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Energy demand, supply and efficiency in rural Armenia: baseline data collection and analysis

Report

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Executive summary

Republic of Armenia has struggled a number of political and economic hardships in the past thirty years. While economic crises and political transitions can be up and down, their environmental and social consequences are more lasting for people and the environment. Rural Armenia has been hit the worst: independence left rural communities without jobs generating thousands of migrating workers, growing energy prices left rural households without affordable modern heating options, energy blockade resulted in dramatic deforestation throughout the country, enhancing climate change vulnerabilities.

The efforts of the country to rehabilitate forest cover struggle with the opposite trends of illegal logging with continued use of fuelwood in rural communities for heating and hot water preparation purposes. Due to low affordability of other heating options, majority of rural households routinely use fuelwood as the primary heating fuel, with natural gas and electricity only as second and third options. Even more concerning is the very low efficiency of used heating devices and major energy losses from building envelopes. Inefficient use of energy, high energy prices and ecosystem degradation continue to perpetually impoverish rural communities. Women and children are at most risk – exposed to indoor air pollution, burdened with heavy housework related to fuelwood combustion, constrained in time for other household and personal chores. At the same time, low efficiency of energy use in Armenia directly affects national security – all fossil fuels in Armenia are imported.

This multitude of problems can only be solved by a comprehensive approach which tackles the sustainability of energy use throughout the whole value chain of energy supply and demand. More specifically, the solutions can include the following:

Strengthen and Enhance the Enforcement of Strategies and Policies

- Recommendations for long-term forest policy and regulatory changes, forest management planning and implementation, promoting sustainability of forest management through economic incentives and regulation of fuelwood market sales and enforcing sanctions for illegal logging,
- Establishing a platform for generating an active dialogue and intersectoral cooperation on issues of forestry, energy, economy, etc., including representatives from the state actors and other players (CSOs/NGOs, private companies, education institutions, donors, local authorities etc.),
- Creating incentives for sustainable use of fuelwood, commercial timber production,
- Promotion of testing, standardization and certification of local production of energy efficient heating (and hot water preparation) devices, sustainable fuel alternatives (e.g. biofuels), sustainable procurement practices,
- Promotion of investments in home insulation practices, high-efficiency heating and demand-side energy efficiency solutions;
- Ensuring participation of rural women to the discussions by ensuring their access to the services (transportation, babysitting service etc.)

Enhance the Generation, Analysis and Use of Reliable Data for Decision-Making and Policy

Data generation, analysis and continued use of high-quality data and its utilization for informed decision-making for:

- state of forest and evolution trends;
- household energy use, utility affordability, social and gender issues;

- secondary raw materials as biowaste, agriwaste, other solid or liquid waste that can be used as energy source; and
- gender-disaggregated energy consumption patterns on national level.

Enhancing Fuelwood Value Chain through Training and Capacity Building

Targeted support for various stakeholder groups, acting as links in the entire value chain, including:

- organization of user-groups for optimisation of plantation, logging, harvesting and marketing practices, biofuel preparation (dry wood, manure, etc.);
- streamlining of logging and transport, access to alternative supply channels and formalized sustainable fuel market;
- Capacity building of local skilled workers to generate local offering of energy efficiency technologies and services for heating, insulation, forest management; ensuring sustainable jobs and disseminating new technologies;
- designing sustainable forest management projects, promotion of conservation agriculture, reforestation, natural forest management, agro-forestry and nurseries on community level;
- development of schemes for business and technical support to community (private) forestry, financial incentives to farmer committees; initiating PPP projects in joint design, establishment, nursing and development of managed forestry, alternative fuel production;
- better integration of livestock into the circular bio-economy to be achieved by increasing the share of by-products or waste that humans cannot utilize in the livestock feed ration or by recycling and recovering nutrients and energy from animal waste (e.g. biogas production, production of briquettes and pellets).

Demonstration Projects

To help inform decision making and streamlining of sectoral support initiatives, implement series of demonstration projects which will allow the following:

- Design and implement pilot projects to test and demonstrate working models of improved rural energy use that is safe, sustainable, affordable and economically viable, documentation of results from previously implemented pilot projects.
- Development of exemplary models for EE stoves, boilers and training; supporting the commercialization and marketing of local producers of market-ready EE and biofuel solutions.
- Identification of solutions for most high-risk and high-impact parts of Armenia such as forest-adjacent communities, forest-rich provinces, coldest climate regions, highest concentration of low-income households, and combination of the above.
- Produce set of case studies from data collection and implemented energy projects on how women benefit from energy improvement projects in rural areas; seek opportunities to scale.

Financing Products

Work with various stakeholders to develop customized financing tools for low-income rural HHs which will eliminate the need for upfront capital investments and deliver EE solutions (equipment and works) for rural HHs with third-party financing; with special focus on female-led households including:

- international and local financial institutions for tailor-made lending instruments
- local authorities to design targeted social assistance solutions for low-income EE programs (low-income insulation, sustainable fuel subsidies, subsidizing commercial loans, etc.)

- national and local authorities for development of guarantee tools for providing flexible financing for third parties

Information and Outreach

Raise the public awareness to cultivate better understanding and behavioral change aimed at:

- Eliminating unsustainable use of fuelwood (wood moisture, air quality, dung use, deforestation threats, lost ecosystem services, etc.)
- Promoting efficiency of energy end-use (stove inefficiency, building energy use, opportunities offered by EE solutions in heaters, windows, wall and roof insulation, etc.)
- Empowering women, local CSOs, media representatives addressing issues of sustainability of household energy-use (fuel selection, health concerns, efficiency of heating devices, etc.), low-cost energy efficiency solutions, raising informed and sustainable energy users, etc.; facilitating women's decision making in their households' and communities' sustainability.
- Development of community/ies of practice around the sustainable energy challenges focused on rural households and natural resources.
- Development of hands-on EE retrofitting training for local craftsmen for creation of locally available professional work-force for insulation of rural homes. These could be organized in cooperation with well-established construction companies, solar energy system vendors, etc.
- Partner with other organizations in advocacy campaigns for reduction of social resistance to gender equality and establishing more positive profile of rural women.

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List of Abbreviations

ADB	Asian Development Bank
AFD	French Development Agency
E5P	Eastern Europe Energy Efficiency and Environment Partnership
EBRD	European Bank for Reconstruction and Development
EE	Energy Efficiency
EIB	European Investment Bank
ENPI	European Neighborhood and Partnership Instrument
EU	European Union
EUR	Euro
FAO	Food and Agriculture Organization of the United Nations
FHH	Female-headed households
GDP	Gross Domestic Product
GGF	The Green for Growth Fund
GIZ	German Agency for International Cooperation
GoA	Government of Armenia
ha	Hectare
HFHA	Habitat for Humanity of Armenia
HH	Household
IFC	International Finance Corporation
IFI	International financial institution
IRR	Internal Rate of Return
KWh	Kilowatt-hour
MAB	Multi-apartment building
MDG	Millennium Development Goals
MEINR	Ministry of Energy Infrastructures and Natural Resources
NEEAP	National EE Action Plan
NGO	Non-governmental organization
NIF	Neighborhood Investment Facility
NIP	Neighborhood Investment Platform
NMC	National Mortgage Company
NSS	National Statistical Service
PPP	Public-private partnership
PFI	Private Finance Initiative
RE	Renewable Energy
RA	Republic of Armenia
SNCO	State Non-Commercial Organization
TFEC	Total Final Energy Consumption
toe	Tons of oil equivalent
TPES	Total Primary Energy Supply
UN	United Nations
UNDP	United Nations Development Program
USAID	United States Agency for International Development
USD	United States Dollar
VAT	Value Added Tax
WB	World Bank

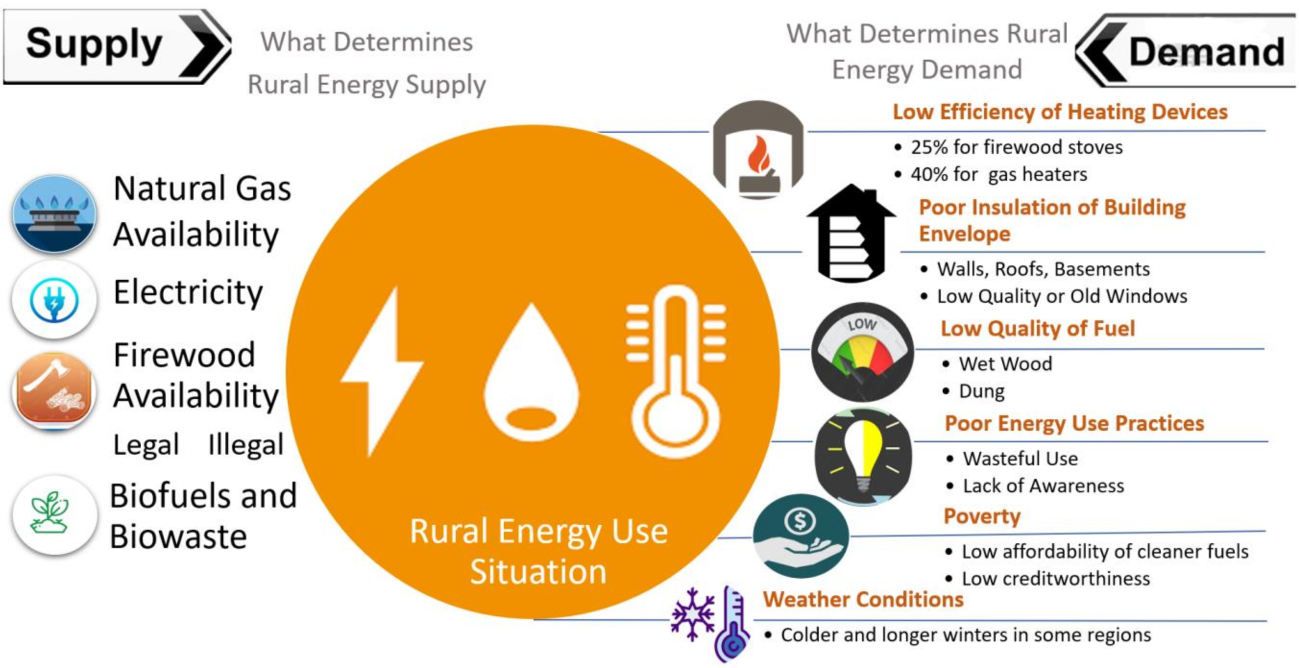
1. Introduction

The “Management of natural resources and safeguarding of ecosystem services for sustainable rural development in the South Caucasus” (ECOserve) programme implemented by GIZ is part of the wider German support in the priority area “Environmental policy, conservation and sustainable use of natural resources in the South Caucasus”. As part of broader effort to improve the conditions for the sustainable and biodiversity-friendly use of natural resources in the prevailing land-use systems in the South Caucasus, ECOserve places a special focus on energy situation in rural Armenia.

The present assignment was meant to conduct a comprehensive review of the energy demand and supply for the main target groups of ECOserve in Armenia’s rural communities, the use of rural households that use fuelwood or manure as a source of heating energy, while also stocktaking of the donor landscape in delivery of technical assistance and finance in this sector. ECOserve aims at seeking a marketable approach to promote more efficient use or substitution of fuelwood or dung as a source of heating energy that addresses the specific benefits of women (e.g. indoor air quality, room temperature, fuelwood procurement legality).

The approach taken to assess the situation was to analyze the key factors affecting the supply and demand of rural households for energy sources for heating and hot water preparation (see below graph) focusing on the factors affecting the energy supply options in rural communities, including considerations for their sustainability. On the other hand, the assessment also focuses on the variables affecting the energy demand including the efficiencies of the fuel combustion, heat losses in the buildings, quality of the fuels, energy use habits and household incomes affecting their affordability and willingness to pay.

Figure 1: Rural Energy Supply and Demand



The study has been based on statistical analysis, desk review of published secondary data and analytic reports, consultations with stakeholders and an interactive workshop[1] with key engaged partners from relevant ministries, local authorities, NGOs/CSOs, professional organizations, where the findings and conclusions were validated.

[1] Held on 23 May 2019 at Elite Plaza, Yerevan.

2. Armenia's energy supply and efficiency profile

Energy Supply Profile

In Armenia virtually all fossil fuels are imported creating a major dependence on fuel imports. **Gas** is imported predominantly from Russian Federation (80-85%) and from Iran (15-20%). Gasification level is 95% covering 594 populated areas. All non-gasified communities are rural. It is noteworthy that transport sector consumes 22% of the gas. Number of natural gas fueling stations for cars is 335 with 455 mln. cubic meter consumption. The remainder is used for electricity and heat generation in all sectors, including households. TPES in 2017 was 3,293.9 thousand toe. While electricity is also used for heating, the predominant fuel is natural gas, which, in rural communities, is strongly supplemented by fuelwood and animal waste.

Figure 2: Total Primary Energy Sources (TPES), 2017

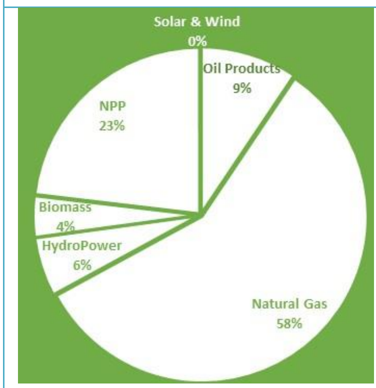


Figure 3: Final Energy Consumption by Sector, 2017

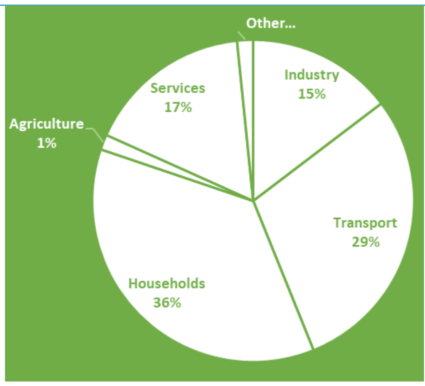


Figure 4: Final Residential Heat Energy Consumption, 2017

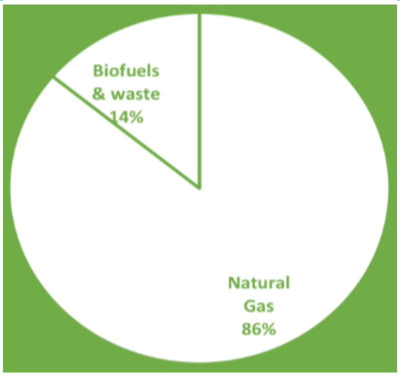
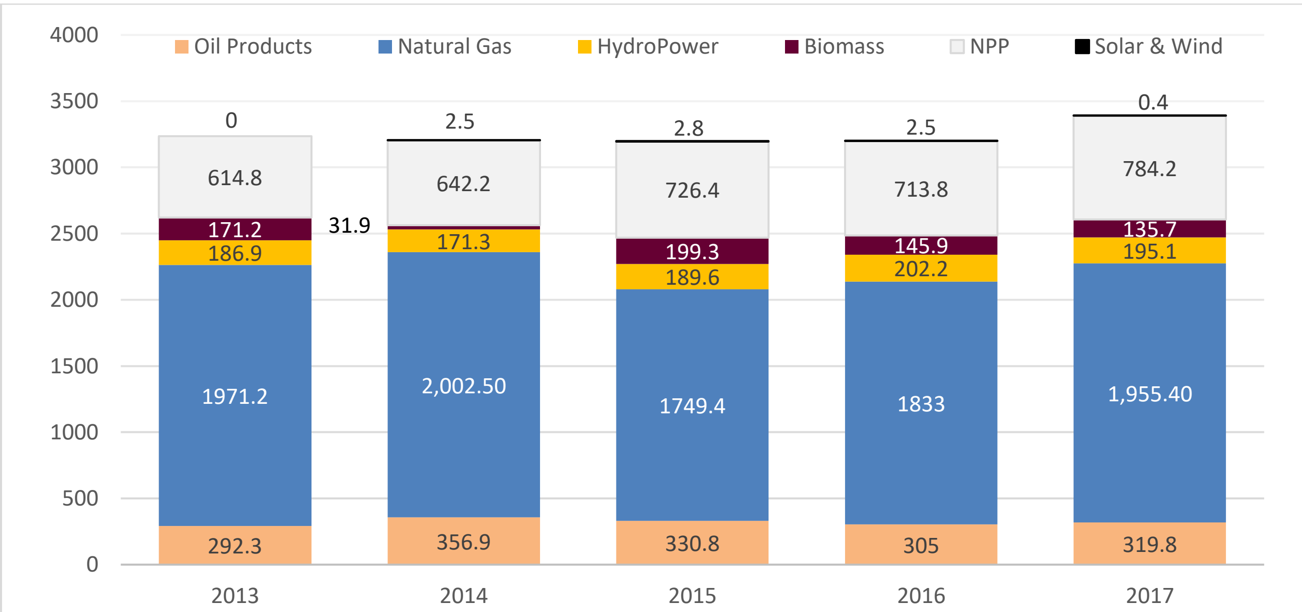


Figure 5: Total Primary Energy Supply, 2013-2017, K.T.O.E. (excluding electricity trade)



Source: Energy Balance of RA, 2013-2017

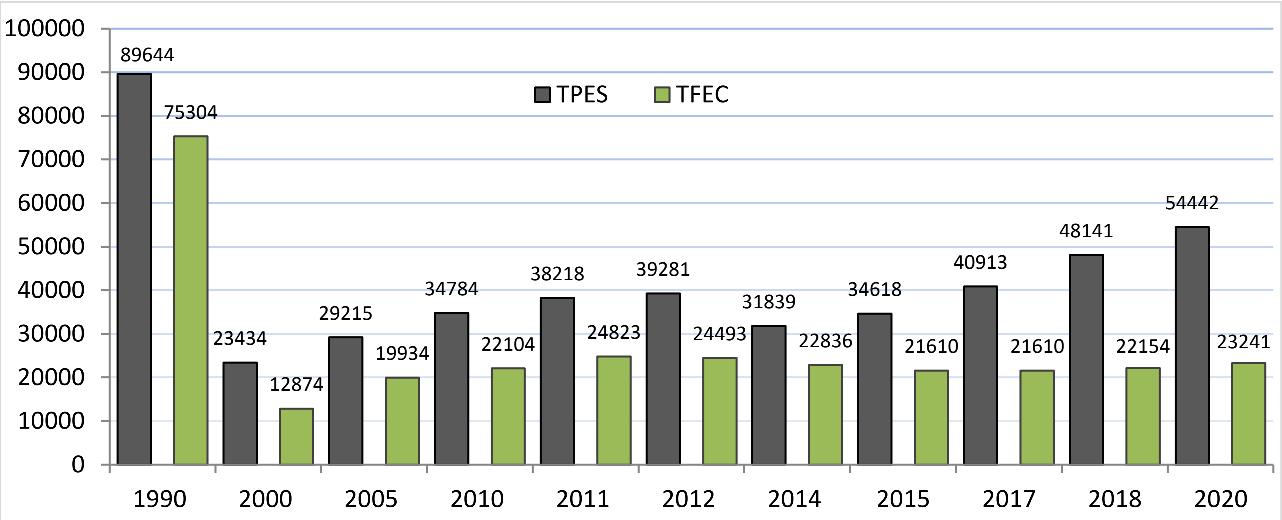
After the deep fuel crisis in 1992 when consumers had only 2-4 hours of electricity per day and most HHs depended on fuelwood or electricity for heating (WB, 2011), the electricity system has been restored. **Electricity generation** in Armenia relies mainly on natural gas (54% of total installed capacity) followed by hydropower (22% of installed capacity). The nuclear power plant built in the

Soviet period is still in operation and contributes 19% of total installed capacity.

National Energy Consumption Profile

Armenia's energy consumption currently represents only a small fraction of the level prior to collapse of the Soviet Union.

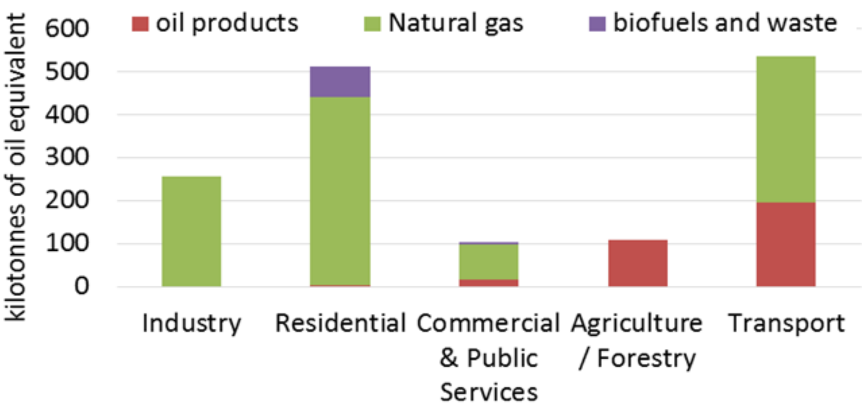
Figure 6: Total primary and final energy sources used in Armenia since 1990, statistics and forecast.



Since independence, Armenia has struggled to recover the level of economic output and the economy has grown at a steady rate, and so did the energy use. The restructuring of the economy with more focus on services and away from heavy industry has helped reduce the energy intensity of economic growth and decouple energy from growth which is a major step towards a sustainable energy pathway and green economy (see Figure 3).

The residential sector was the most relevant, consuming over one third of total final energy (36%), followed by the transport sector with a share of 29% in 2017. However, both sectors have only marginal direct contributions to GDP. Industry used only 15% of energy, which is far beyond the industry's share in the Soviet era. Commercial and public services accounted for about 17%, and agriculture for about 1%. The share of the residential sector fluctuates depending on weather conditions. HHs consume 25% of natural gas, where natural gas is a predominant fuel in urban housing, while it is a supplement fuel in rural households (According to Living Conditions Survey 2017 in rural areas 72% of HHs uses wood, and only 12% - gas).

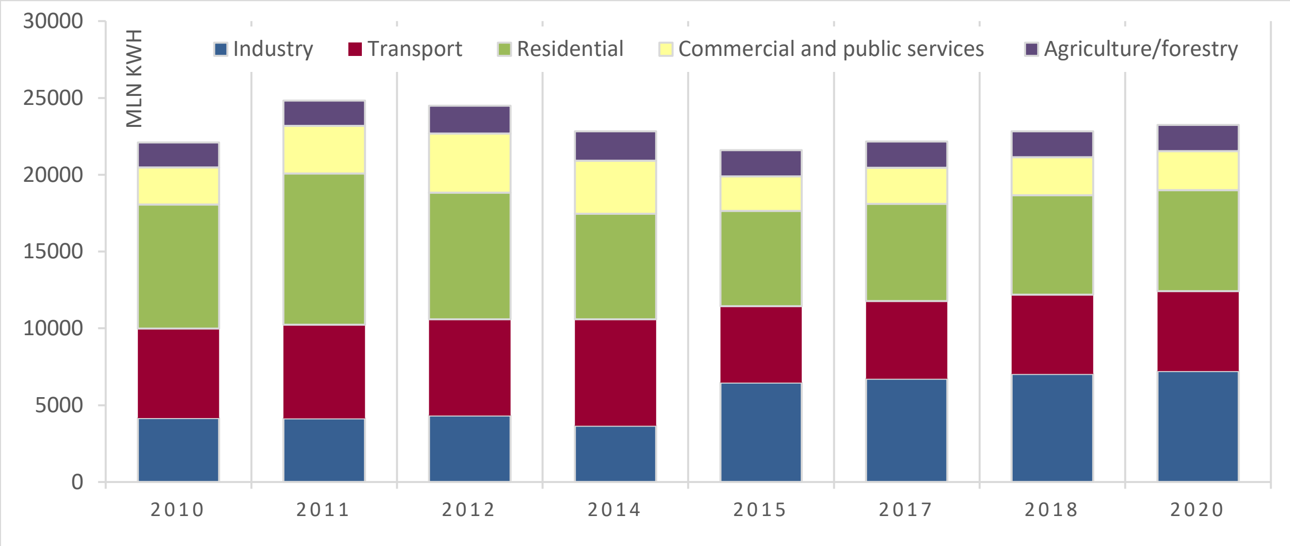
Figure 7: Primary Fuel Consumption by Customer Groups, 2017



The historical trend based on 2013-2017 energy balances indicates a slow rate of increase in total primary energy consumption.

Nevertheless, final energy consumption has increased in recent decade. The residential sector was the largest consumer, responsible for over one third of total final energy, followed by the transport sector with a share of 23% in 2017. Nevertheless, both sectors make only insignificant contributions to GDP. Industry used only 18% of energy, which is far beyond the industry's share in the soviet era. Commercial and public services accounted for about 16% and agriculture - for about 7%. Only the commercial and the public service sector showed steady increase of energy consumption over the last years.

Figure 8: Final energy consumption in Armenia by sector (in mln. kWh) *



Source: USAID, 2012. Reference scenario for 2015-2030.
**Data for 2000 and 2005 are from International Energy Agency, Statistics*
Source: Annual Report of the Ministry of Energy and Natural Resources of RA

Currently available projections[2] are based on 2006 data and assume an increase of the share of industry in overall final energy consumption until 2030, as well as a slight increase of the share of transport. The share of all other sectors was expected to decrease. Practice seems to develop differently. The *Long-Term Strategic Development Program of the Armenian Government 2014-2025* plans an annual economic growth of up to 6-7% and a doubling of GDP by 2025. Highly qualified jobs ensuring high labor productivity are considered as the main directions. The Program, in fact, may become a straightforward strategy for a country poor in natural resources. The envisaged workplaces indeed may be less energy intensive. Therefore, in a reference scenario, one would expect an increase in energy consumption in commercial and public services.

Pressure of Energy Use on Armenia's Forests

Armenia's has been ranked as fourth among Europe and Central Asian countries in its very high exposure and sensitivity to climate change. The vulnerability to the threats of climate change is especially high due to very low adaptation capacity[3]. Forests play a critical role in enhancing the

[2] Although the projections are not compatible with current development and need to be adjusted there was no other projection to rely on. Further demand planning is necessary to come up with more realistic forecast of future demand trends.

[3] According to the WB study, Armenia's index of exposure to climate change equals 23 out of 25 maximum points; Armenia's index of sensitivity to climate change is equal to 22 out of 25 maximum points, and the adaptation capacity index equals 4 out of maximum 25 points. See Adapting to Climate Change in Europe and Central Asia, WB, 2019 at http://documents.worldbank.org/curated/en/127181468024643244/Adapting-to-climate-change-in-Europe-and-Central-Asia

country's resilience and coping potential against the risks that are already happening due to climate change and will be escalated further, as predicted by the Intergovernmental Panel on Climate Change (IPCC).

A longer-term target was set in the Intended Nationally Determined Contributions (INDC) of the RA under the UN Framework Convention on Climate Change with a target of 20.1% of forest cover to be achieved by 2050[4]. Considering the average lifetime of trees and ability to absorb carbon, the impact period of this measure can be extended up to 2100.

According to the clarified data obtained by GIZ in 2011 through remote sensing method the forest cover of Armenia makes 332,333 ha or 11.17 % of the total territory of Armenia, including about 283 thousand ha natural forests and about 50 thousand ha artificial forests[5]. There is no consistency in estimates of forest cover in data provided by NSS, Land Cadastre and various studies by FAO, UNDP, etc, which testify to the urgent need for a comprehensive and reliable forest inventory. Various estimates of Armenia's forest cover presented in publicly available sources are shown in below table.

Table 1. Indicative Forest Cover Estimates by Various Studies for 2015 (FAO, MDG, NSS), %.

Sources	**1990**	**2000**	**2005**	**2010**	**2015**
Global Forest Resources Assessment, UN FAO, 2015	11.9%	11.8%	11.8%	11.7%	11.8%
MDGs: National Progress Report of Armenia, 2015		11.2%	11.2%	10.3%	
National Statistical Service				12.4%	11.2%

Despite with forest cover statistical disagreements, there seems to be common conclusion that there has been a downward trend of the forest cover in Armenia[6]. As of 2016, an estimated 6% of Armenia total land area was degraded. Degradation is caused by unsustainable agricultural activities, deforestation/logging, mining activities, and development of hydropower production sector. Yet, one of the main reasons for forest felling is the heavy social situation of the population, which results in a great deal of pressure on the forests, using wood as a fuel. Biomass consumption is 4-6.2% of total final energy.

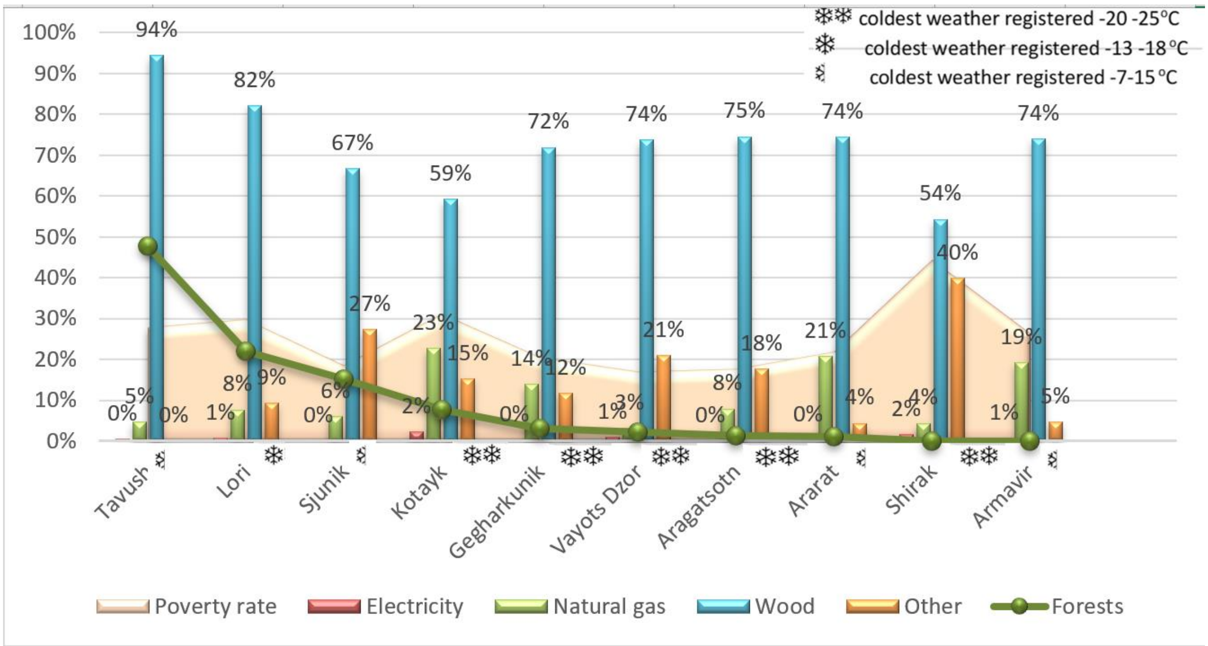
HHs Integrated Living Conditions Survey conducted by NSS in 2017 came to a striking finding that fuelwood has become and fundamentally established itself as a fuel of choice for many urban citizens, and nearly every rural HH. The use of fuelwood in rural areas as main heating option is usually explained with socio-economic issues existing in regions. The graph below shows connection of fuel choice, forest proximity, poverty and climate. It shows that the poverty does not directly link to fuelwood use, but forest proximity does.

[4] Protocol Decision of the Government of the Republic of Armenia No 41, from 10 September 2015 "On approving the Intended Nationally Determined Contributions of the Republic of Armenia under the UN Framework Convention on Climate Change"; and Government Decision No 1232 of 21 July 2005 "On Adoption of the National Forest Program of the Republic of Armenia"

[5] Sixth National Report to the CBD of the RA.

[6] SDG IMPLEMENTATION VOLUNTARY NATIONAL REVIEW (VNR) ARMENIA, Report for the UN High - level Political Forum on Sustainable Development (transformation towards sustainable and resilient societies) –18 July 2018, Yerevan, p.51

Figure 9: Level of Poverty, Forest Cover and Choice of Heating Fuel by HHs in Armenia's Marzes



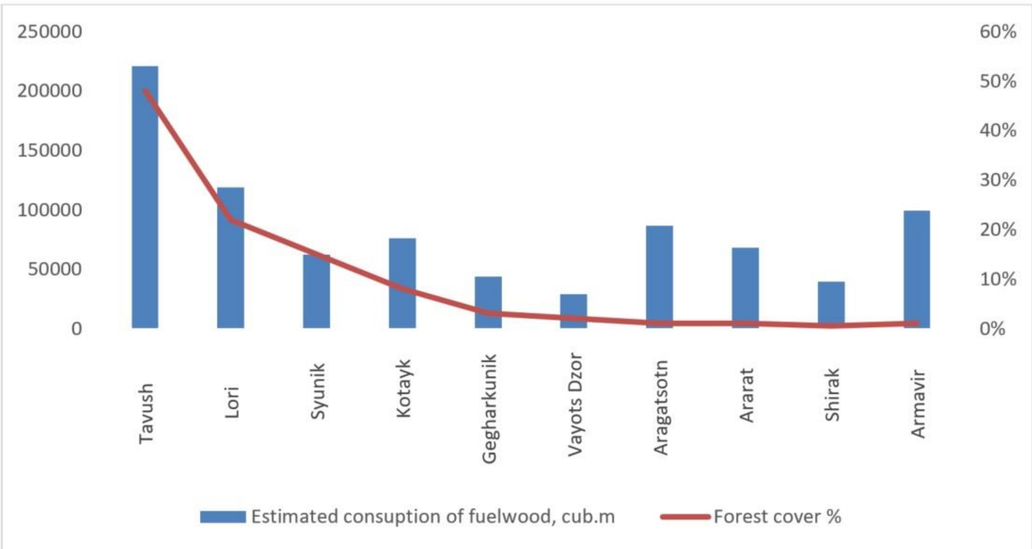
Source: GIS expert analysis of the 11,17% of forest cover distribution by marzes, 2011,
ARMSTAT's Household's Integrated Living Conditions Survey anonymised microdata database (by households), 2017
Social Snapshot and Poverty in Armenia, 2018 at https://www.armstat.am/file/article/poverty_2018_english_2.pdf

According to RECS data, an average HH in Yerevan consumes 4.7 c.m. wood during the heating season, while the consumption reaches 7.1 c.m. in other cities and towns. Meanwhile, average consumption of wood per season is 8.1 c.m. in villages[7].

The estimates of the fuelwood consumed for heating vary:

- According to the "State Forest Monitoring Center" SNCO surveys the demand of fuelwood during 2010-2011 season made 709,851 c.m, during 2013-2014 season - 977,011 c.m., during 2017-2018 - 842,477 c.m.

Figure 10: Estimated consumption of fuelwood during 2017-2018 by marzes



[7] RECS and EDRC estimates, Residential Energy Consumption Survey, Analytical Report, October 2015. Available at http://www.edrc.am/images/Publications/Statistical_Surveys/undp_recs_2015_eng.pdf

Source: Annual Report by Forest Monitoring Center, 2017
GIS expert analysis of the 11,17% of forest cover distribution by marzes, 2011

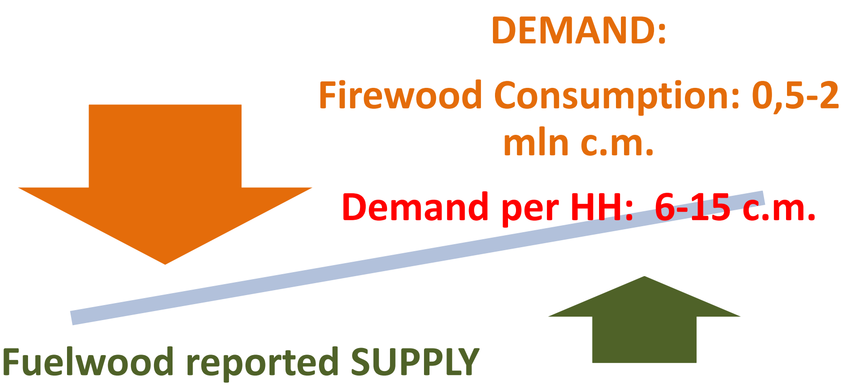
- According to "Understanding the forestry sector of Armenia: current conditions and choices" (Nils Junge & Emily Fripp, 2011) the estimated HH wood consumption in 2010 was 457,000 c.m.
- According to RECS estimate[8] about 2 mln c.m wood was used for heating by HHs in Armenia (2014-2015), of which 1,5 mln c.m. in villages, 0,07 mln c.m. in Yerevan and 0,5 mln c.m. in other cities.

Annual allowable cut by "Hayantar" SNCO in 2014 was 29,023 c.m., in 2015 – 25,977c.m., in 2016 – 25,641 c.m. and in 2017 – 29,926.5 c.m.(with about 10% of construction wood)[9] . Meanwhile, in the mentioned period the surface of logging areas has been increasing: 1558 ha in 2014, 1501 ha in 2015, 1940 ha in 2016 and 2010 ha in 2017.

According to FAO, the maximal forest renewal increment is estimated at 600,000c.m./ year, which is based on forest renewal capacity of annual growth rate of 1.30-2.86 c.m./ha/year. Climate change, forest fires, pest outbreaks, draughts, result in even slower growth rate.

From given facts above, it is clear that the fuelwood demand significantly (at least 20 times) exceeds the fuelwood supply, persistently leaving damaging impacts on forests, harvesting beyond the natural recovery rate. The demand is also likely to grow with the growing energy tariffs as more families cross the affordability threshold on utility bills.

Figure 11: Fuelwood Supply and Demand Estimates



Sources: State Forest Monitoring Center SNCO, "State Forest Monitoring Center, RECS

Main sources for fuelwood are sanitary and maintenance cuttings (authorized), fallen dead wood, unauthorized (illegal) loggings, wood from orchards/gardens and other wood waste (e.g. scrap wood or wood products from furniture production) and paper waste (junk carboard, packaging, etc.).

GoA decision N 1535-N approved in 2011 "on granting privileges for nature use fees to extract dead wood for non-production (non-industrial) use by families residing in the forest adjacent settlements of the RA" allowed the families residing in forest adjacent communities to collect on their own expense up to 8 c.m. of dead wood free of charge. Demand for other biomass (dung) is high in areas that are poor with forests, for instance in Shirak region, which is one of the coldest marzes with the highest level of poverty. However, the fuelwood consumption there is lower than in much warmer regions with closer proximity to forests (see Figure 9).

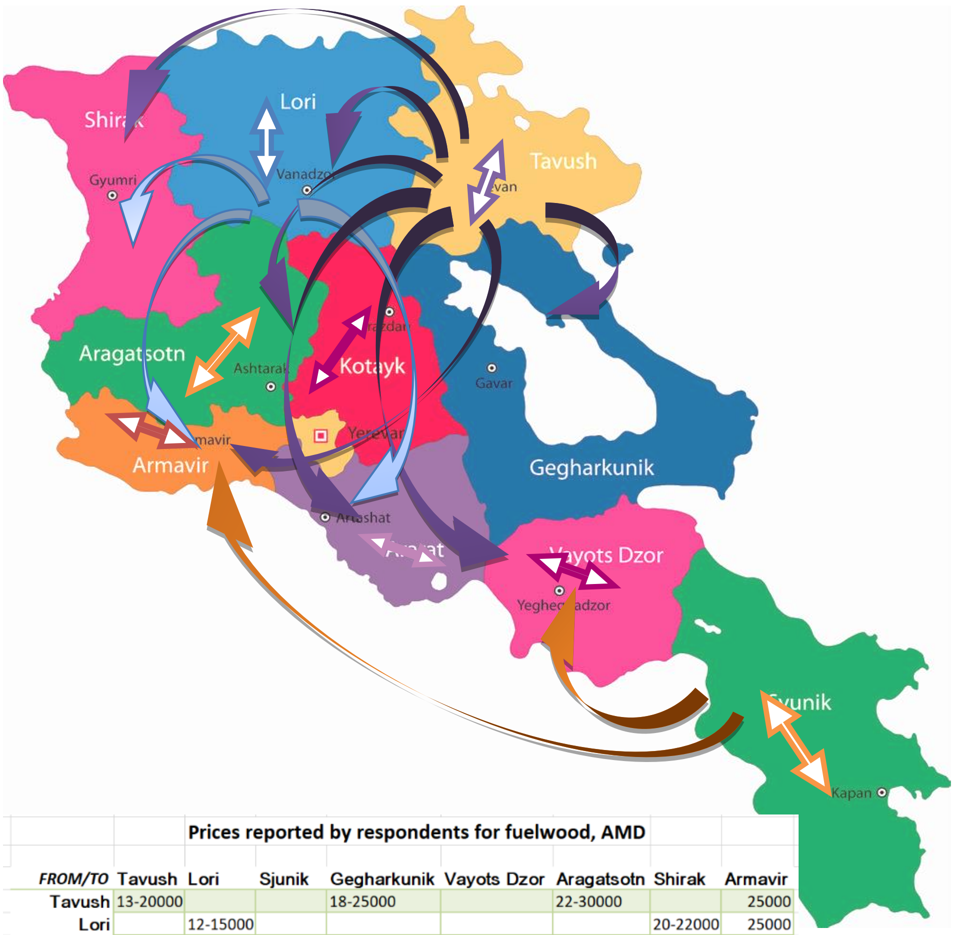
About 75% of the forests of Armenia is managed by "Hayantar" SNCO (state forest management enterprise), including 13 forest sanctuaries, and 25% are the forests in specially protected nature areas (state reserves, national parks, sanctuaries) managed by respective SNCOs – all under the

[8] RECS and EDRC estimates, Residential Energy Consumption Survey, Analytical Report, October, 2015, at http://www.edrc.am/images/Publications/Statistical_Surveys/undp_recs_2015_eng.pdf
[9] Sixth National Report to the CBD of the RA.

RA Ministry of Environment. A minor proportion of established forest areas belong to communities or they are on community owned lands leased to other organizations (e.g. Armenia Tree Project). Armenia virtually has no commercial forestry aimed at construction wood (or fuelwood) production. The growing prices for natural gas, deteriorating economic conditions in rural communities, unemployment rate, as well as poor enforcement of forest protection regulations led to sustained rate of deforestation, hence - negative changes in forest ecosystems. For the prevention of illegal logging, on 9 July 2019 the National Assembly of Armenia adopted the amendments proposed by the Ministry of Environment to the Criminal Code, Code on Administrative Violations, and Law on Penalties for Environmental Violations Damaging animals and vegetation. Among others, these amendments aim to increase the criminal and administrative responsibility for illegal cutting and forest destruction.[10]

The efforts of the State (and other related structures) have not been able to exercise full control of the problem. The survey conducted by authors in spring 2019 indicated, fuelwood continues to remain a market commodity. Tavush, Lori and Syunik regions remain suppliers of fuelwood which travels tens and hundreds of kilometers, while other regions, such as Kotayk, Aragatsotn, Vayots Dzor and Ararat, keep harvested wood for internal consumption (see below map). This also creates major demands on the capacities of the State to control and prevent the illegal wood traffic throughout Armenia.

Figure 12: Traffic of Fuelwood throughout Armenia's Regions



FROM/TO	Tavush	Lori	Sjunik	Gegharkunik	Vayots Dzor	Aragatsotn	Shirak	Armavir
Tavush	13-20000			18-25000		22-30000		25000
Lori		12-15000					20-22000	25000
Sjunik			15-20000					
Vayots Dzor					20000			
Aragatsotn						30000		

Prices reported by respondents for fuelwood, AMD

Source: Based on survey conducted by authors in the frames of this study in spring 2019.

The surveys revealed a big spread in prices for fuelwood sold on Armenia's territory (from AMD

[10] RA National Assembly website http://www.parliament.am/

12,000 to 30,000 per c.m). According to Annual Report by State Forest Monitoring Center an average price for 1 c.m. was 13600 AMD in 2017. When prices are low for fuelwood, it reaches a considerable share in the energy supply mix of any country due to increased demand.

The long-term negative changes of the ecological status are observed in the areas, which have been subject to intensive loggings. The current state of forest ecosystems in one of the most forest covered Lori region of Armenia, which is presented in the socio-economic development program for 2014-2017, is a good example. It was registered that due to illegal loggings for fuelwood and construction wood during 1991-2000 the conditions for natural regrowth of the forests in Lori region have worsened and significant territories on the mountainous slopes have been deforested.

To summarize, the key problems of the forest sector in Armenia related to the use of fuelwood for heating purposes include the following:

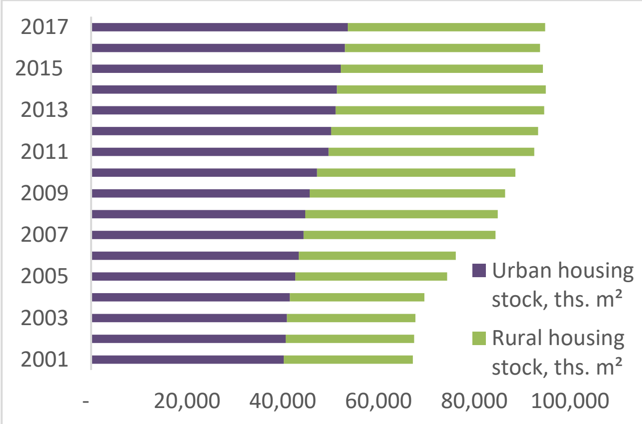
- There is no reliable and up to date data for forest’s resources and so there is an urgent need for a comprehensive and reliable forest inventory.
- High fuelwood demand is a major factor for excessive use of wood resulting in deterioration of forest ecosystems (unsustainable forest use).
- With legal and illegal cutting combined to meet increasing demand, the use of forest biomass for energy exceeds the country’s resource base. This causes damage to the ecosystem in the long run.
- Unless pricing fuelwood includes the monetarized value of ecosystem damage, the pricing of the fuelwood will not be able to protect the ecosystem services. It is also highly possible that if the pricing for fuelwood is revised to be based on ecosystem services approach, the price will significantly rise and demand will go down.

3. Current Housing Stock Profile and Building Energy Efficiencies

The Armenian housing sector comprises about 95 million m^2, of which 46% is in rural settlements. 60% of all private houses are located in rural areas, while 36% of all multi-apartment buildings (MAB) are also in rural areas.

Figure 13: Total Housing Stock and Breakdown by Urban and Rural Settlements (thousand m^2)

Numbers of residential buildings, 2017	
Private Houses:	**396,948**
of which:	
• Houses in rural areas:	240,921
• Houses in urban areas:	156,027
Multi-apartment buildings:	**19,195**
• Total apartments:	443,023
of which:	
• MABs in rural areas:	6,929



Source: National Statistical Service

Rural Housing: Stock and Utility Affordability

The total number of private houses is 396,948, out of which 240,921 units or 39 million m^2 in rural areas. In 2017, HHs spent an average 20% of their total expenditures on electricity, heating, and hot water.[11] The increasing costs of natural gas and electricity pose a problem, especially for low-income HHs. In the last decade (2007-2017), the electricity price rose by 94-112%, while the natural gas price rose by 250%. Up to 50% of the income of poor families is spent on heating during winter months (but still may not reach comfort level).[12] Note that the housing sector continues to grow. Since 2001 the urban housing stock has grown by 33%, while the rural housing – by 53%, and homes tend to get bigger with living area per inhabitant in a rural community having increased by 62%. This also poses demands of heating for larger homes with less occupants.

In 2015, 38.5% of the rural population was poor. The estimated extreme poverty was 1.3%. The poverty rate in Shirak, Lori, Kotayk, Tavush and Gegharkunik regions was higher than the country average. With 45% of the population below the poverty line, Shirak region was still the poorest in Armenia. Over the period of 2008-2015, the poverty rate increased countrywide. And as a multi-dimensional poverty measure, “healthy heating” is a basic need, which a HH is deprived if uses wood, animal dung or other heating means as primary source for heating due to the inefficiency of heating devices and unsustainable wood harvesting practices which will deprive rural communities of ecosystem services offered by the forests in the long run. Wood heating can be modern and sustainable if adequate investments are made in wood production to ensure sustainable recovery of consumed biomass, and wood is used more efficiently on the appliance and building envelope level.

While energy prices in Armenia are among the highest in the CIS region but still quite lower than prices in EU countries. Armenian population has pronounced fuel poverty (usually defined as use of over 15-20% of disposable income on energy in heating months) among 7-12 % of rural HHs. For example, electricity costs 8.4 eurocents/kWh in Armenia, 9 eurocents being the lowest end of the

[11] Source: EDRC Residential Energy Consumption Survey, UNDP/GEF, 2015.
[12] Poverty in Armenia has been assessed since 1996. Starting from 2009, the country has used a revised methodology developed with the assistance of the WB. The poor are defined as those with consumption per adult equivalent below the upper total poverty line; the very poor are defined as those with consumption per adult equivalent below the lower total poverty line, whereas the extremely poor or the undernourished are defined as those with consumption per adult equivalent below the food poverty line. In 2015, poverty rate was 29.8% with only 0.2 percentage point reduction from its 2014 level. This means that every third person in the country was below the upper poverty line of AMD 41,698 (less than EUR 80/month).

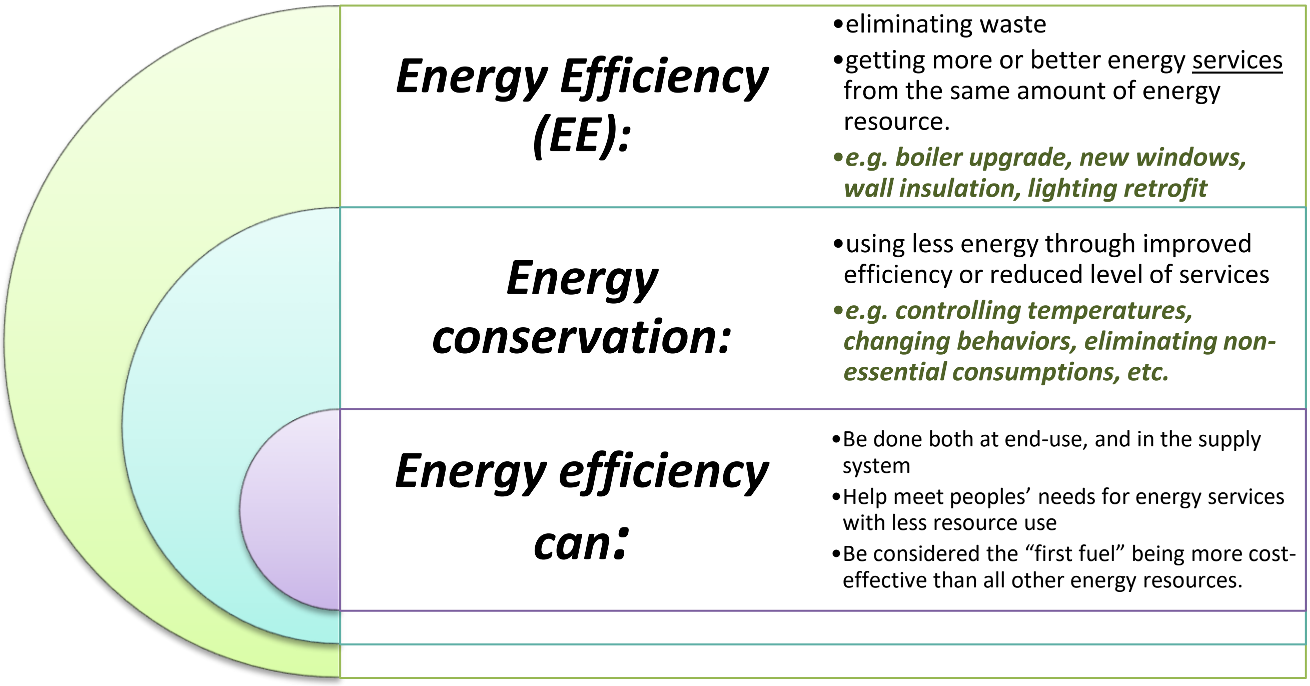
EU and accession countries markets and reaching up to 30 cents/kWh in Belgium, Denmark and Germany. Nonetheless, the electricity and natural gas tariffs are at cost-recovery rate and do not explicit energy tariff subsidies unlike Ukraine, for example, which provides energy subsidies to over half of country's population. In Georgia electricity is cheaper because it is produced with "strategically" cheap natural gas imported from Azerbayjan.

Gas prices in Uzbekistan are only one-fifth of those in Armenia, clearly due to availability of indigenous supplies, similar to Azerbaijan, Kazakhstan, Russia, etc. Where gas has to be imported prices vary considerably, depending on the negotiated cost of imports and the level to which government may decide to subsidize the population. In Ukraine, residential costs are EUR 92/1000m^3, less than half the reported import price and leading to substantial debt issues; in Armenia residential prices are EUR 270/1000m^3.

With high energy tariffs and low efficiency of rural energy end use, devastating unsustainability of illegal forest harvest has no alternative, unless policies and programs are put in place to remedy the situation.

In addition to controlling and protecting forests on the supply side, much can be done to address the issues of fuel poverty and excessive fuelwood use on the demand side. Some tools that have proved effective worldwide include enabling access to financing for rural HHs and introducing low-income energy efficiency programs to improve the efficiency of HH heating stoves, building envelopes, hot-water preparation equipment, lighting, HH appliances, etc. Due to the high poverty levels among rural population, as well as high level of indebtedness among rural population due to agricultural farming investments, their ability to borrow large funds or offer securities is limited. Despite the multi-million credit lines available at local financial institutions, the rural HHs cannot afford to borrow to improve their HHs' energy performance and reduce their utility bills to remain within their affordability limits. The unsecured loan accessibility for rural HHs is limited, commonly, to monthly income. Most banks view home renovation loans as mortgage loans and collate rise the client's property.

Figure 14: Defining Energy Efficiency: Key Terms



To date, the accumulated experience and expertise have demonstrated that EE improvements can help vulnerable HHs in Armenia, and that EE is the quickest, cleanest and cheapest way to bring comfort and economic mitigation to these HHs. IFI resources can cover only a small fraction of the investment needs in this sector; the private sector should thus be tapped for investment capital to address the modernization and efficiency improvement needs over the next 20-30 years.

The potential for EE in the buildings sector has been estimated and Armenia is no exception—the latest studies have confirmed there is an energy saving potentials. The National Program on Energy Saving and RE estimates a 40% potential for energy savings in Armenia's building sector. While the program is targeting the buildings sector as a whole, majority of investments usually go to urban areas, where the borrowing capacity of the population is higher. The rural households are mainly covered through eligibility for private HHs for soft energy efficient home renovations and mortgages set up by various international financial institutions at the local commercial banks. The loans cover heating systems, windows, insulation, solar water heaters, etc.

There are important experiences and lessons learned from the projects/initiatives on EE in urban areas/MABs.

According to the results of donor-funded pilot projects, an average household residential building in Armenia has 30%-50% energy savings potential at current energy prices. Some examples of donor efforts include:

- The most indicative of all were the pilot projects implemented by the UNDP-GEF Improving EE in Buildings Project. The UNDP-funded thermal retrofit of a multi-apartment panel building in Yerevan reduced energy consumption from 178 kWh/m^2 to 74 kWh/m^2 (by 58%) after thermal rehabilitation of the building façade. The UNDP efforts have scaled to various initiatives aimed at designing financing schemes for De-Risking Climate Investments in Energy Efficiency in Buildings.
- Moreover, the HFHA has also found the appropriate lending model and implemented loan-funded thermal enveloping of three existing typical panel buildings. The Municipality of Yerevan provided grant co-financing for such loan-financed projects within the scope of a bilateral memorandum of understanding with the HFHA. In some cases, the investments received modest co-financing by residents (homeowners association). While this instrument is effective, it has significant administration cost. However, as typical small-scale housing finance, such products cannot succeed in the absence of massive outreach, face-to-face liaison with customers, "door-to-door" marketing. In such projects community outreach is even more important than energy auditing of buildings. Furthermore, given the fairly uniform typology of MABs, if standard EE retrofitting packages can be designed of typical panel/monolith/stone multi-apartment buildings, the technical assistance can be better used to help reach out to home-owners, help them unite and make joint decisions, mobilize home-owner groups until there are ready to converse with the banks and reach loan agreements.
- In addition to EBRD, IFC and GGF loans for EE investments, the AFD and the National Mortgage Company (NMC) have launched the "Warm Home" Social EE Housing Finance Program for Armenia's Housing Sector.
- KfW launched a Housing EE Credit Line in 2016 (EE Mortgages), which is also partnered with the NMC (similar to AFD) and covers another niche for residential EE.

The barriers to EE investments in rural HHs can be summarized as follows:

- lack of housing government strategy or clear policy on supporting rural HHs in energy utility affordability and access to modern energy services, unclear role of state/local government responsibilities towards vulnerable groups among rural dwellers;
- unclear separation of responsibilities among state and local authorities;
- limited private-sector involvement in housing renovation industry and finance (availability of home renovation services, skilled companies offering insulation services, etc.);
- lack of financial resources due to low maintenance fee rates and low collection;
- poor creditworthiness of rural HHs due to the cash-based rural/agricultural businesses, limited formal employment opportunities, massive agricultural loans drawn to cover investment costs and weather damage costs, their new status, slow development, failure to

collect service fees, and failure to conduct creditworthy accounting, bookkeeping and reporting;

- lack of overall awareness and understanding of the benefits EE and renewable energy (RE) offer to HHs. the legal and regulatory framework, the rights and responsibilities of home-owners associations, the general benefits of EE.

Studies show that with a maximum of 15% marginal investments, EE can be locked-in in new construction. MEINR reports that the specific energy consumption in Armenia's residential buildings varies from 260-320kWh/m^2 to as much as 690kWh/m^2 per year. This exceeds the EU averages 3-5 times.

The 2nd NEEAP of Armenia estimates that 1kWh saved by investing in EE costs 4 cents, while generating 1 kWh in Armenia's power system currently costs roughly 4.3 cents and will cost as much as 8 cents if all planned new generation capacities are built.

Current Energy Efficiencies

The Armenia - Integrated Living Conditions Survey (2017) found that among all – urban and rural – the HHs relied on the following types of fuel for heating: natural gas – 40.2% (as compared to 57.1% in 2010), wood – 35.9% (as compared to 25.8% in 2010), electricity – 18.5% (as compared to 11.7% in 2010) etc. In comparison to the previous year, the share of HHs using electricity and wood for heating purposes has increased both in rural and urban communities, respectively, from 16.8% to 18.5% and from 33.2% to 35.9%. Meanwhile, the share of HHs using other types of fuel for heating purposes decreased, from 6.0% to 5.3%. As of 2015, some 99.6% of HHs had electricity supply and 84.0% had centralized supply of natural gas. While up to 2013 use of electricity and fuelwood for heating purposes was a desperate choice for customers who were not connected to the natural gas network, now it is quite common for customers to go back to electric or fuelwood heating, or supplementing gas-fired heating with cheaper fuels. The current structure of types of fuel and appliances for heating used by rural HHs in Armenia is presented in Table 2 below, and the efficiencies of commonly used heating devices are presented in Table 3.

Table 2. Rural Heating Options and Appliances

Armenia Rural Heating Options 2010 and 2015, %

	Rural	
	2010	2015
Total	**100**	**100**
Not heated	0.5	0.8
Heated, including by the use of the following options	99.5	99.2
Central heating	-	0.0
Oil, diesel	0.1	0.0
Electricity	1.0	1.1
Natural gas	33.2	14.4
Wood	52.5	71.2
Other	13.2	13.3

Types of Appliances Used for Heating in Rural Communities, 2015. %

	Rural
Electric stove	0.3
Electric heater	0.8
Gas stove	0.4
Home-made oven	82.0
Factory-made oven	11.6
Local individual boiler	4.8
Local collective boiler (for the whole building)	0.0
Central heating	0.0
Other	0.1
Total	100.0

Source: ILCS 2010 and 2015 Surveys

The efficiency of the fuelwood use depends on several factors:

- Condition/quality of wood to be used as fuel
- Efficiency of the combustion equipment
- Efficiency of the heated dwelling in its ability to retain thermal energy with the building envelope.

Fuelwood is used without thorough drying, which reduces the calorific value of wood. High moisture content diminishes the net heat value of biomass to the point that at slightly higher than 80% moisture content, much of the heat content of the biomass is used up to evaporate its moisture, thus does not contribute to the thermal comfort of the HH, and the tree has fallen for nothing.[13] For example, completely dry wood (commercially dried), depending on tree species, can deliver 16.5-19.6 MJ/kg of calorific value. If air-dried in domestic conditions leaving about 15% of the moisture in the wood, the calorific value drops by 25% delivering 13-16 MJ/kg. In most cases wood is not thoroughly air-dried due to the duration and conditions at which stored. Consequently, the fuelwood used in Armenian HHs is likely to still contain 50-60% of the moisture, and has 6-8 MJ/kg calorific value, 2.5 times less than could be achieved with adequate drying. The reasons for such gross inefficiency of fuelwood use due with high moisture content are numerous:

- Inefficient wood harvesting practices by the state forest management bodies, which often implement the wood harvesting too late in the year, not allowing for enough time for wood to airdry. Forest management practices must be improved with smooth functioning of forest-related state structures to get on-time approvals and start of the field operations.
- Lack of knowledge on benefits of drying wood and proper airdrying: some rural energy users believe that the more humid the fuelwood, the slower it burns, allowing the families to “stretch” the fuel for a longer period of time. There is little understanding of the energy content “slowly” being used for humidity evaporation instead of space heating, as well as limited knowledge on how to apply no-cost air-drying techniques (no exposure to sun, snow, several months of duration, windy and shady location, etc.).
- Limited disposable income: most rural families’ revenues come from the sale of agricultural produce which allows them to gradually accumulate their financial means towards the end of fall, which is when they tend to make major expenses in preparation for the winter, including the winter fuel. Due to late purchasing, the wood does not have time to air-dry naturally and remains humid at the time of combustion.
- Lack of commercial drying facilities: over years the fuelwood supply has been in the shadow market, therefore the infrastructure for proper storing, (commercial) drying and quality control of the wood and its humidity was not feasible. The price for commercially kiln-dried fuelwood will be higher, but the benefit in thermal output will increase substantially, the humidity and quality of the output will be controlled.

Table 3. Major heating devices used in the Armenian homes categorized by their use and efficiency

Type of Heating	**Heating devices used, % (used in combination)**	**Efficiency, %**
Gas boiler new	10	90
Gas boiler old	15	70
Gas heater new	15	75
Gas heater old	20	60
Electric Appliances	25	100
Biomass stoves/wood (old)	55-60	25-50*

*This 50% efficiency is an indication, which is a guess. None of the hand-made wood stoves in Armenia has been tested or certified for quality, safety and / or efficiency. Even those, that have more elaborate design, also lack professional lab testing and certification and only exist in the shadow market.
Source: Alliance to Save Energy and R2E2 Fund Study on Residential Energy Efficiency, 2015

Based on the reviews, it was identified that a typical 100m^2 private stone house needs 52,159 kWh of thermal energy (degree days (DD)=3779°C days, average for Armenia) for heating purposes throughout the heating season,[14] or 348 kWh/m^2 energy use. According to Armstat half of population

[13] For more information see: The Effect of Moisture on Heating Values, by Shahab Sokhansanj, Oak Ridge National Laboratory, September 2011. Available at http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.730.3430&rep=rep1&type=pdf

[14] Degree days are essentially a simplified representation of outside air-temperature data. They are widely used in the energy industry for calculations relating to the effect of outside air temperature on building energy consumption. They are used for calculations relating to the energy consumption required to heat buildings. For more detail, see for example www.degreedays.net

cannot afford sufficient warmth in their homes – due to high heating costs (on average $10.36/m^2, if 100% thermal comfort is guaranteed). The heavy heating demands due to low efficiencies and large heat losses place major financial burden on household disposable incomes, leading them to fuel poverty (spending over 15% of household income on energy bills). Many families chose to save by underheating or partially heating their homes. Energy audits indicate that most homes are heated up to 60% of optimal thermal comfort (20-22^{o}C for indoor comfort).[15] This provides a very low baseline energy consumption which does not create possibilities for economically justified EE improvements. It is common to expect that EE improvements do not result in reduction in energy bills, but they do deliver significant comfort improvements. The EE improvements must be calculated with normalized (corrected for comfort) energy consumption as baseline, corrected for comfort sacrifice.

To assess typical interventions possible for fairly common private homes (100m^2, stone-built, one floor) it is also important to understand the level of ambition that homeowners can aim at. Most rural HHs have constrained incomes and would only attempt basic, low-cost measures. While more affluent rural dwellers could afford more intensive EE retrofits. As the analysis indicates (for details see Annex II), to allow that lower-income rural dwellers could afford the comprehensive measures, significant grant co-financing will be necessary. The technical and economic parameters of EE improvement packages for a typical single-family house dwelling are described below.

Table 4. Technical and Economic Features of Basic and Comprehensive EE Interventions in Single-Family Houses (100 m2).

	Scenario 1: Basic refurbishment of a family house including	**Scenario 2: Comprehensive refurbishment of a family house including**
EE measures	1. Replacement of windows and entrance door 2. Thermal insulation of the roof with expanded perlite blankets 3. High efficiency biomass boiler ≥75% with space heating installation, heaters, thermostat control.	1. Replacement of windows and entrance door 2. Roof insulation 3. High efficiency biomass stove ≥75% with space heating installation, heaters, thermostat control 4. Solar thermal thermosiphon set
Total cost	$ 4,956.64	$ 8,197.64
Annual thermal energy amount required for heating purposes after the EE measures	22743.7 kWh (~26% reduction from status quo)	17,701.5 kWh (~42% reduction from status quo)
Level of energy use per sqm	154.7 kWh/m^2	120 kWh/m^2
IRR (Internal Rate of Return)	15.5% (without financial costs)	19.2%
Project payback	5 years	6 years

If based on real, sub-comfort heating data, the above investments will have substantially less attractive metrics, and will require significant grant co-financing to allow them breaking even.

[15] According to Armstat (2017) half of population cannot afford sufficient warmth in their homes.

4. Regulatory and Institutional Framework for Energy Efficiency and Renewable Energy in Armenia

GoA's commitment to promotion of EE and RE is reflected in the Law on Energy Saving and RE (2004) and the buildings codes regulating building thermal performance. The Law defines EE as technical and technological upgrades to modern technology in compliance with environmental requirements, which will make energy use economically beneficial and aims at delivering the highest possible efficiency. The Law further lays out the principles of the government's policy and governance structure supporting EE, and provides for EE standards, audits and awareness raising. To a large extent these policies address new building construction.

As Ministry of Energy Infrastructures and Natural Resources seized to exist in 2019, now Ministry of Territorial Administration and Infrastructures is also in charge of energy sector policy, including EE and RE. However, a number of other related institutions are in charge of the EE and RE, technical norms and standards, housing policy, etc. The institutional landscape in this field is presented in the below graph.

Figure 15: Institutional Structure of Energy Policy Framework

Ministry of Territorial Administration and Infrastructures	• Supports Renewable Resources and Energy Efficiency Fund (R2E2) • Owns Scientific Research Institute on Energy in charge of developing technical norms
Public Services Regulatory Commission	• sets tarrifs for electricity, natural gas, terms and conditions for RE promotion
State Committee on Urban Development	• adopts construction norms, in charge of housing policy, mainly focusing on multi-apartment buildings and new construction
Ministry of Environment	• manages HayAntar responsible for Armenian forest management and conservation • in charge of promoting decarbonization of economy, climate change mitigation
Ministry of Economy	• responsible for adoption of standards (including efficiency of heating devices, fuels)
Ministry of Finance	• in charge of tax incentives, fiscal stimulate, engagement of international financial resources
Regional and Local Government	• Responsible for implementation and oversight of state policies in places

While seemingly a populated institutional landscape, the issue of rural HHs and their energy use is not sufficiently targeted by any institution. Most of the state-supported initiatives have targeted either new construction or existing public/residential buildings. Individual HHs in private, stand-alone houses are considered "private sector" with minimal public intervention. Consequently, this sector has been underserved with technical assistance programs and also donor assistance, since these are not adequately reflected in the national plans and programs.

The individual HHs can only indirectly be affected by the state efforts in appliance certification and labeling, which primarily address imported equipment, since Armenia does not have local production of such appliances. The only direct policy instrument, which private HHs, including in rural communities, can utilize is the net metering provision for rooftop solar photovoltaic (PV) systems, which the owners can use to store the excess output of solar electricity in the electric grid and use it when needed, while the annual surplus, if any, will be purchased by the Armenian Electric Networks at 50% of the retail electricity price.

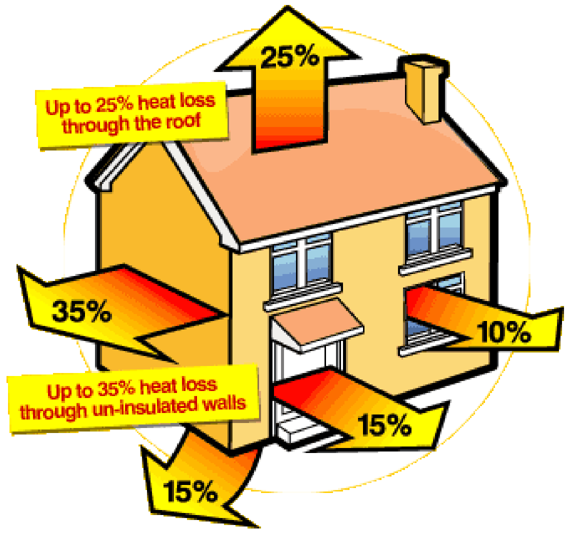
The rural HHs, utility affordability, efficiencies for energy use in rural communities are not explicitly spelled out in any state policies, with the exception of a focus on non-gasified communities, where since 2017 the Ministry of Energy Infrastructures and Natural Resources (Since March 2019 merged with Ministry of Territorial Administration and Infrastructures) has been supporting subsidized lending and installation of solar energy systems in these non-gasified communities as an alternative energy source to help these communities cope with the absence of gas supply. There is no other institution or program that directly and regularly works with the issues of rural energy use. The 2011 RE Roadmap identified the RE technical-economic potential (e.g. almost 4 Terawatt-hours of solar photovoltaic (PV) electricity per year, and over 4 TWh in geothermal heat pumps). In 2013 the President of Armenia approved the National Energy Security Concept. In 2014 the Scaling Up RE Program Investment Plan set targets for RE development until 2025. At present the draft RA Strategic Plan for Energy Sector till 2040 is in circulation. It is planned also to develop the National Program on Energy Saving and Renewable Energy for 2021 to 2030.

5. Demand- and Supply-Side Energy Efficiency and Renewable Energy Solutions for Rural Households

Demand-Side Energy Efficiency Solutions for Rural Household

EE offers many opportunities to reduce and manage the HH energy demand. While there are numerous energy saving opportunities in lighting upgrades to light-emitting diodes, and rich market offering in energy efficient home appliances, such as refrigerators, television sets, laundry machines, etc., the current study focuses on the heat demands of rural homes. Typical thermal energy losses occur through fenestration, roof/attic, walls and basement.

Figure 16: Typical Energy Losses Occur from Building Envelop



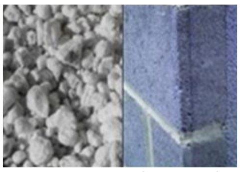
Several groups of measures are eligible and cost-effective to apply under the current energy prices in Armenia, as presented in the sections below.

Building envelope insulation

Effective insulation slows the rate that heat flows out of the house in winter or into the house in summer, so less energy is required to heat or cool the house. If a house has no insulation on the building shell/envelope (walls, roof, attic, basement), there is significant heat loss through wall cavities. Built-in insulation, or thermal retrofitting of the building envelope can greatly improve indoor comfort and save 30-50% of home energy demands. If planned and implemented properly, reduced energy bills can save sufficient amount of funds on energy bills to make such investments cost-effective. The insulation market in Armenia offers both locally and imported materials such as expanded perlite, glasswool, rockwool, extruded and expanded polystyrene, foam insulation and heat reflecting shields. There is lab testing and certification of insulation materials in Armenia and informed customers can demand respective documentation to ensure that the purchased materials indeed will deliver the thermal protection, when applied. UNDP has supported development of a Catalog on Insulation Materials[16] as well as an Advisory Handbook for Insulating Residential Buildings in Armenian language[17].

[16] Catalogue of Insulation Materials available at http://www.nature-ic.am/Content/announcements/7297/Material%20Database%2027%2011%202015%20arm.pdf
[17] Advisory Handbook for Insulation of New and Retrofitted Residential, Public and Industrial Building Envelopes in Armenia available at http://minurban.am/lows/files/dzernark.pdf

Figure 17: Indicative List of Insulation Materials


Expanded (Swelled) Perlyte


Foam Polyurethane


Mineral (Rock) Wool


Expanded Polystyrene (EPS)


Extruded Polystyrene (XPS)


Heat reflecting Shield

Thermal insulation is best when done externally and offers the following benefits:

- Reduces heat loss by up to 45%
- Improves indoor thermal comfort
- Cuts condensation, mold and associated interior damage
- Long term durability
- Essentially maintenance free
- Minimal disruption to the home if done externally
- No reduction to internal floor space
- Can improve the appearance of the property

The thermal performance can also significantly benefit from good landscaping, particularly with deciduous trees. Planting a deciduous tree, if planted on the house's Western side, can save energy by blocking infrared radiation that would warm the house with its foliage in the summer, while in winter the bare branches let this radiation come through opening the way for passive solar heat gains.

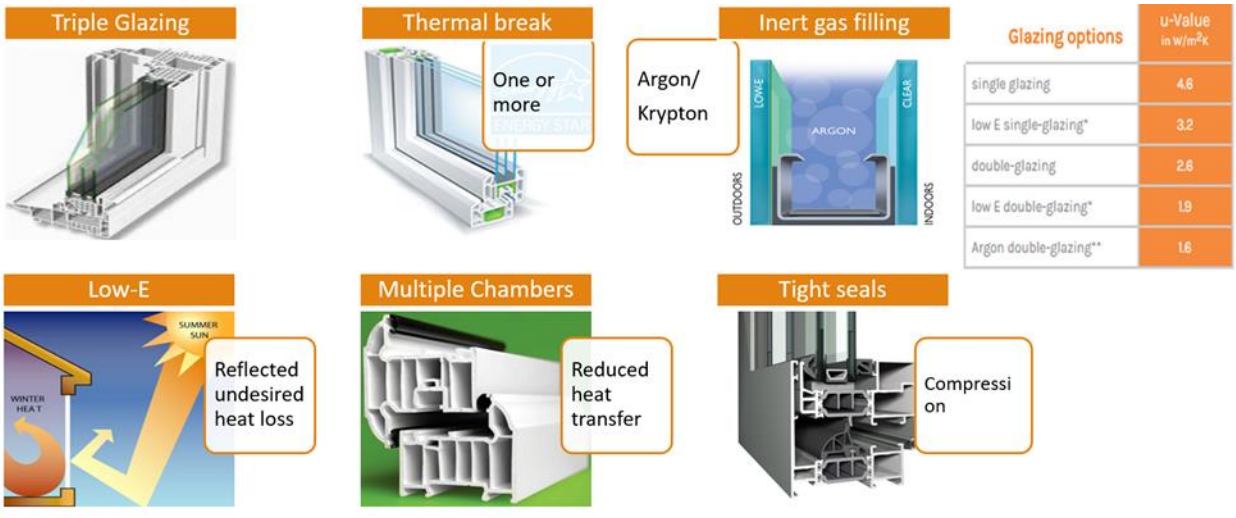
Upgrading or replacing windows

If windows are old and leaky, replacing them with energy-efficient models or to boost their efficiency with weather-stripping and storm windows. It is almost never cost-effective to replace old double-glazed windows just to save energy due to the significant investment necessary: the windows will reduce energy bills, but not save sufficient amount of funds to repay the cost of the window in reasonable timeframe. The larger savings would be associated with replacing single-glazed windows. However, if the time has come to replace aged windows during renovation or for other reasons anyway, in many areas the additional cost of energy efficient windows can be cost-effective—and increase indoor comfort, especially if combined with wall and roof insulation. Unfortunately, there is no lab testing and certification for windows in Armenia, thus customers need to rely on references and opinions about reliability of window suppliers and the quality of windows based on word-of-mouth interactions.

The market offers windows with frames made of plastic (PVC), aluminum, wood or fiberglass. The frames are available with 3 to 7 chambers, with larger number of chambers resulting in higher price due to reduced heat transfer of the frame. Window frames for aluminum windows require thermal breaks, which reduce the heat conductivity through the frame.

Window glass packages are available with double and triple glazing, with varying thicknesses of the glass package. Ticker glass packages with most glazing offer the lowest heat conductivity of the window. These can be further enhanced with inert gas filling of the glass package and low-emissivity (low-E) coating of the glass, which reduce the radiant thermal energy loss through windows. The tightness of windows to air leaks also strongly depends on compression of locks and tightness of rubber caulking.

Figure 18: Energy Efficient Window Features



Replacing an Older Heating Device with a High-efficiency System

Many rural HHs use traditional (not factory-manufactured) heating devices that have low efficiencies of fuel combustion and can also be unsafe in operation. It is recommended to replace firewood stoves or old heating furnaces with condensation boilers with efficiency of at least 90 percent for houses with boilers and hot-water heat distribution (radiators). Understanding that such systems, despite their comfort and efficiency benefits, can be unaffordable for many rural HHs as well as beyond their borrowing capacity, even if loan-funded, for many rural HHs the realistic alternatives are:

- Vented gas heaters: the minimum required efficiency of these devices should be over 80%, while many low-quality and low-cost alternatives available in the market are at 40-50%. For safety considerations, it is also important that the chimneys have a pipe-in-pipe system delivering the outdoor air for combustion, instead of using indoor oxygen.
- High-efficiency firewood stoves and boilers: if firewood is the only alternatives, the same fuel can be used to deliver more heat and hot water in high-efficiency firewood stoves and boilers. A limited number of factory-manufactured, imported models are available in the market with varying efficiencies of 65-70%. The supply is scarce, and the selection is limited due to limited market demand, since most consumers use self-made, low-cost and low-efficiency alternatives. There are locally designed higher efficient wood stoves, which are not in the market due to the higher price compared to the traditional stoves.
- Heat exchanger: the local craftsmen have started to experiment with own upgrades of fuelwood stoves adding heat exchanges and hot water circulation loop. The pilot tested efficiency of such devices is around 60%, however these require thorough lab testing and certification.

Supply-Side Alternatives: RE Applications for Heating and Hot Water Preparation

As Armenia lacks own fossil fuel resources. Russian and Iranian gas is imported and supplied to 97% of country's HHs through a unified distribution system. Wherever natural gas supply is available, it is a recommended fuel source due to diverted demand from forest biomass. Natural gas heaters are also cleaner in operation. However, rural HHs have raised their concerns about the growing natural gas prices, and many of them switched back to firewood as their primary heating option. There are, however, other alternatives in addition to firewood and natural gas.

Utilization of EE in combination with country's significant renewable energy (RE) potential are key to sustainability of Armenia's forests and reduced energy import dependence. In order to facilitate investments in EE and RE solutions, and increase the use of clean, efficient, safe and affordable heating technologies the GoA has joined the donor community to create replicable technical and financial models for enhanced access to RE use. While the country is promoting commercial large-scale, grid-connected RE systems, there is a lot of potential for integrating small-scale, autonomous RE solutions for own use along with EE. Such autonomous RE sources, which can be integrated with EE with on-site, generating RE for own needs, enhancing the efficiency of energy use. These include, for example, solar water heaters used to preheat water for uptake by conventional gas-fired boiler for heating purposes; rooftop solar photovoltaic (PV) electric systems installed for own use, combined with the storage of excess RE-electricity in the electric grid, and further net metering to reduce the electricity bill.[18]

Solar Photovoltaic Electricity

The survey of Armenian RE equipment vendors[19] conducted in June 2015 revealed that there is a notable growth trend in implementation of RE practices in many different sectors of the economy. The current industry data shows that from only 115kW capacity of autonomous solar photovoltaic (PV) systems connected to the grid in 2011, as of January 2019 this number reached 10,000kW, and continues to grow. There are over 30 vendors operating in the market and these systems have a payback period of 9-12 years and are also amply financed by Green loans and leasing products at the local financial institutions. The small-scale, autonomous PV systems for own use can take advantage of the regulatory provision called "net metering". Net metering provides PV customers with opportunity to have a zero charge against their electricity consumption if it is offset by the PV generation; in case they produce and export to the grid more energy than they consume, they will receive the relevant remuneration equivalent to 50% of retail electricity price or, alternatively, will be charged for the excess consumption, if it exceeds the level of PV generation. With the growing energy tariffs, the small-scale solar PV systems hold a large potential to help develop the distributed RE generation.[20] Though, at the moment at individual (rural) HH level solar PV systems are not feasible to tackle the issue of heating.

Solar Thermal Energy

The solar water heaters' market has been evolving rapidly. A vendor survey conducted specifically for purposes of second NEEAP preparation revealed a trend much faster than expected.

The growing energy prices, and the availability of loan financing from green lending programs have jointly lead to an expansion of the SWH capacities of over 4.7 MWh throughout Armenia in various consumer groups, which leads to annual cumulative thermal energy output of over 8,600 MWh per year as of mid-2015. If the growth trend continues, which is highly probable given the increased availability of loans and leasing schemes for SWHs, Armenia may accomplish more than the targets set for 2020 for SWH installed capacity and energy output (at current rate, by 2020 there will be 15 MW installed capacity, which is more than the SREP target by 5MW, similarly the energy output will be 25GWh per year instead of the 13 GWh / year set in the SREP Investment Plan).[21]

In August 2017, with Government support the "Energy Efficient" loan program was launched for the RA non-gasified communities in cooperation between the public-private sectors and financial institutions. The beneficiaries of this continuous project include 38,242 families from 282 non-

[18] Net metering allows residential and commercial customers who generate their own electricity from solar power to sell the electricity they are not using back into the grid. For more information see www.minenergy.am
[19] Conducted by the Alliance to Save Energy in 2015.
[20] The 2004 Law on Energy Saving and RE created the legal provision for net metering. In 2005 the PSRC developed the procedures for parallel operation of autonomous RE producers, which defined the non-commercial relationship of the electric network with the micro-generation facilities with capacity under 150 kW for physical entities, and up to 500kW for legal entities (PSRC Resolution №194, 30.11.2005, amended in 2016).
[21] Scaling up RE Program (SREP) Investment Plan, 2014.

gasified communities who benefitted or are expected to benefit from special financial tools and consume energy more efficiently. As of February 2019, 126 communities have already engaged in the program with 2083 SWHs and 71 PV systems installed.

Geothermal Heat Pumps for Scalable Heating Solutions

Geothermal heat pump technology has been estimated to have significant potential for space heating. The RE Roadmap of Armenia has estimated maximum 75MW capacity for geothermal energy, which can be even more if utilized for supply hot water and heating to nearby locations on a district level. Unlike other countries, there is no applied experience of geothermal heat pumps in Armenia. The second NEEAP proposes development and piloting of geothermal district heating system for the resort town of Jermuk as a pilot to supply heat to municipal, residential and commercial buildings (sanatoriums/spas), utilizing the water from local high-temperature mineral springs. Geothermal heat pumps can also be efficient on individual house level.

Such investments have to be estimated for each particular site and terrain (variable borehole drilling cost), however, under Armenia's general circumstances a pilot project for a typical home is necessary to verify the cost-effectiveness and economic viability of this technology for heating residential and public buildings. There are episodic cases of new expensive housing (e.g. Solar City[22]) real estate or greenhouses[23] with integrated heat pumps, etc. There is a need to publicize the findings and recommend possible scale-up and replication. Geothermal heat pumps for heating can reduce the demand for firewood or imported gas for heating purposes and associated greenhouse gas emissions, utilize indigenous clean and sustainable energy resource. To promote this technology, it is important to pilot this technology, document the results and develop replicable applied solutions which can be used by a large number of home-owners.

Biogas Utilization from Animal Waste

The use of manure as a fuel is a quite widespread practice in the rural areas of Armenia. Technical assistance and financing solutions are necessary for reducing the need to burn dung for heating purposes by promotion of small biogas fermenters. The most known example is at the MAX Group Lusakert Poultry Plant where chicken manure is used in a digester for un-aerobic fermentation and produces biogas for energy. If the practice of burning dung could be discontinued, considerable amounts of nitrogen could be saved and used in crop production. Despite obvious benefits and low cost, manure-to-biogas applications have not spread in Armenia. People have commented on the inconvenience of extra work related to regular loading of the manure into the digester, long idle phases when animals are grazing in the mountains, as well as need for a minimal number of cows for the system to be economically rational (no less than four cows). It is noteworthy, that these issues are not unique to Armenia, and solutions must be sought to help them evolve in Armenia, for example, through bundling cattle, building joint digesters that service several neighbors, etc.

Furthermore, with EU support production of biogas from animal dung for heating purposes was successfully tested for a greenhouse by SHEN agricultural cooperative in Geghamasar, Gegharqunik Marz. The biogas can also be used to produce electricity for own consumption or sale to the grid, as needed. The 1,200 m^2 greenhouse heating would have been used by 25,000 AMD-worth (approx. EUR 50) of firewood per week otherwise.[24]

Renewable Fuels Alternatives from Biomass

It is also noteworthy, that local startups have attempted to enhance the fuelwood value chain by offering biomass waste – based alternatives, such as briquettes or pellets produced based on straw

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[22] www.solarcity.am

[23] See Basen Community Greenhouse project with Air-Water heat pump at http://www.sgp.am/res/Publications/CC/Basen%20solar%20system_results%20analysis.pdf

[24] Source: https://www.euneighbours.eu/hy/east/eu-in-action/stories/ekologiapes-makowr-ev-grete-anvcar-em-i-snorhiv-haykakan-hamaynknere?fbclid=IwAR0s3eNpDMb4pj6ePnmr2ztF148aTTpR2AOuQZM_f9V0yzNixdh04MbOxDk

and wood-waste, coupled with paper/cardboard waste.

The straw, for example, is available in abundant supply throughout the country's agricultural territories. According to the National Statistical Service, the 26,025 hectares of cultivated fields produce a calculated average of 714,175 tons of straw (average for 2015-17).[25] Some of that straw is used for forage, a smaller share is used for its hydroscopic purposes, while majority stays in the fields and gets covered with soil, where it can help enrich the soil fertility. However, in most cases, farmers burn straw in the fields as useless agricultural residue, which damages the soils and causes greenhouse gas emissions.

Some examples of pellets and briquettes produced from straw, other biomass or wood/paper/cardboard waste are summarized below.

Table 5. Selected Examples of Domestic Production of Fuel Alternatives

Product Name	Input Material	Technical features (self reported)	Price	Producer/Location	
Eco Briquettes	Straw	1 ton equivalent to 3.3. m^3 firewood Density: 1050-1300 kg/m^3 ; Ash: 4-7%; Humidity: 6-10% Claimed Calorific Value: 4000-4200 kCal/kg	80,000 AMD/ ton	**Range LLC, Zoravan, Kotayk marz**	
Waste-based Briquettes	Waste cardboard; Wood waste	Humidity: 9-13% Claimed Calorific value: 3500- 4900 kcal/kg	40-48,000 AMD/m3, Note: $1m^3$ = 800 briquettes, 1 briquette (300 gram) = 600 AM	**HOORAK LLC, Yerevan**	
Pellets/briquettes	Straw	Capacity: 200 kg/day	1kg = 50 AMD	**Basen Community, Shirak Marz**[26]	
Briquette	50% straw, 50% waste wood	Claimed to have 1 ton briquette substitute 3 tons of firewood. Hydraulic press capacity = 400 kg/hour	1 ton =70,000AMD, if all produced from wood = 80 000 AMD/ton	**Mets Parni Community, Lori Marz**	

Such grass-root activities and start-ups should be supported by subsidized or grant-funded lab testing and certification, small grants' support for improving production chain and adding business development and marketing to the simple production process, developing expos where these

[25] For more detail, see the findings of a study by Yerevan State Economic University on Bioenergy Potential of Agricultural Waste in Armenia Production of Biofuels available at https://asue.am/am/amberd/publications/analysis/agricultural-production-waste-republic-armenia

[26] Building on the rich experience and knowledge generated by an SGP-funded project on biomass energy use in Basen community, a project "Expanding production of solid bio-fuel and application of energy-efficient stoves in Akhuryan community of Shirak region" plans to introduce biological waste management system (with the capacity of up to 600 kg/hour) in Shirak region through scaling-up bio-fuel production practices, combined with introduction of fuel-efficient stoves in Akhuryan community.

companies could present their products and services, advocating the use of their products and subsidized installation cost (through state, local authority, donor/IFI grants) in one part, provoking the interest of others. Renewable biofuels could also be a good substitute for existing social assistance initiatives by some communities for helping low-income HHs cope with utility affordability.

After the velvet revolution, there is strong political will to enforce the ban on illegal logging. While the enforcement of the wood extraction from forests has indeed improved, the issue of illegal logging is directly linked to the underserved demand for affordable heating fuel. The efforts to fight illegal logging need to be combined with programs that concurrently implement the following:

- Supporting demand-side energy efficiency efforts to reduce fuel demand through:
    - Insulation of homes
    - Upgrading heating devices efficiency
- Offering fuel alternatives to reduce the demand for local fuelwood:
    - Promoting production of local biofuels as described above
    - Imported fuels: biofuels, fuelwood or charcoal
- Raising public awareness and outreach campaigns, to trigger interest among the rural HHs in higher efficiency of energy generation and use.
- Piloting commercial production of (fuel)wood by private or communities with use of native and non-invasive species. Prior to promotion of non-native fast-growing species, the risks to natural ecosystems should be thoroughly assessed.
- Proper fuelwood drying practices must be introduced through outreach, community groups, commercial drying practices, etc.

Imported High Efficiency Biomass Heating Technologies

There are no formal restrictions on import of any equipment, particularly EE technologies into the market. Moreover, if granted a policy priority, a given technology can be added into the list of customs waiver products, which usually refers to RE technologies, and in the past has also been applied to EE technologies.

Given the Eurasian Customs Treaty and the Favorable Trade rules with the EU, there are favorable conditions for the import of EE technologies from Belarus, Kazakhstan, Russian Federation and the EU. Once again, given clear indication that there will be demand backed-up by purchasing power (affordable loan products, leasing, grant co-financing, etc.), all trade routes with Eurasian Economic Union, EU and Iran are open and operational. The only usual limitation is the winter season, when roads become temporarily inaccessible at times, hence the shipping and deliveries need to be planned ahead of time to be available prior to the heating season. These trends have already been observed with first the single-pipe gas heaters, followed by double-contour gas heaters, later followed by gas boilers. Once the demand appeared, the market was flooded with various alternatives of different country origins, prices and classes.

There is a broad spectrum of high-efficiency biomass stoves and boilers on the Armenian market, however vendors comment on the low demand. Many of these are available in the catalogues of appliance stores for pre-ordering, but not many are on display, due to limited demand. The efficiencies of these stoves and boilers varies between 70% and 80%. The appliances offered by the local appliance stores is presented in Annex III.

Local Production of EE Technologies

Since the energy crisis of the 1990s, local craftsmen have been making wood stoves with great success and non-declining sales. While wood heating has been declining until 2015, since 2015 markets reported nearly doubling of wood stove sales. The most basic ones are simply a plain combustion chamber with an exhaust pipe. However, local craftsmen have attempted making both fuelwood stoves and boilers, introducing heat exchangers which raise the efficiency of fuelwood use, producing both heat and hot water, using water-based heat exchange for production of thermal energy instead of the direct wood combustion.

The main barrier is the lack of easily accessible and known laboratories, where these prototypes, which are already being actively sold in the flee-markets across country, could be tested and certified. The customers could then receive adequate information which they could compare with other certified equipment.

Figure 19: Upgraded Firewood Burning Technologies by Local Producers

Given the absence of organized manufacturing of high-efficiency fuelwood stoves, and the presence of skilled professionals even in the most remote villages who can weld metal and make stoves, it can be safely assumed, that if provided with the tested blueprints and provided basic training, such stoves can be produced locally to provide lower cost alternatives, compared to the organized import from abroad.

Table 6. Locally Available High Efficiency Heater Alternatives

Producer/Model	Technology	Fuel	Claimed efficiency, %	Price, AMD	Price, USD
“PYROGEN-20” /ECOGAS (by BARVA)	Boiler	Synthesized gas, produced from dry biomass[27]	~72-90%	250,000	520
“TAVUSH – 80”	Stove	Fuelwood (or biomass alternative)	~70%	86,000	180
	Heat & Hot water supply	Fuelwood (or biomass alternative)	n/a	160,000	400
Local craftsmen hand-made	Boiler: Heat & Hot water supply	Fuelwood (or biomass alternative)	~ 60 % (self-assessed)	120,000	300
Local craftsmen hand-made[28]	Heat exchanger (installed on the pipe with traditional stove)	Firewood (or biomass alternative)	~60%	16,000	35
BARVA[29]	System for generating thermal energy from biomass	Biomass pellets. Note: 3 phase process in technology that crushes biomass, produces pellets, puts them through burner & boiler	n/a	n/a	n/a

To summarize, various technical solutions are available to reduce the demand and manage the supply of rural HH energy. These technical solutions have varying levels of readiness for market penetration depending on their prices, availability throughout the country, effectiveness in mitigating the environmental impacts of energy use (saving energy while saving the environment). The expert assessment of the above parameters is summarized in the below table.

[27] Three modifications of the system are now produced - EcoGas-2, EcoGas-10 and EcoGas-60 generating correspondingly 1.5, 10 and 60 m^3 synthesized gas.
[28]http://www.sgp.am/en/Projects?id=101&fbclid=IwAR01YYrJyURLOysRDm5wZZAcW4NazeZ5E409EAlqZ55sWtBuVCpiVnDmRZI
[29] http://www.barva.am/Shared/Images/Booklets/EN/Thermal%20Energy%20from%20Biomass%202%20EN.jpg

Table 7. Comparison of Market Readiness by Various Technical Solutions for Enhanced Efficiency of Rural Energy Supply and Demand (expert assessment)

Technical Solution	Ranking Market Readiness (1-min; 5 - max) based on:			
	Local Market Availability	Affordability for rural households	Effectiveness (in mitigating env. damage and reducing fossil fuel use)	Total Score
Windows & entrance doors				
Double (or better triple) glazed	5	2	4	**11**
Multiple chambers (the more the better!)	5	3	4	**12**
Thermal Break(s)	2	2	3	**7**
Quality Assurance, Certification & Warranty	1	2	5	**8**
Low emissivity glass package (Low-E)	1	1	3	**5**
Filled with heat resistant (inert) gas	1	1	4	**6**
Insulation of building envelope (walls, roof, attic, doors, ceiling, floor, basement)				
Mineral wool mat/slabs	5	5	5	**15**
Expanded/extruded perlite (slabs, blocks, loose fill)	5	5	4	**14**
XPS - Extruded Polystyrene (blocks, panels)	5	3	5	**13**
EPS - Expanded Polystyrene (blocks, panels)	5	4	4	**13**
Glass foam/wool	5	5	2	**12**
Foam Polyurethane	4	2	5	**11**
Heating source upgrade/replacement				
Heat & Hot Water Gas Boiler (efficiency >90%)	5	2	5	**12**
Gas Heater (>80%)	5	4	4	**13**
High-efficiency firewood stove (>70%)	2	2	4	**8**
Heat Exchanger (60%)	2	5	3	**10**
Fuel Replacement (switching away from firewood to...)				
Natural Gas	4	3	4	**11**
Pellets/Briquettes	2	4	5	**11**
Electricity	5	2	3	**10**
Solar Water Heating	4	2	4	**10**
Solar Photovoltaic	4	1	4	**9**
Geothermal Heat Pumps	1	1	5	**7**

6. Women and Energy in Rural Areas

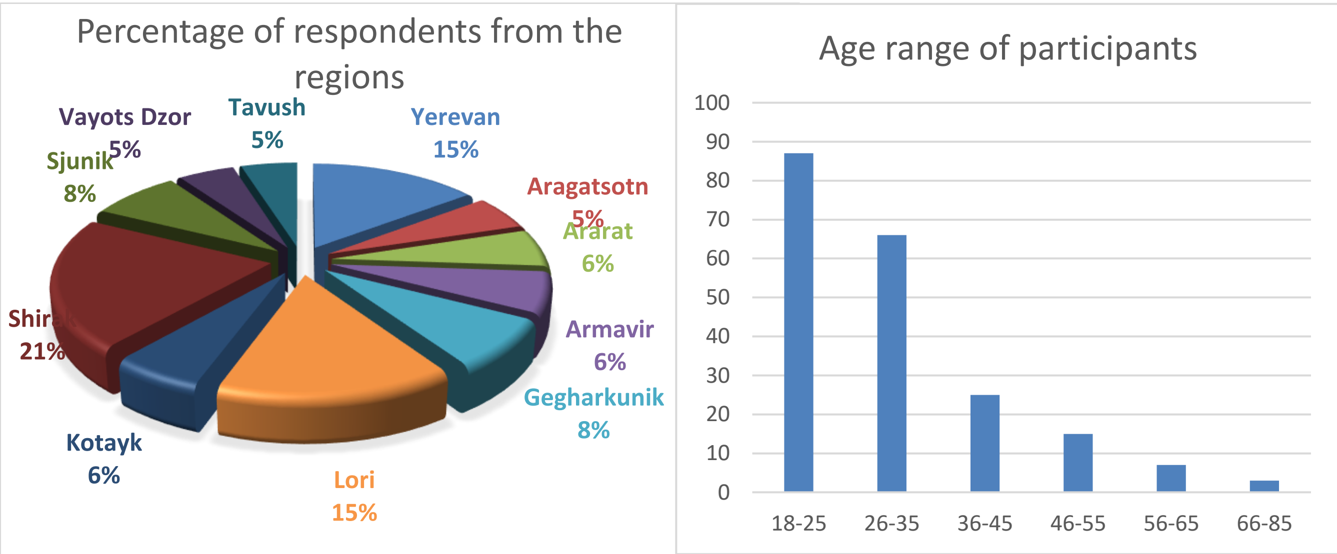
Understanding gender face of energy in rural areas is crucial in solving energy and climate change issues and improving quality of life in rural areas. This chapter summarizes the results of the assessment of rural women's issues and concerns depending on the selected ways for heating system and water heating, also their needs in improving EE of their houses. It also highlights the negative chain effect of underestimation of women's role and poor knowledge of energy issues on the HH prosperity.

The methodology of the assessment included collection and analysis of secondary data through desk-based review of the relevant materials. The review focused on selected documents pertaining current energy related programs and reports, researches, implemented programs and articles from donor agencies, international organizations, NGOs (GCF, ADB, EDRC, UNDP, R2E2 etc.). Data from RA NSS was also used and analyzed, particularly HH's Integrated Living Conditions Survey anonymized micro data database (by HHs, where 7776 HH were studied), 2017.

Complimentary a survey was conducted to analyze energy related issues from a gender perspective, as there was no data on women's concerns regarding energy consumption (heating system, water heating, energy efficiency etc.).

203 HH participated in the online survey. 145 females and 58 males answered to the questions related to their HH energy consumption. Survey included questions related to women's concerns and to general information about used fuelwood, energy efficiency issues, generated income etc. Survey involved HHs from all regions of Armenia, from rural and urban areas. The graph below shows percentage of respondents from respective regions and quantity by age groups.

Figure 20: Survey on energy and women: general data



Respective sources of used information and selected data is mentioned in footnotes.

Profile of Rural Women

Women are usually associated with child care and housework and men are usually seen as responsible for the economic well-being and survival of their family as the main bread winner and "head of HH".[30] This is linked with stereotypical gender roles and has a direct impact on unequal access to resources and economic opportunities. Research[31] shows that rural women spend 6 hours 6 minutes per day, from Monday to Sunday, on their domestic workload, while urban women spend 4 hours and 53 minutes and rural men spend 2 hours and 37 minutes. From the total 2,9 mln

[30] Armenian Association of Women with University Education
[31] Gender, agriculture and rural development in Armenia, Country Gender Assessment Series, FAO, Budapest, 2017

population of Armenia 64% live in urban areas and 36% live in rural areas. In rural areas more than half of population are women (51%).[32] If we calculate “lost” hours per day for all rural women compared with women in urban areas (547670* (6 hours 6 minutes - 4 hours and 53 minutes) the numbers are frightening. This gender imbalance leads to time poverty, to the limitation of women’s capabilities in engaging in gainful activities, and to the economic dependence of women.[33]

In rural communities, 27.2 percent of HHs are female-headed HHs (FHH).[34] The high rate of long-term, male labor migration has increased the prevalence of FHH, since women tend to be regarded as heads of the HHs only in the absence of men. FHHs are more likely to suffer from extreme poverty compared with male-headed HHs (31.5 % and 29.4 % respectively)[35] due to women’s limited economic opportunities, the gender pay gap (average difference between the remuneration for men and women who are working) and, above all, because FHHs tend to be single-parent HHs, with fewer economically active family members who bring in HH income. On an individual basis, the proportion of women suffering from poverty is higher than that of men (54.7% and 45.3%, respectively), which is, inter alia, a reflection of women’s limited economic opportunities in comparison with men.[36] Women also face material barriers to engaging in investment including difficulties in obtaining loans, limited access to monetary funds and property for collateral and burdensome interest rates. According to data of “Energy Efficiency Improvement Project” for non-gasified communities in Armenia only 35% of borrowers are women.[37]

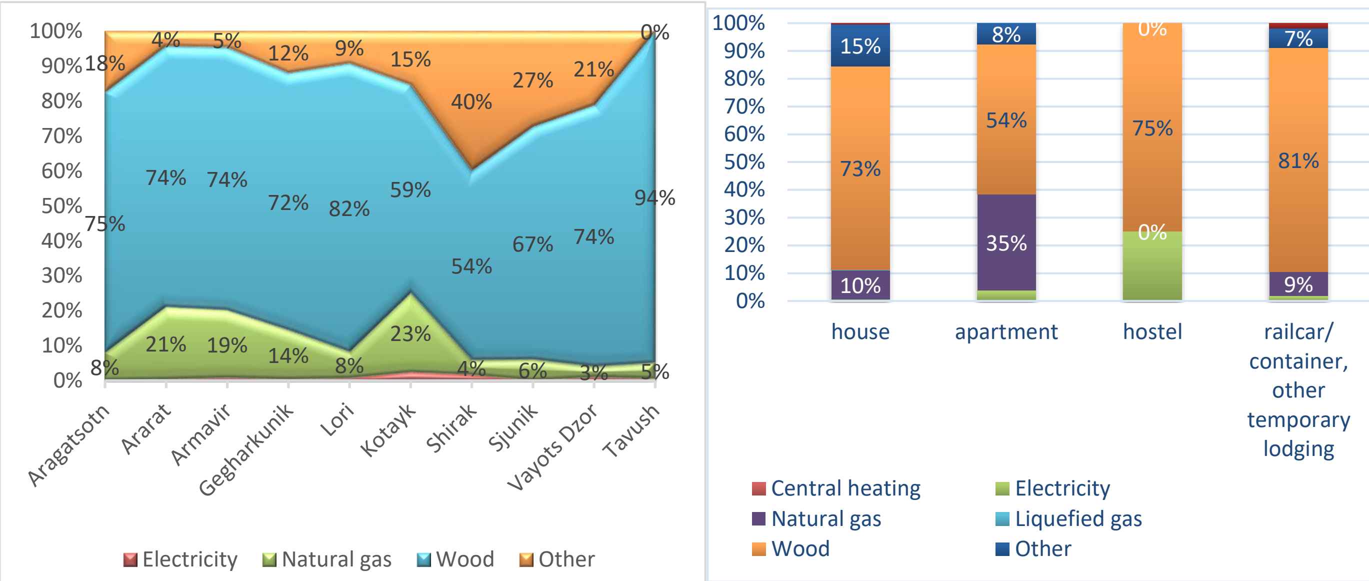
Energy access and used heating systems impact on wellbeing of people, health and safety risk. For women, particularly in rural areas, it may also occupy their time, as food preparation, laundry in the houses, water heating along with childcare and other HH related works are considered women’ work.

Heating

According to the statistics in rural areas 72% of HHs uses wood, 12% uses natural gas, 1% uses electricity and 14% uses other type of energy (the share of biofuel (animal-based) is high among these options). In rural areas 92% of HHs live in individual houses, while 6% live in apartments and 2% in railcars or other temporary lodging.[38] Depending on the type of housing the heating system options are different, but there is no correlation between female and male headed HHs and used energy type as main heating option.

[32] Armstat, 2018
[33] The number of women in rural areas by armstat, updated for 01.01.2018 at www.armstat.am/file/article/gender_2018.pdf
[34] Armstat, 2015
[35] Armstat, 2015
[36] The 2014 UNDP Human Development Index (HDI) score for Armenia was 0.73, ranking it 87th out of 187 countries (UNDP, 2015). The Gender Inequality Index (GII) of that same year was 0.318, with Armenia ranking 62nd out of 155 countries (UNDP, 2015). Another global indicator, the World Economic Forum’s Gender Gap Index (GGI), ranks Armenia at 105 out of 145 countries, and the country’s position has steadily deteriorated since 2007 (World Economic Forum, 2015). The most problematic spheres in the Gender Gap Index are the economy, politics and the health sector.
[37] Data provided by R2E2, 2019.
[38] Household’s Integrated Living Conditions Survey anonymized microdata database (by households), 2017

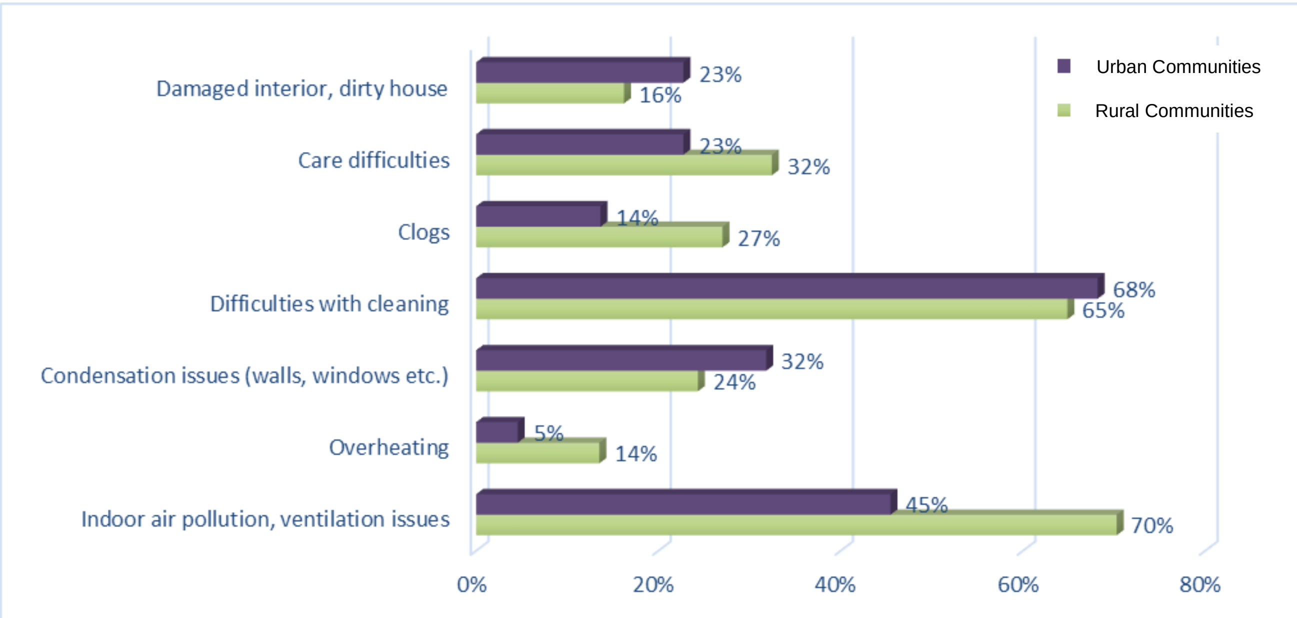
Figure 21: Main Heating Energy Options Used by Rural HHs by Regions *(left)* and by Dwelling Type *(right)*



Source: Household's Integrated Living Conditions Survey anonymised microdata database (by households), 2017

Burning of solid fuels in inefficient stove indoors creates a danger for women and children who spent most of their time next to the stoves breathing polluted air, which according to WHO has the same adverse health impacts as smoking two packs of cigarettes a day.[39] According to the conducted survey, in rural areas 70% of HHs using ovens have problems with indoor air pollution, because of the difficulties with ventilation of smoke.

Figure 22: Issues Related to Wood Heaters Reported by HHs in Urban and Rural Communities in Marzes, %

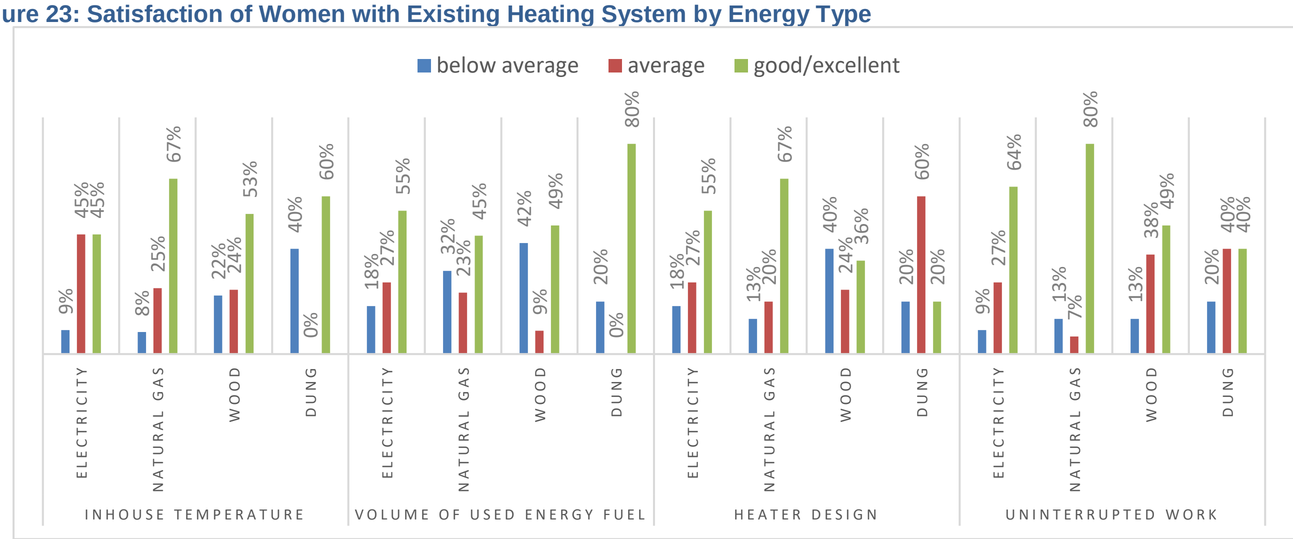


Source: Conducted survey, 2019

According to conducted survey, among women 34% are not satisfied with heating system and 45% are satisfied partially. The chart below shows that women in wood- or dung-using HHs are not satisfied with the inhouse temperature, existing heating systems, amount of used fuel, heaters' design, preparation of dried manure cakes (traditionally done by women).

[39] https://www.who.int/airpollution/publications/fuelforlife.pdf

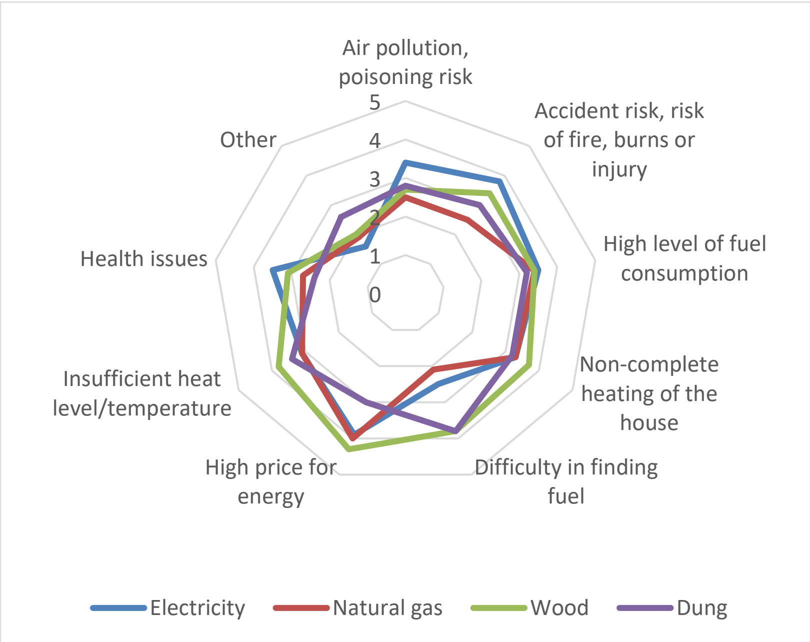
Figure 23: Satisfaction of Women with Existing Heating System by Energy Type



Source: Conducted survey, 2019

The survey showed that for all HHs energy price is highly important and it determines the selection of heating system. Another thing to mention is non-complete heating of the house that decrease the level of comfort for HHs and may cause health issues. It is also obvious that HHs that use wood and dung as main heating option are poor also in time, as they need to deal with almost all the issues related to heating.

Figure 24: Heating issues by women respondents prioritized from 1 to 5 (1 - not important, 5 - very important) by energy type



Source: Conducted survey, 2019

Up to 70% of respondents of the conducted survey use the heating system also for other purposes, like water heating, food preparation and baking, laundry drying etc. A big share goes to water heating, which is about 43%.

Water heating

The option for water heating mostly depends on the choice of primary heating option. In rural areas, during the heating season, 62% of HHs heated water with natural gas, 22% heated with wood, 10% got hot water using electricity.[40]

Table 8. Main energy source for hot water in rural areas, %

	Heating season	Off heating season
Electricity	10.1	16.0
Natural gas	62.1	70.7
Wood	22.3	7.2
Biofuel	4.0	2.5
other	1.5	3.6

Source: Source: EDRC, Residential energy consumption survey, Yerevan, 2015

HH that use wood and animal-based biofuel heat the water on the self-made heaters, which was noted as time consuming. Hot water is used for food preparation, dish washing, laundry and other HH purposes. Worth to mention that in rural areas up to 20%[41] HH's water tap is located outside, which adds additional workload for women and children.[42] This fact has been also highlighted in ADB report (2015), which states that when there is no centralized water supply, women are responsible for fetching water.

33% of surveyed women from rural areas were not satisfied with existing water heating option and 26% noted that it needs to be improved. They mentioned that the existing water heating process is time consuming and they do not get needed temperature, the system is not safe and domestic work such as laundry or dish washing process is long and inefficient. More than 30% of women from regions think that the existing water heating is time consuming and laborious.

Energy Efficiency

In rural HHs 78% use non-manufactured heaters for the primary heating option. In urban areas (excluding Yerevan) 34% of HHs use manufactured gas heaters, 28% use self-made wood stoves and 25% - individual heat boilers.

Table 9. Main equipment used for heating in the regions, %

	Urban areas	Rural areas
Centralized heating	0.6	0
Individual heat boiler	24.6	7.1
Manufactured gas heater	33.5	12.2
Non-manufactured gas heater	1.1	1.1
Gas stove	0.8	0
Non-manufactured stove (wood, biofuel etc.)	27.7	78
Manufactured heater, fan heaters, oil-filled radiator or other heaters	7.9	1.4
Self-made or non-manufactured electric heater	3.9	0.3

Source: EDRC, Residential energy consumption survey, Yerevan, 2015

[40] EDRC, Residential energy consumption survey, Yerevan, 2015

[41] Household's Integrated Living Conditions Survey anonymized microdata database (by households), 2017

[42] An assessment carried out by AVAG Solutions (2014) into access to water supply in 3 cities (Masis, Ashtarak and Echmiatsin) found that women were usually responsible for collecting water, unless the water source was a long distance from home; in such cases men would usually go by car.

All these self-made heaters/stoves run on wood and biofuel. Individual heat boilers, manufactured and non-manufactures gas heaters and stoves use natural gas.

An energy efficient house should be warm, and it should not lose heat. The survey showed that almost all HHs need to renovate their houses (walls, windows, doors, roofs, basement) and only 3% of HHs do not have any issues with EE in their houses.

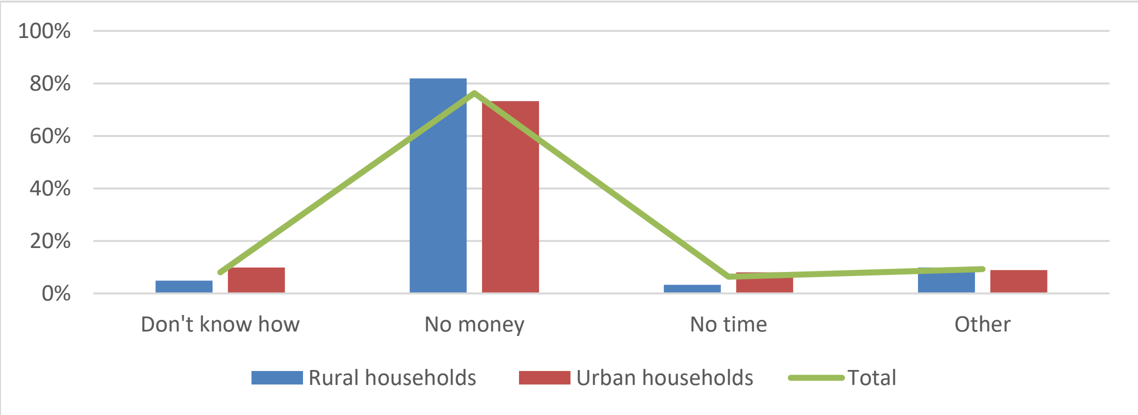
Table 10. Issues related to EE of houses by settlement

	Rural	Urban	Total
It is blowing from old windows	17%	17%	17%
It is blowing from front/main door	13%	14%	14%
Roof is not insulated	24%	18%	20%
Walls are cold and not insulated	19%	21%	20%
The floor is cold (basement is not heated/there is no basement)	24%	24%	24%
No issues	1%	4%	3%
Other	1%	1%	1%

Source: Conducted survey, 2019

76% of HHs noted lack of finance as the main obstacle for solving the efficiency issues as it is shown in the graph below. This also may indicate about lack of knowledge of HHs about the benefits from implementing EE and RE measures.

Figure 25: Survey Feedback on Known Obstacles to Solving the EE Problems



Source: Conducted survey, 2019

Women's concerns

There have not been any comprehensive assessments of women's specific energy needs or concerns,[43] but the conducted survey showed that women in rural areas of Armenia has the following concerns depending on the energy form used in their HHs.

Table 11. Women's concerns related to house and water heating

Energy Form	Women's concerns related to house and water heating
Electricity	- *High price for energy* - *High level of energy consumption* - *Partial heating of the house* - *Accidents risk* - *Water heating is time consuming*

[43] https://www.adb.org/sites/default/files/institutional-document/162152/arm-country-gender-assessment.pdf

	- *Lack of electric appliances*
Natural gas	- *High price for energy* - *Level of energy consumption*
Wood **Dung**	- *Air pollution* - *Physical load (cleaning of heaters, house).* - *Frequently break downs of the heaters* - *Safety issues* - *Time consuming* - *Difficulties in getting wood fuel* - *Insufficient heat level* - *Inefficient laundry and dish washing processes* - *Water heating is time consuming* - *Insufficient temperature of water* - *Need to fetch water*

Source: Conducted survey, 2019

Unfortunately, there is no disaggregated data by gender to report how women benefit from energy improvement projects. But obviously, for rural women, efficient heating systems and solutions for water heating (for instance solar water heating systems) will mean health gains, more free time to participate in productive activities and decreased workload.

7. Energy initiative and financing

Financing schemes for EE/RE technology by IFIs

In practice, main EE improvement was so far at the supply side carried out mainly by international investment into modernization of the power sector, although major inefficiencies still remain in this sector. In the near future, the substantial international support available for implementation of the planned EE and RE activities will remain a major driver. These and many other efforts by IFIs (EBRD, IFC, KfW, USAID, ADB, GGF, AFD) aim at eliminating investment barriers and channeling relatively affordable finance and technical assistance for sustainable energy lending.

The interventions of international donors and financial institutions in Armenia's energy sector has been immense. Many of these programs targeted supply side solutions, but there are also initiatives that have made development assistance and affordable financing to private HHs.

EU projects have brought together KfW, EBRD, GGF and AFD in to offer financial products for private HHs for EE improvement and RE initiatives with below market interest rates or combine commercial lending terms with grant incentives. The commercial loans for home improvement are currently priced at 13-16% annual interest rate, while the green loans, which use softer, IFI funds, are often available at 11-13%. These funds become available from donor and IFI-supported international programs, which later establish on-lending in the local commercial banks and universal/credit institutions. As part of these IFI-funded credit lines, numerous commercial banks have access to credit specifically for EE activities. The key indicators of these credit lines are presented in the table below.

Table 12. Summary of international financing programs that individual HHs are eligible to benefit from

##	Program	IFI/ donor/ partner	Sovereign (SVG) / non-Sovereign (NSVG)	Budget (Mln Euro) *[1]	Sector: Public Buil-ding	Sector: House-hold (HH)	Sector: Mixed (SME & HH)	Time-line
1	Armenia Energy Efficiency Project (EEP) lending, Renewable Resource and Energy Efficiency Fund revolving fund	WB/GEF /GoA	SVG	10.1	10.1			2012-2016
2	EE and Thermal Building Refurbishment Project for Public and Private Buildings (EIB loan, YM co-financing, and E5P grant)	EIB/E5P /UNDP/ GCF/YM	NSVG	16.0	16.0			2016-2019
3	Seismic Safety Improvement Program	ADB/ GoA	SVG	95.0	95.0			2015-2021
4	[Pending] Yerevan Municipality Public Building EE - Phase 2	EIB/NIP	NSVG	15.0	15.0			2019-2023
5	[Pending] Armenia Universities EE-Retrofitting EIB, seeking NIP and UNDP/GCF support	EIB/NIP	NSVG	25.0	25.0			2019-2023
6	Energocredit/ArmSEFF - EE/RE Loans to Households and Businesses	EBRD/E U	SVG-CBA	31.0			31.0	2008-ongoing
7	Household EE loans and EE mortgage loans "Warm Home"	AFD/ NMC/NI F	SVG-CBA	13.7		13.7		2014-2020
8	Specialized re-financing to advance energy EE and RE for Households, Finance in Motion	GGF	NSVG	17.7		17.7		2012 - ongoing
9	Financing for EE (KfW): Housing EE credit line	KfW/NM C	SVG-CBA	20.0		20.0		2016-2020
10	Habitat for Humanity On-lending through UCOs for HH EE/RES	HFH/ UCO	NSCG	2.1		2.1		2015-2020
11	KFW Renewable Energy Financing Credit Line for all types of RES	KFW/ GAF	SVG-CBA	40.0			40.0	2016-2020
	Total			275.5	151.0	53.5	71.0	

*[1]- US $ amounts indicatively recalculated to Euro at the rate of $1.13=Eur 1, valid rated of Nov 2018

Local Financial Market Offering for Sustainable Energy Solutions

The banking sector of Armenia has recorded slow but steady decline in lending interest rates in parallel with the expansion of the green lending portfolio at banks.

The “green” or “energy efficient” loans are generally, on average offered at more favorable conditions.

Key information on Home Renovation Loans available on the Armenian Market is presented in Annex III.

Alternative Sources of Support for EE technologies

Potential Fiscal Incentives: Customs Clearance

The Article 20 of the Energy Saving and RE Law of RA provided for the possibility of adding the energy saving and RE products in the list of “0%” customs clearance. Specifically, the “Transitional Provisions” of the 5th Chapter of the Law stipulated that “...The state administration authorized body in the area of energy saving and RE shall submit proposal to the Government to make required additions to the RoA Customs Code of and RoA Law “On the Approval of List of Products imported by organizations and individual entrepreneurs eligible for zero (0) rate customs duty and excise duty exemption, for which the customs service does not calculate or charge VAT”.[44] Article 16, in turn, defines, that “Energy examination/audit positive conclusion shall be the basis, in the fields defined in the article 3 of the present law, for the provision of privileges defined under the RA tax and customs legislation”. Hence, should relevant technological solutions be adequately examined, and conclusions formed about their features, the GoA can interfere to request their inclusion in the list for 0% rate customs clearance. Note, that there is no active provision in place as of November 2018 for efficient fuelwood stoves, hence such a provision would require regulatory effort.

Potential Fiscal Incentives: VAT Waiver

For activities related to procurement of goods and services through any of the UN organizations, according to the Standard Basic Assistance Agreement (SBAA) signed with the Government, taxes are not applicable. If included in the list, the equipment related to rural energy efficiency, can be exempt from all direct taxes, which entail the payment of VAT amounting to 20% of the turnover of taxable goods and services, which is equal to 16.67% of VAT-inclusive prices.

Local-Government Support for Socially Vulnerable HHs

Traditionally, the wood cut from sanitary cutting of city green spaces is provided to at-risk families, including low-income families, families who have lost or injured members in military conflict, etc. This is a common practice in Yerevan.[45] However, in other communities the municipality may choose to establish a social support initiative with additional procured wood. For example, the municipality of Ejmiadzin procures wood on large scale and distributes to registered socially vulnerable families throughout the heating season. With the growing gas tariffs, as more HHs switched back to fuelwood for heating, the applications for social assistance also increased two-fold.[46]

Such decisions are made and implemented as the Law on Local Self-Government prescribes the social protection function in the residential sector to the local authorities.

On a national level, to support the local (also vulnerable) HHs, the deadwood was sold as fuelwood to forest-adjacent communities at a below-market price of 1200 AMD/cub. m[47]. On 27.10.2011 the

[44] Non-official translation of the Law on ES&RE available at http://parliament.am/legislation.php?sel=show&ID=2119&lang=eng
[45] https://www.aravot.am/2015/12/01/634572/
[46] [46] http://ejmiatsin.am/maiin/619--.html for 2012 and http://ejmiatsin.am/maiin/2897--varelapayt.html for 2015
[47] https://www.a1plus.am/51222.html

GoA made decision to allow free of charge access to deadwood (waiving the nature use fee) targeted to forest adjacent communities (including vulnerable HHs).[48]

EE for Low-Income HHs

The 2017 electricity price increase triggered major social unrest, followed by a promise made by the Government to shoulder the burden of the tariff increase with extra-budgetary sources, while the justifications for a tariff increase are being scrutinized through an audit of the utility. To cope with the proposed tariff increases in the building sector, the second NEEAP proposed an EE program for low-income HHs. To remedy the impact of tariff increases, the Government must offer EE solutions to low-income HHs as opposed to traditional subsidies. The impact of electricity tariff increases on low-income HHs could indeed be mitigated by offering subsidized efficient LED light bulbs to replace incandescent light bulbs in low-income HHs (32% of the population is considered to be living below the poverty line). A measure addressing the need to mitigate the tariff increase via subsidized LED lamps is included in the Financing Section of the NEEAP. The program did not receive Government funding due to lack of resources and was implemented through a crowdfunding campaign "Bright Boarder" supported through ledify.am website. The initiative was supported by major utilities, power companies, NGOs, donor-funded projects, and many individual citizens. Similar programs can be designed and implemented for heat energy consumption. The WB Global Partnership for Output-Based Aid has helped provide 5000 low-income HHs with EE gas heaters in replacement of their baseline inefficient appliances.

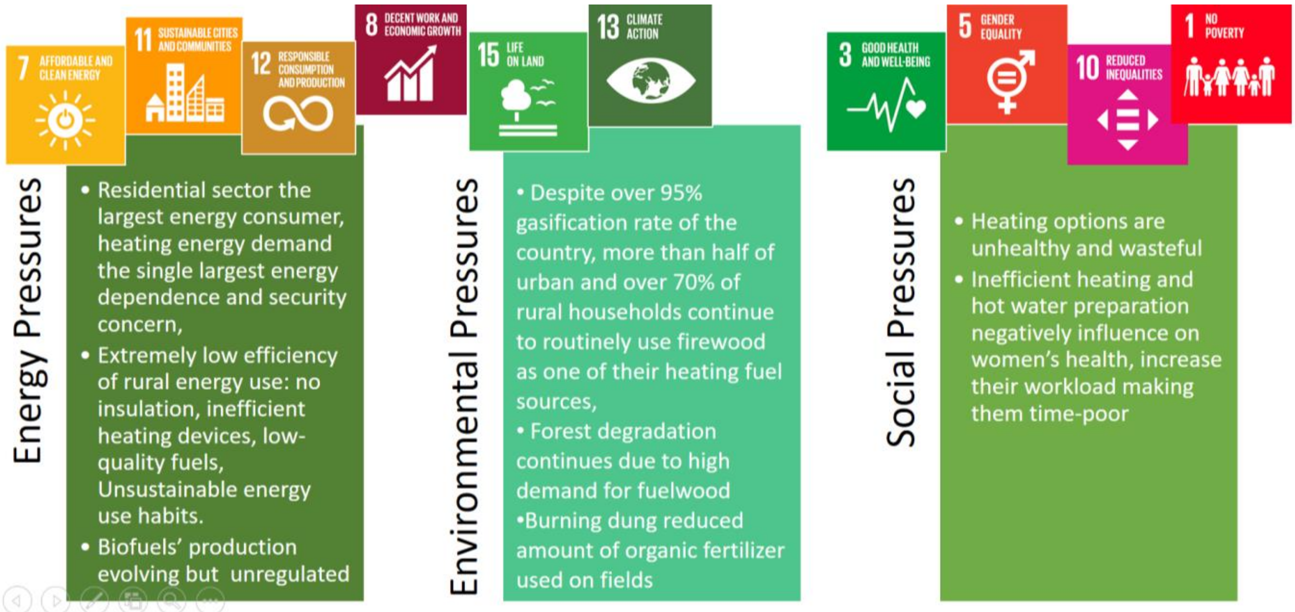
[48] GoA decision N 1553 -N from 27.10. 2011

8. Conclusions and Recommendations

Armenia's energy consumption largely happens in residential heating, creating a major energy dependence and energy security concern, and by global estimates the dependence on traditional biomass (wood, agricultural waste, animal dung, etc.) for cooking and heating will remain high during the coming decades. Given the regional energy geopolitics, the prices for natural gas and electricity are not likely to reduce in the coming years, if not the opposite.

Years of energy crisis have left Armenia with devastating rates of deforestation. When the energy crisis ended, gradually over 95% of country's energy consumers were connected to natural gas network. Nonetheless, this reduced the pressure on forests only temporarily. Due to the doubling of the gas prices over the past fifteen years more than half of urban and over 70% of rural HHs now routinely use fuelwood as one of their heating fuel sources. To make things worse, the often unsustainably harvested wood is used in inefficient heating and hot water preparation equipment. The used combustion technologies negatively influence on women's health, increase their workload making them time-poor.

Figure 26: Conclusions on Key Energy, Environmental and Social Pressures Related to Rural Energy Use in Armenia (linked to SDG goals)



The forest degradation continues to remain an issue throughout Armenia due to persistent forest felling for fuelwood supply, with baseline data on forests still sporadic, inconsistent and insufficient for adequate decision-making. The forest conservation and management policies often lack reliable data, as well as institutional capacities to adequately enforce adopted policies and plans. The national and local authorities need enhanced capacities to manage forests sustainably and cultivate sustainable fuelwood marketing strategies.

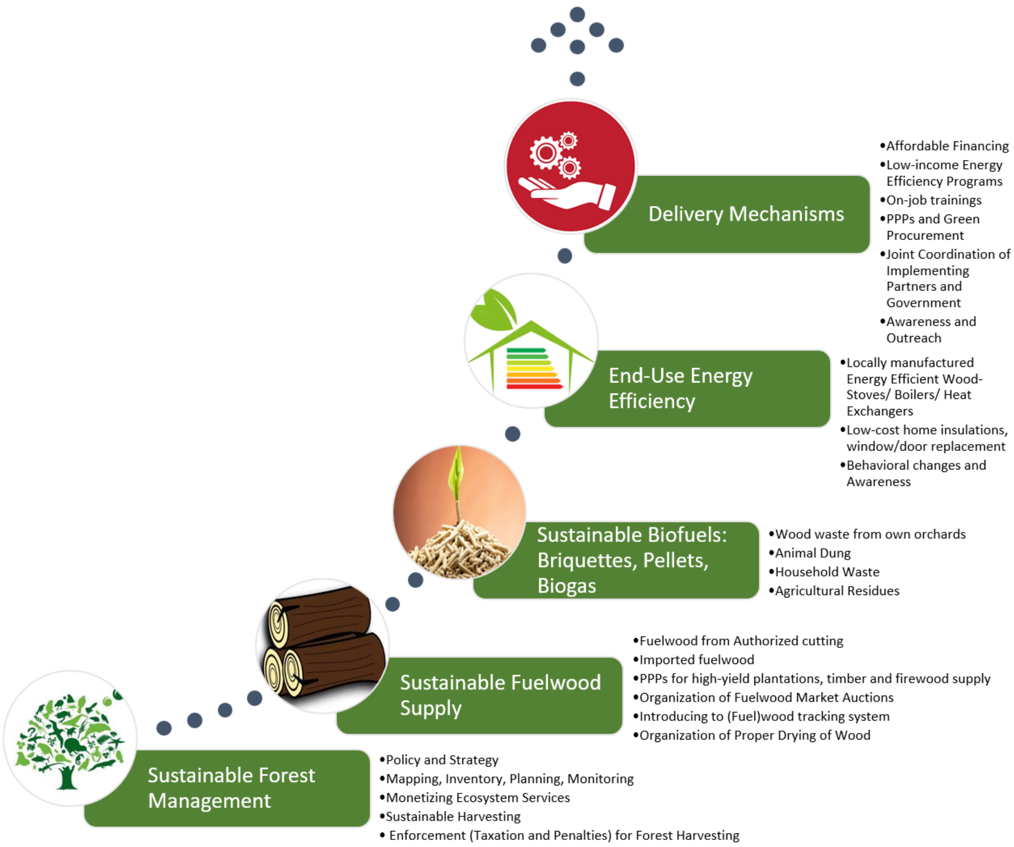
Legally or illegally, when wood arrives at the HHs, the efficiency of energy use in housing sector is extremely low: building envelope are no insulated, heating devices are inefficient (regardless of the fuel), burned fuelwood often has high moisture content, the whole fuel combustion process is inefficient due to the poor quality of fuel and low efficiency of the heating device. Overall, energy use habits are not sustainable either – in addition to fuelwood burning in old-fashioned stoves, rural inhabitants often burn dried animal dung, household waste, rubber, broken furniture, etc. Consequently, the used heating options are not only environmentally unsustainable, but unhealthy and wasteful. Here as well – there is no regular HH energy use survey data that would be generated with the uniform methodology for a long timeframe and into foreseeable future, addressing utility affordability, gender-disaggregated energy consumption and energy poverty data, social and vulnerability data. Decision-making related to low-income, gender-focused, energy vulnerabilities of rural HHs is constrained with the limited data and capacities of state and national authorities.

The solution of the multitude of problems related to deforestation, ecosystem damage, fuel poverty, energy waste, unhealthy fuel use, women's empowerment and others can only be done in a holistic approach tackling all areas from policies to finance.

As the figure below illustrates, the situation can only be improved if efforts equally focus on:

- Sustainable Forest Management
- Sustainable Fuelwood Use
- Availability of Sustainable Biofuels: Briquettes, Pellets, Biogas
- Promotion of End-Use Energy Efficiency
- Provision of Adequate Delivery Mechanisms

Figure 27: Approach to Tackling Deforestation, Energy Waste and Low Utility Affordability in Rural HHs of Armenia



More specifically, the necessary interventions proposed include the following:

Strengthen and Applying Strategies, Policies and Standards

- Identify and recommend policy and regulatory changes in the following directions:
  - Long-term forest strategy and policy on sustainable forest management, forest management planning and implementation.
  - Establishing a platform for generating an active dialogue and intersectoral cooperation on issues of forestry, energy, economy, etc., including representatives from the state actors and other players (CSOs/NGOs, private companies, education institutions, donors, local authorities etc.),

    - Creating incentives for sustainable harvesting of fuelwood, use of dry wood, commercial timber production.
    - Promotion of and standardization of local production of energy efficient heating (and hot water preparation) devices.
    - Ensuring participation of rural women to the discussions on their engagement in community life and local development plans by ensuring their access to the services (transportation, babysitting service, etc.).
    - Support for economic policy measures (differentiated taxes and charges) and enhanced enforcement for forest harvesting and fuelwood sales practices.
    - Better spearheading of system of ecosystem damages and sanctions, stronger enforcement.
    - Rewarding sustainable forest management and private forest development activities through tax incentives (e.g. land tax, irrigation water pricing/permitting).
    - Tax/fiscal incentives for production of sustainable fuel alternatives (e.g. biofuels), promotion through green public procurement practices.
    - Proper planning of rural communities to introduce eco-village, sustainable community. circular economy and green business principles into the ideology of community development.
    - Lab testing and certification and publicizing the features of locally produced biofuels and high-efficiency boilers and stoves.

  These regulatory tools can include legal provisions, fiscal incentives, laboratory testing and certification of equipment, development of exemplary designs (e.g. high-efficiency heater, insulation of a rural single-family house);
- Considering the dedication local governments have illustrated to this function – through fuelwood subsidies, cash support for utility bill support from municipal social funds, and alike – cultivate partnerships with the local authorities in supporting the improved efficiency of energy end-use in rural HHs, seek to co-financing the EE-retrofits, partially subsidize the cost of EE fuelwood stove purchases, adopt green procurement policies by supplying sustainable biomass fuels (briquettes and pellets) to the officially registered low-income HHs.

Data Support

- Assessment of forest resources, baseline analysis of forest data and evolution trends, regular monitoring and accountability on forest condition, enforce grassroot, citizen-driven alerting tools for forest monitoring, information management.
- Baseline data on HH energy use, utility affordability, social and gender issues.
- Development of an inventory and online data exchange on secondary raw materials as biowaste, agri-waste, other solid or liquid waste that can be used as fuel.
- Collect baseline gender-disaggregated data pertaining to energy on national level, do researches on women’s specific energy concerns, needs and benefits from energy projects in Armenia to be used by politicians and decision-makers to address these issues in elaborating respective policies and projects.

Enhancing Fuelwood Value Chain through Training and Capacity Building

- Targeted support is necessary for various stakeholder groups, acting as links in the entire value chain, specifically:
    - Organization of user-groups for optimisation of plantation, logging, harvesting and marketing practices, biofuel preparation (dry wood, manure, etc.).;
    - Optimisation of logging technology.
    - Energy plantations: fast-growing species with 5-8 year rotations, including through PPPs with the local authorities, potentially on eroded lands for re-cultivation purposes and with necessary precautions of invasive species.
    - Achieving high-quality fuels (dry wood, manure, etc.).

    - Promoting imports of sustainable and affordable fuel alternatives, reducing tax liabilities.
    - Streamlining of logging and transport to sustainable, centralized, transparent fuelwood markets, banning unauthorized sale of firewood.
    - Harmonizing harvesting with reliable resource assessment based on reliable data and forecasting.
    - Secondary vocational education, training for EE specialists, insulation workers, welders to allow local on-job trainings and creation of cadre of professionals who can locally offer low-cost home insulations, locally manufactured high-efficiency heating devices, forestry services, etc.
    - Building EE stove/boiler production skills though offering of high-quality design documentation, blueprints and instruction manuals for easy manufacturing.
- Organized marketing of fuelwood supplies:
    - Marketplace: establishment of formalized local sustainable biofuel markets, competitive bidding and auctioning practices.
    - Supply chain: promotion of fuelwood production based on PPP principles for legal harvesting purposes, including for fast growing species, with necessary precautions of invasive species.
    - Proof of origin: introduction and enforcement of a proof of origin for all forms of sold solid fuels, both for local and imported fuels.
    - Quality assurance: standardization and improved product quality both for fuels and heaters though development and enforcement of necessary national standards, user-friendly instruction manuals for application and compliance with these standards.
    - Profit sharing: more equitable benefit sharing of ecosystem services, including carbon sequestration and forest existence values, biodiversity conservation, etc.
- Designing sustainable forest management and sustainable fuel production projects:
    - Promotion of forest conservation, reforestation, agro-forestry and tree nurseries on community level.
    - Organization of farmer committees to jointly lobby and collectively organize around production of sustainable fuels, including from agriwaste (briquettes, pellets, biogas).
    - Business approach and technical support to communities (private) to introduce international best practices of profitable forest management with consideration of principles of sustainability and conservation.
    - Provision of financial incentives to farmer committees for development of local sustainable models of clean and safe fuel supply or local fuel generation.
    - Initiating PPP projects in joint design, establishment, nursing and development of managed forestry, alternative fuel production.
    - Better integrating livestock into the circular bio-economy to be achieved by increasing the share of by-products or waste into the livestock feed ration or by recycling and recovering nutrients and energy from animal waste (e.g. biogas production, production of briquettes and pellets).
    - Ensuring sustainable jobs and disseminating new technologies of energy efficiency and renewable energy in rural communities, creating databases of service vendors, promotion and outreach to ensure better utilization of these services.

Demonstration Projects

- Test and demonstrate working models of improved rural energy use that is safe, sustainable, affordable and economically viable;
- Design and implement pilot projects in the below listed areas as well as assess previously implemented pilot projects (by different organizations) in terms of replicability, which should include affordability:
    - Application of geothermal heat pump for stand-alone house heating.
    - Application of biogas digester for home-heating based on animal manure.
    - Establishing community-level pellet/briquette production facilities where villagers can bring their own raw materials for on-site biofuel production.

- Training and implementation of do-it-yourself home insulation festivals, monitor the results and publicize the results.

- Supporting the commercialization and marketing of local producers of market-ready EE and biofuel solutions,
- Development of typical models, blueprints and building instructions for EE stoves, boilers and training for local skilled workers,
- Partner with organizations with mutual interests and goals in implementing demonstration projects that can be scaled-up nation-wide,
- Identification of solutions for most high-risk and high-impact parts of Armenia such as forest-adjacent communities, forest-rich regions, coldest climate regions, highest concentration of low-income households, areas with agriwaste acceptable for biofuel production, and combination of the above. Develop solutions tailored to the needs of those sensitive communities such as:
    - Forest adjacent / forest-rich communities: high efficiency heaters, home insulation, commercial forestry, etc.
    - Cold regions without forest: home insulation, biogas production, high-efficiency heaters, etc.
    - Socially vulnerable communities: subsidized financing schemes, on-job trainings, subsidized biofuel supply chains, etc.
- Produce set of case studies from data collection and implemented energy projects on how women benefit from energy improvement projects in rural areas.

Financing Products

- Work with the international and local financial institutions (AFD, EBRD, KfW, HFHA) to develop customized financing tools for low-income rural HHs which will eliminate the need for upfront capital investments and deliver EE solutions (equipment and works) for rural HHs with third-party financing, also with special focus on female-led HHs. For example, private companies can enroll commercial financing to deliver energy efficiency services to rural households, while the payment will be deferred and extended to a bank on factoring basis.
- Work with local authorities to design targeted social assistance campaigns, which deliver low-income EE solutions (instead of cash subsidies, free fuelwood assistance, etc.). Many countries have successfully implemented publicly co-funded energy efficiency improvement measures in low-income family homes as a means to help them improve energy utility affordability.
- Develop interest-free or subsidized loans for energy efficiency upgrades in low-income and female-headed rural households.
- Development of guarantee tools for providing flexible financing for third parties who can step in as intermediaries between rural HHs and banks to deliver energy efficiency solutions, while eliminating the need for up-front capital investments from rural borrowers (which may already be fully indebted). These could include factoring contracts, whereby the private company vends the retrofitting service, gets paid by the bank, while the rural HH becomes the responsible party for repayment of the investment to the bank.

Information and Outreach

- Develop a one-stop-shop web portal for all information related to efficient and sustainable home energy supply and demand management, insulation and weatherization techniques, heating and window systems, biofuels, etc. all with supplier information and full technical features.
- Development and implementation of a public outreach campaign (targeting local government, residents, businesses, farmers, etc.) elucidating the issues of:
    - Excessive use of fuelwood and use of dung (deforestation threats, lost ecosystem services, wood moisture, air quality, less nutrients in the field, etc.)

- Efficiency of energy end-use (stove inefficiency, building energy use, opportunities offered by EE solutions in heaters, windows, wall and roof insulation, etc.)
- Consider a mobile educational facility, such as Ann “Energy Bus”, which would be equipped with all necessary demonstration equipment on home energy efficiency to tour around the country and deliver information and showcase energy efficiency.

- Development of special capacity building program for women, local CSOs, media representatives addressing issues of sustainability of HH energy-use (fuel selection, health concerns, efficiency of heating devices, etc.), do-it-yourself (DIY) EE solutions, educational tips on “how to raise a smart energy user”, etc.
- Development of community of practice around the sustainable energy challenges focused on rural households and natural resources.
- Provide support to the rural HHs by initiating “Help Center” or “Energy hot line” to facilitate decision making in households and communities (including by women).
- Development of hands-on EE retrofitting training for local craftsmen for creation of locally available professional workforce for insulation of rural homes. These could be organized in cooperation with well-established construction companies, solar energy system vendors, etc.
- Partner with other organizations in advocacy campaigns for reduction of social resistance to gender equality and establishing more positive profile of rural women.

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10. Annexes

Annex I. Calculation of EE improvement packages for a typical single-family house dwelling

For comparative analysis of technical interventions, the following financial scheme was considered both for basic and comprehensive improvement measures:

- Loan tenor: 5 years
- Loan Grace period: 0 years
- Interest rate: 13% per annum (nominal)
- Bank Administration Fee: 3.0% per loan
- Maintenance: 0.0%per year

The analysis also incorporates an expected change in energy prices (based on past trends), specifically:

- Annual price escalation of gas prices 10% yearly
- Annual price escalation of electricity prices 7% yearly

The economic parameters for EE investments in the Armenian economic can be summarized by the following key features:

Average lifetime of EE measures, years	18.00
Nominal interest rate	13.00%
Inflation	4%
Real interest rate	15.18%
Annuity factor	0.138
Discount rate	11.00%
Average heating degree-days in Armenia[49]	3779

The technical and economic parameters of reviewed EE improvement packages for a typical single-family house dwelling is described below.

Scenario 1: Basic refurbishment of a family house including

1. Replacement of windows and entrance door;
2. Thermal insulation of the roof with expanded perlite blankets:
3. High efficiency biomass boiler ≥75% with space heating installation, heaters, thermostat control. [the market offers such alternatives]

Total cost of estimated capital investments for EE measures is $ 4,956.64.
Annual thermal energy amount required for heating purposes after the EE measures are implemented will be 22743.7 kWh (~26% reduction from status quo), level of energy use per sqm 154.7 kWh/m^2.
Project lifetime is 18 years.
Such an investment will deliver the following economic features:

IRR without financial costs	15.5%
Project payback (years)	5

Summarizing this option, it is obvious that the project is cost-efficient and will be paid back in 5 years by ensuring net profit during the whole continued duration of the project of up to $7,042.21.

Scenario 2: Comprehensive refurbishment of a family house including

1. Replacement of windows and entrance door: with total investment cost of $3,006.64
2. Roof insulation: with total investment cost of $ 1,300.00
3. High efficiency biomass stove ≥75% with space heating installation, heaters, thermostat control with total investment cost of $1250

[49] Provided by the Construction Climatology code

4. Solar thermal thermosyphon set, cost of $1,000.00/m^2$

The total size of capital investments for EE improvement is $ 8,197.64 Annual thermal energy amount required for heating purposes after the EE measures are implemented will be 17,701.5 kWh (~42% reduction from status quo), level of energy use per sqm 120 kWh/m^2.

Table. Thermal characteristics of building envelope before and after EE measures

	Before EE measures		**After EE measures**	
	Thermal Resistance (R-value*), m^2 K/W	Thermal Conductivity (U-value*), W/m^2 K	Thermal Resistance (R-value*), m^2 K / W	Thermal Conductivity (U-value*), W/m^2 K
Walls	1,32	0,76	3,01	0,33
Windows	0,3	3.3	0,55	1,82
Roof / attic	0,86	1,16	5	0,2

* - “R-value” is the thermal resistance of building envelope elements, “U-value” is the thermal conductivity.

Such an investment will deliver the following economic features:

- Internal Rate of Return (IRR) 19.2%
- Project payback (years) 6

If based on real, sub-comfort heating data, the above investments will have substantially less attractive metrics, and will require significant grant co-financing to allow them breaking even.

Annex II. High Efficiency Biomass Stoves Available in the Armenian Market

Producer country	Brand	Model	Nominal heat output, kW	Efficiency, %	Price (thousand AMD)	Price (EUR)
Russian Federation`	Zota	"Topol"-M 14	14	75	303	544
		"Topol"-M 20	20	75	334	600
		"Topol"-M 30	30	75	383	688
		MASTER	20	73	299	537
		MASTER	32	73	350	628
		MASTER	12	73	265	476
		MASTER	25	73	395	709
		"Dymok"	12	70	n/a	n/a
		"Dymok"	20	70	222	399
		"Dymok"	18	70	n/a	n/a
		Carbon	15	80	n/a	n/a
		Carbon	20	80	n/a	n/a
		Carbon	26	80	n/a	n/a
		Carbon	60	80	n/a	n/a
		Carbon	40	80	n/a	n/a
		Carbon	50	80	n/a	n/a
	Lemaks	Forward	16	77	n/a	n/a
		Forward	12.5	77	n/a	n/a
South Korea	Kiturami	KF	N/A	N/A	n/a	n/a
Germany	Budaro	Logano S111	16	N/A	n/a	n/a

Source: Market survey in shops of Yerevan

Fuelwood Heater (Luxury Model)
Price: 1 000 000 AMD
Efficiency: 80,4%
Dimensions (L-H-P): 526x1267x505 mm
Net weight: 176 kg
Hourly consumption: 2 kg/h
Smoke outlet diameter: 150 mm Sup

Kitchen Wood Burner
Efficiency: 76 %
Dimensions (L-H-P): 1280x860x660 mm
Net weight: 321 kg
Hourly consumption: 3,5 kg/h
Smoke outlet diameter: 160 mm s/p

Fuelwood-Combustion Boilers
Fuelwood Boiler KALVIS 5-20
Price: 240 000 AMD
Efficiency: 78 %
Nominal Capacity: 20 kW
Heat Regulation System: RT3
Heated Space: 120 - 280 m2
Water Volume in Boiler: 100 l
Maximal length of logs:350 mm
Maximum Pulling Capacity of Chimney:18 Pa

Annex III. Detailed information on available products and eligibility criteria for EE and home renovation loans in selected banks

Bank	
EBRD Energocredit/ GEFF	EBRD Energocredit offers loans to owners of apartments and houses. The loan can be used to buy and install EE boilers and heaters, windows, insulate roofs and walls, install air-conditioning systems etc. EBRD Energocredit pre-selects high-quality materials and equipment. Each Energocredit loan for individuals comes with an Incentive Payment. Once a borrower has drawn a loan and installed EE equipment, they may apply for an incentive amounting to 10 % cash back of the Energocredit loan value. The use of the Incentive Payment will be verified by a team of experts through on-site inspection carried out randomly on selected equipment. Among Partner Banks, currently ACBA Bank, Ameria and SEF International specialize in issuing residential loans. There are 2 types of loans: • Point of Sale (PoS) loans obtained for a selected equipment at the supplier's premises or store. The loan agreement is between the borrower and the Bank even if the agreement is signed in the store. • Residential EE loans: These loans are provided in the branches of banks directly. Eligibility criteria for heating equipment includes Natural Gas Boilers (90%+ efficiency or condensing boilers), Solar Heaters, Heat pumps, Auxiliary systems for boilers, Biomass Boilers.
ACBA Leasing	**ACBA Leasing** allows financing residential/household loans for solar PV and water heating equipment. Terms and conditions include:[50] • Currency: AMD, • Down payment: 20% - 70% calculated out of the property, • Annual Interest Rate: 13% - 24%, • Maturity period: 3 - 84 months, • Lump Sum Commission Payment: 1% out of the contract value, • Annual Compulsory Insurance: 0.3% (min. AMD 5000) - 0.8% (for the first year - toward the property whole value, whilst upon each year end - toward the lease amount residue), • One or two guarantors (without any reference on income), • Repayments are completed monthly in equal amounts. ACBA Leasing's "Green Leasing" Product offers customers resource-efficient equipment and machinery. The terms are as follows: • Annually starting from 8% for Currency AMD • Annually starting from 5,35% - Currency /USD, EUR/ ACBA Leasing also has eligibility criteria for businesses who become vendors under their EE/green leasing products. These include: • A minimum of 6 months of working experience in the field • Warranty and post-warranty service (for RE technologies no less than for 5 years) • Be either a producer, distribution or dealer in RA, • Registered VAT payer • Not be registered for origin of business in the Islamic Republic of Iran • Minimum 1-year depreciation period or financing terms.

	Option 1	*Option 2*	*Option 3*	*Option 4*
Ameria Bank 24% interest rate 6-60 months	8 x documented income	monthly income <400,000AMD; 50% Regions: ≥ AMD 36,000	monthly income is 400,000- 800,000 AMD 55% Regions: ≥ AMD 60,000	income >800,000 AMD 60% Regions: ≥ AMD 90,000
HSBC Bank 11% interest rate (mortgage lending)	Hold account with Bank and at least 3 months employment record with Bank client employer. with a company, and	Hold account with Bank and at least 3 months employment with other Bank client employer and	Hold account with any bank with at least 6 months employment history and salary being transferred	Non-salaried account holders: Have satisfactory account record and banking relationship for min 6 months and more, and the

[50] http://www.acbaleasing.am/en/leasing/individuals/other.html

	your net monthly salary is at least AMD 200,000	your net monthly salary is at least AMD 200,000.	to HSBC account for 6 months, and net monthly salary is at least AMD 250,000	last 6 months average monthly balance and average balance of the last month have been at least AMD 200,000 (or equivalent in other currency)
Byblos Bank	To be middle to upper income salaried individual or self - employed such as small/medium merchant and industrialist. To have a working experience of at least 6 months with a reputable company or Governmental institution and a total 2-year experience in the same business field. To have a minimum monthly net income of AMD 200,000 for single and AMD 300,000 for married. The ratio of the loan repayment to the net available income shall not exceed 35% and the ratio of the loan repayment plus all other regular debt repayments to the available income shall not exceed 45%. To have a good credit history.			
Ararat Bank	Ararat Bank, under Green for Growth Fund – Finance in Motion, offers Green loans at 11-14% interest rate within the framework of the project “EE for SMEs” (GGF) except for HHs engaged in the primary agriculture (cultivation of agricultural products and cattle breeding). Working through local banks, GGF supports the development of an EE lending product within the institution (ACBA bank, ACBA Leasing, INECO, Ararat Bank), enabling HHs in Armenia to reduce energy costs, consumption and CO2 emissions.[51]			
NMC/Warm Home credits	Unsecured loans for home EE retrofits with third party guarantee letter, combined with bank’s internal credit evaluation procedures. AFD “Warm Home” Loan program is working through the NMC.[52] This loan product is designed for EE improvement of an apartment or a house. The product is available in 21 commercial banks and credit institutions. Minimum 40% of the loan amount should be used for EE improvements, replacement or purchase of home appliances. In addition, the amount spent on home appliances cannot exceed 15% of the overall EE improvement expenses.			

AFD “Warm Home” Loan program is working through the NMC. This loan product is designed for EE improvement of an apartment or a house. The product is available in 21 commercial banks and credit institutions. Minimum 40% of the loan amount should be used for EE improvements, replacement or purchase of home appliances. In addition, the amount spent on home appliances cannot exceed 15% of the overall EE improvement expenses.
EE improvements include:

- replacement of windows and main entrance door,
- installation or replacement of heating system,
- isolation of outer walls, roof and floor,
- installation of solar water heaters and solar PV panels, and
- purchase or replacement of home appliances.

Home appliances, which can be purchased or replaced within this loan product should have high EE and have EE class of at least A+. The list includes refrigerator, washing machine (including dish-washer), heating boiler and air-conditioning system, and LED bulbs.

The minimum requirements for EE eligibility regarding materials, equipment and home appliances are presented in the refinancing act on “Housing financing, 4th phase”.

EE renovation loans' terms

Amount: from AMD 5 mln up to AMD 25 mln
Maturity: minimum 5 years
Interest rate: Defined by PFI (around 10%-13% annually)
Pledge: the real estate to be renovated

[51] https://www.ggf.lu/project-portfolio/investments/armenia/
[52] http://www.nmc.am/en/1479303615

Table. Lending Terms under “Micro” and “EE” loan products of the AFD/NMC “Warm Home” program

Category	“Micro” Loan Requirements	“EE” Loan Requirements
Client Type:	private individual	private individual
Purpose:	housing renovation investment	housing renovation investment
Loan Size:	275,000-2,200,000 AMD	2,200,001 –5,500,000 AMD
Interest:	NMC refinancing rate + maximum 6% margin	NMC refinancing rate + maximum 3% margin
Maturity:	at least 5 years	at least 10 years
Grace Period:	6 months-1 year	6 months-2 years
Collateral:	third party personal guarantee, no mortgage!	mortgage
Grant*	10% of the loan amount	5% of the loan
Other Conditions:	At least 50% of the loan must be invested in EE equipment.	At least 70% of the loan must be invested in EE equipment (loan requirement). At least 40% energy saving should be achieved. Is granted: after 1) completion of investments based on the approved budget of the loan 2) effective investment audit. Grant will reduce the principal amount of the loan

*The Loans are accompanied with a grant component. Investment should be done after loan agreement and grant applications were signed. Each expenditure needs to be justified by invoice and proof of payment and/or other evidences (photos etc.). Photos are obligatory.

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