up consultations on technical, economic, financial and pricing issues during the district heating project implementation, and investment support for design work, provision of metering equipment, and conducted awareness raising and information-sharing activities among the residents.
	A separate feasibility study for the Sevan cogeneration based district heating project was developed, at the request of the private investor. The project provided consultations on technical, economic, financial and pricing issues during district heating project implementation, along with investment support for design work.
Information sharing and capacity building	Development, publication and dissemination of the "Manual on implementation of thermo technical testing and efficiency assessment of gas fired boiler plants" (47 pages) for companies providing energy services.
	Development, publication and presentation in Yerevan State University of Architecture and Construction of the tutorial "Current state and future prospects of renewable energy sources and technologies" (282 pages).

	Development and dissemination of information leaflets (fact sheets) on 21 completed pilot projects.
	Based on the project's studies and findings six Master theses were written and defended: four in the Yerevan State University of Architecture and Construction and two in the State Engineering University of Armenia
	Organisation of study tours for specialists from public and private sectors: - Denmark, 2006: to study the Danish experience in the district heating sector, including familiarity with advanced technologies, cogeneration applications and equipment applied in the sector, legislation aimed at ensuring the energy efficiency of the sector, the existing tariff policy and measures aimed at the reduction of GHG emission. - Czech Republic, 2008: to study local and EU experience on energy efficiency standards and the labelling procedures of natural gas consuming household appliances (Czech Trust Fund). - Czech Republic, 2009: to study testing and certification procedures for natural gas consuming household appliances and for familiarisation with those institutions responsible for testing and certification procedures (Czech Trust Fund).
	A number of international consultants were involved in the project to assist in the application of relevant international best practices: International consultant (Finland), Ramboll consulting company (Denmark), International expert on multi-apartment building energy audit, ACE Group ZT-KEG (Austria); Danfoss (Denmark), GE Jenbacher (Austria) and Caterpillar (US)
	Reports and presentations on project achievements at international conferences and seminars: Moscow, 2006; UNFCCC COP side event, Bali and Almaty, 2008; Astana, Tbilisi and Dushanbe, 2011; Ashkhabad, 2012.
Training and consultation	Development and presentation of the software for providing calculations in small-scale heat supply systems (45 participants, including both private investors and condominium association representatives and equipment suppliers).
	Seminars on the types and performance characteristics of equipment used in district heating systems: the cogeneration equipment produced by Caterpillar company; heat pumps; measuring and regulating equipment and demonstration and practical application of composite pipes and fittings produced by Danfoss company (180 participants in total, including investors and designers, and representatives from educational and scientific institutions).
Monitoring and efficiency assessment	Monitoring of gas-fired small heat supply boiler plants in Aparan during three heating seasons.
	Monitoring of the cogeneration based district heating system in the Avan residential area of Yerevan during two heating seasons.
	Monitoring, adjustment and troubleshooting of operating solar hot water systems in Yerevan and marzes and training of operating personnel.
	Monitoring of out-door and in-door air quality in Yerevan and Gyumri cities during the 2006-2007 heating season.

Analytical studies on heat supply sector development	Development of annual analytical reports and submission to the Project Steering Committee, stakeholders and uploading onto the project's website (nature-ic.am).
	Analysis of heat tariffs in small-scale heat supply systems, 2006.
	Analytical study on heat supply in multi-apartment buildings of Armenia based on the large-scale statistical survey (2,500 respondent households)
Institutional and organisational capacity building	Co-operation agreements signed with 21 private (international and local) companies, public organisations and municipalities on joint actions to improve EE and ES.
	Comments and recommendations made at the request of the RA state authorities regarding strategic development projects in the energy sector.
Awareness raising	22 TV and 9 radio broadcasts on: heat supply restoration projects; progress of the pilot projects implemented with project support; feedback on the consultancy services provided by Advisory Centre.
	40 articles were published in local newspapers on the project activities and the services provided by the Advisory Centre. Information was also disseminated via electronic media.
	Success story entitled "The Benefits of Energy Efficiency" was published on the website of the UNDP Regional Centre in Bratislava (europeandcis.undp.org). The story featured the project's activities regarding improving the energy efficiency of heat supply in Armenia.
	The Project website (www.nature-ic.am) was established and is updated on a continuous basis.

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