TECHNOLOGY NEEDS ASSESSMENT AND TECHNOLOGY ACTION PLANS FOR CLIMATE CHANGE MITIGATION

GEORGIA

Supported by

Tbilisi–September 2012

PREFACE

On 2 July 2010 the Government of Georgia adopted governmental program “UNITED GEORGIA WITHOUT POVERTY”. The program lists short-term priorities of the Government which should be fulfilled for reaching the devoted objective of the Government of Georgia “United Georgia without Poverty”. Among these short-term priorities are: development of infrastructure (energy, road and water supply), village development towards development of agriculture, revitalization of Georgian cities and recreational territories, minimizing a risk of natural catastrophes pursuant to early notices. All these directions as well as others require high advanced technologies and in this regard the establishment of advanced/innovative technologies university in Batumi city of Adjara Autonomous Republic, has been several times declared by the Government. Another strategic document developed in the country and adopted by the Government is the “State Strategy on Regional Development of Georgia for 2010-2017”. This document also considers technologies as one of the priority directions in the sustainable development of regions. Chapter VI of the Strategy considers the support to the development of innovations, new technologies and entrepreneurship. The Strategy highlights that “Comprehensive technological progress entails the growth of competition, its scale and speed amongst nations with competitive knowledge and innovation capacity playing a determining role in this process. The growing competition in the world makes it clear that Georgia‘s economic development and security require the creation of a regional economic strategy which is oriented towards a knowledge of economy, innovations and new technologies”. Support to the creation of Regional Innovation Centres is one of the tasks planned in the Strategy and this approach echoes the international process on technology transfer initiated at the Rio Summit in 1992 and intensified after Poznan’s decisions regarding the climate change related technologies.

Georgia is actively involved in the technology transfer negotiation process under the UNFCCC and welcomes the idea of establishment of regional centres of excellence. Conducting the national level technology needs assessment process is being considered by the Government of Georgia as very important contribution from the UNFCCC and GEF to the development of indigenous know-how and transfer of climate change adaptation and mitigation technologies within the framework of international process. Several advanced technologies are recommended by the project and action plans suggested to help the country in their import and implementation. Development of technology reviews and database in the framework of Techwiki system can be considered as an important achievement of the project which should be further extended by the country with the support of the Centres of Excellence and Technology Transfer.

It is hoped that the work conducted under TNA will facilitate introduction of advanced climate technologies and contribute to development of national innovation system of Georgia.

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Minister

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ACKNOWLEDGMENTS

This Technology Needs Assessment (TNA) report was prepared by the Ministry of Environment Protection of Georgia with the technical support provided by UNEP (United Nations Environment program) Risoe Center.

The project team: Ms. Maka Tsereteli, coordinator; Ms. Marina Shvangiradze, adaptation team leader; Mr. Murman Margvelashvili, mitigation team leader; Mr. Goga Lominadze, expert in the Black Sea coastal zone; Mr. Vakhtang Geladze, expert in agriculture and irrigation; Mr. Merab Gaprindashvili, expert in extreme geological events; Ms. Nata Shatirishvili, expert in energy efficiency and renewable energy; Ms. Anna Sikharulidze, expert in technology database; Mr. Bakuri Beritashvili, expert in climate change vulnerability and editorial assistance to the project; Ms. Natia Kakiashvili, technical assistance to the project would like to thank all invited consultants and contributors to the report: Mr. Nodar iDzidzikashvili, the Black Sea coastal zone; Mr. Gizo Gogichaishvili, land degradation; Ms. Medea Inashvili, market mapping of adaptation technologies.

The project team would like to express its high appreciation to the project reviewer Mr. Grigol Lazriev and members of the Project Steering Committee (PSC): Mr. Giorgi Zedginidze, Deputy Minister of Environment Protection, Head of PSC; Ms. Marine Arabidze, National Environment Agency of MoE, Head of the Department of Environment Pollution Monitoring; Ms. Marita Arabidze, Ministry of Energy of Georgia, Department of International Relations, Main Specialist; Mr. Tariel Beridze, National Environment Agency of MoE, Head of the Department of coast protection; Ms. Tamar Bukhrashvili, Ministry of Agriculture of Georgia, Head of the Division for Euro Integration and Relations with International Organizations; Mr. Michael Tushishvili, Ministry of Environment Protection and Natural Resources of Georgia, Head of the Department of Integrated Environmental Management; Mr. Michael Kvesadze, Ministry of Regional Development and Infrastructure of Georgia, Department of Regional Development; Mr. Grigol Lazrievi, Ministry of Environment Protection and Natural Resources of Georgia, Department of Integrated Environmental Management, Head of the Hydro meteorological and Climate Change Division; Mr. Emil Tsereteli, National Environment Agency of MoE, Head of the Department of Geological Hazards and Geological Environment Management; Ms. Lali Gogoberidze, Ministry of Economy and Sustainable Development, Head of the Economic Analysis and Policy Department; Mr. Ramaz Chitanava, National Environment Agency of MoE, Head of the Hydrometeorology Department.

The project team acknowledges the contribution of all stakeholders participating in the technologies selection process. Mitigation team would like to thank the following experts who provided their valuable input to the findings of this report: Grigol Lazriev , Karine Melikidze, Nunu Mgebrishvili, Dimitri Kostiadi – Geothermal Energy Expert, Paata Janelidze – UNDP project manager, Nino Lazashvili – Winrock Int. project manager, Natela Dvalishvili –Chief researcher (waste management), Shota Mestvirishvili - Academician (gas transportation systems), Oleg Shatberashvili–innovation policy expert, AbesalomBeroshvili –CNG specialist, George Papuashvili – Student Tbilisi State University, Kote Kobakhidze– Solar energy expert, Otar Vezirishvili- Professor GTU, Renewable energy expert, Ketevan Vezirishvili – Professor GTU, Director of KIMS, Otar Vardigoreli – Geothermia Ltd. George Melikadze– Chairman, Geothermal Association, Archil Zedginidze – Karienergo, wind energy expert Manana Gelovani Karienergo, wind energy expert, Rostom Gamisonia – RCDA director, biomass combustion expert, George Abulashvili – Director, Energy Efficiency Center, Nodar Kevkhishvili – Professor, Technical University, Geothermal and solar energy, Irakli Shekriladze- Professor, Technical University, Avtandil Bitsadze – Bioenergia director – Biomass and Biogas expert, Gia Sopadze – NGO Eco Vision Efficient biomass combustion expert, Avtandil Geladze – Green Alternative Biomass and solar energy expert, Omar Kiguradze – Professor GTU, heat transfer and efficient wood stoves expert, Kakha Dzodzuashvili – Director Aydio – Solar systems Teimuraz Kandelaki – Professor, Agricultural University, forestry expert, Revaz Arveladze – President of Georgian Energy Academy, George Kipiani – Architect, Deputy Chair of Architects' union, Alexander Ramishvili – Architect, expert in green construction, Temur Bolotashvili – Project manager USAID/Deloitte/EPI program, Tamar Gogia –Dr. Tech. Sc. Expert in efficient construction materials, Alioni 99, Zaal Kheladze – General Director, Woodservice LTD, Efficiency Construction technologies

The Ministry of Environment Protection of Georgia and the national TNA team express their sincere gratitude to the UNFCCC and GEF for financial support to the technology needs assessment process and UNEP and its Risoe Center for providing technical support material and advice.

ABBREVIATIONS

CC	Climate Change
CDM	Clean Development Mechanism
COM	Covenant of Mayors
DNA	Designated National Authority
MCA	Multiple Criteria Analysis
MCDA	Multiple Criteria Decision Analysis
MENR	Ministry of Energy and Natural Resources
MSED	Ministry of Sustainable Economic Development
NCCC	National Climate Change Committee
NIS	National Innovation System
NPRS	National Poverty Reduction Strategy
GoG	Government of Georgia
GTU	Georgian Technical University
SEAP	Sustainable Energy Action Plan of Tbilisi under COM
SNC	Second National Communication
TAP	Technology Action Plans
TNA	Technology Needs Assessment
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
URC	UNEP Risoe Centre

LIST OF FIGURES

LIST OF TABLES

TABLE OF CONTENTS

PART I

Technology Needs Assessment Report

Executive summary

Current process of Technology Needs Assessment (TNA) builds on the already accomplished and ongoing climate change studies conducted in Georgia. The Project Steering Committee (PSC) was established in November 26, 2010 under the Ministerial Order #i603 of the Ministry of Environment and consists of 11 members, representatives of different Ministries. The mitigation team leader started activities in January 2011 and was later joined by the sustainable energy expert.

A broad stakeholder consultation process has been initiated at the initial stage of the project involving technical experts and other stakeholders from different sub-sectors. Due to limited time and resources available to the mitigation team an approach was taken to use the ongoing activities and projects related to CC mitigation technologies and policies, for personal or group consultations and stakeholder engagement. At the stage of sector selection and technology listing, the emphasis was shifted to individual interviews with knowledge field experts. In parallel a desk study of various studies and reports of completed projects was conducted.

Initial screening of sectors for their mitigation potential and relevance for TNA process was conducted based on emissions inventory from the Georgia's Second National Communication on Climate ChangeSNC of 2009 using the data of 2006. The further trends in GHG emissions were evaluated during stakeholder consultations and with the account of energy/economic information for subsequent years.

Sectors were initially prioritized based on their share in total national GHG emissions inventory. Energy and agriculture sectors were identified as top emissive sectors comprising more than 75% of total emissions in country. Discussions with experts and further review of GHG inventory as well initial assessment of potential mitigation measures in selected sectors showed that subsectors of energy sector were more relevant to TNA both by their share in total emissions inventory and the potential for implementing the mitigation measures. Therefore the agriculture sector was dropped from further consideration and the emphasis was shifted to technology groups in energy sector.

Mitigation TNA encountered some difficulties in availability of resources and information that would allow informed decision making by stakeholders on technology prioritization. Therefore in order to facilitate the selection process it was decided to compile technology reviews at least in selected subsectors to partly compensate for absence of systematized information on most relevant technology options. The first step was to assemble a list of technologies and sub-sectors with higher mitigation potential in Georgia based on stakeholder consultations and literature review. This list of relevant technologies was presented to PSC and was recommended for further development of technology data base. The next step in technology prioritization was to select the subsectors/groups of technologies based on their GHG emissions mitigation potential and compliance with country development priorities.

The following subsectors/groups of technologies were selected:

- Energy consumption in residential and office buildings
- Transport sector including various technologies in public and individual transport systems
- Renewable Energy supply

After subsector selection the preferred technologies in those subsectors were reviewed in more detail and technical and economic analyses were conducted. An attempt was made to cover the wide range of technology options in each selected subsector/technology group. E.g. while considering the geothermal energy use, separate consideration was given to its applicability for residential and agricultural heating needs, power generation and use for hot water supply; Wood fuel, pellets, chips and were separately considered under biomass group of technologies. Technology specific excel spreadsheet models were developed to evaluate economic feasibility and mitigation potential for these technologies. These models can be used for further policy analysis and preparation of country's EE and RE action plans and NAMAs. Technology Fact Sheets were prepared and distributed to stakeholders and PSC to facilitate the technology prioritization process.

After subsector/technology group prioritization more refined scoring for MCDA selection of technologies was conducted. Economic feasibility was included in decision criteria along with economic, environmental social benefits and GHG mitigation potential. These criteria were weighted by a joint decision of TNA team approved by PSC. The weights were further applied in MCDA analysis for technology selection to weigh the respective decision criteria for each considered technology.

The MCDA analysis was conducted with the participation of stakeholders for final prioritization of technology options for further barrier analyses and development of action plans. The top priority technologies identified in each of the above subsectors included: Efficient stoves for fuel wood; Efficient construction of buildings; Use of compressed natural gas (CNG) in vehicles.

At a later stage the CNG retrofit technology in vehicles was substituted by solar water heaters. Indeed the developments during the course of the project showed that due to high profitability this technology does not need any additional supportive actions. Thus rapid dissemination of vehicle CNG switching technology in Georgia confirmed the conclusions of the mitigation team but outpaced the TNA project.

As a result the following three technologies are recommended for development of Technology Action Plans and pilot project ideas:

- Manufacturing and use of high Efficiency residential wood stoves;
- Efficient construction technologies including integrated building design, energy efficient materials and construction practices,
- Solar water heaters for residential and commercial use. The results have been discussed and are endorsed by the Project Steering Committee.

The barrier analysis and Technology Action Plans for selected technologies are provided in the Part II of this report.

Chapter 1

Introduction

Rapid economic development of Georgia requires technological advancement in all fields of economy. Introduction and dissemination of climate change technologies can become a significant factor of sustainable economic development of the country in line with its international aspirations. Current TNA process has served as an important tool for realization of the priorities and preferences in this field and preparing the grounds for their implementation.

The methodological basis for TNA/TAP process is provided in the Guidebook for Technology Needs Assessment .Substantial additional support was provided in the process by RISO center. The project followed the suggested methodology but at the same time specific country conditions and project organization required some adjustments to the suggested process as discussed below.

Although introduction of climate change mitigation technologies in Georgia has multiple positive outcomes including energy security, economic, social and environmental benefits analysed in various studies; there is no special government institution or innovation strategy for the support of CC mitigation technologies neither in Renewable Energy nor in Energy Efficiency. There is no centralized depository although some of the previous studies have attempted to it was considered to systematize technology information and to conduct in-depth analyses for some of the high priority technologies.

Uneven size, importance and data availability in sectors and subsectors demanded uneven treatment. E.g in technology assessment and prioritization it was decided to concentrate mostly on subsectors of energy sector rather than conduct cross comparison with other sectors that have much less emissions or possibility to introduce the mitigation technologies. It was also decided by mitigation team to conduct the economic analyses of technologies before the prioritization process in order to enable more informed decision making by stakeholders having limited information about costs and benefits of relevant technologies.

In spite of the work conducted on expected results of climate change, there is no consensus on its most profound potential impacts for different sectors and the whole territory of Georgia. The common understanding is that the extreme weather conditions and catastrophic events will increase along with the growth of temperatures. This creates an additional linkage between mitigation and adaptation issues, since application of some mitigation measures (e.g. efficient construction, building weatherization) will provide also adaptation by reducing vulnerability to changing climatic conditions.

Although the analysis conducted in this report relied on use of MCDA for decision making with stakeholder involvement, simple excel spreadsheets were used for facilitation of decision making rather than TNA assess. This was done partly due to relative simplicity of the required procedures and partly due to technical difficulties with the TNA Assess available to the team at the time of decision making. Sensitivity analyses were not conducted but rather a thorough discussion of each case and achievement of consensus in scoring was attempted.

During the inquiry and data collection process the mitigation team came across several technology options that are at the early stage of their development and need further research. Without proper advice it was difficult to draw a sound professional opinion about these technologies and their prospects. Therefore the emphasis was shifted mostly to the technologies that might have immediate application in short or medium term.

The project has highlighted the need for further development of comprehensive national innovation system (NIS) to assure better interaction of educational and research institutions with businesses and to promote innovation for the benefit of the local industry and to the extent possible based on Georgian resources. The Creation of technology parks, centers of excellence or technology transfer centers for information storing and sharing, knowledge and know how transfer and for the support of educational, R & D institutions and business can become an important part of such a system. Addressing legal and financial aspects of innovation and developing the National Strategy for innovation are essential steps in this direction although beyond the scope of this TNA project.

Chapter 2

Institutional arrangement for the TNA and the stakeholders' involvement

2.1 TNA team, national project coordinator, consultants.

The TNA project started in September 2010 by appointment of National Project coordinator and involvement of adaptation team. Although the climate change is a multi-sectoral problem, there is no single inter-ministerial coordination body dealing with climate change mitigation or adaptation issues. The reason is frequent changes in high level government officials requiring very frequent update of such Board. Therefore, the practice currently followed by the government is a case-by-case (project-by project) establishment of a Project Steering Committee (PSC) for project related process coordination, identification of project strategy and monitoring its implementation. Such a committee was established by the Ministry of Environment for TNA project as well. One of the barriers identified to the TNA process is absence of one national body or unit responsible for the process.

The PSC was established in November 26, 2010 under the Ministerial Order #i603 Ministry of Environment and consists of 11 members, representatives of different Ministries: Deputy Minister of Environment Protection, head of PSC; Head of Department of Environment Pollution Monitoring (National Environmental Agency (NEA)), member; Main Specialist in the Department of International Relations (Ministry of Energy), member; Head of Department of coast protection (NEA), member; Head of Division for Euro Integration and Relations with International Organizations (Ministry of Agriculture), member; Head of Department of Integrated Environmental Management (Ministry of Environment), member; Head of Department of Regional Development (Ministry of Regional Development and Infrastructure), member. Grigol Lazriev, Head of Hydro-meteorological and Climate Change Division (Ministry of Environment), member; Emil Tsereteli, Head of Department of Geological Hazards and Geological Environment Management (NEA), member; Head of Economic Analysis and Policy Department (Ministry of Economy and Sustainable Development), member; Head of the Hydrometeorology Department (NEA), member; TNA project coordinator. Fig.1. 1 Demonstrates the TNA implementation structure.

The overall structure of coordination and implementation team of TNA is shown below in Fig.1.1

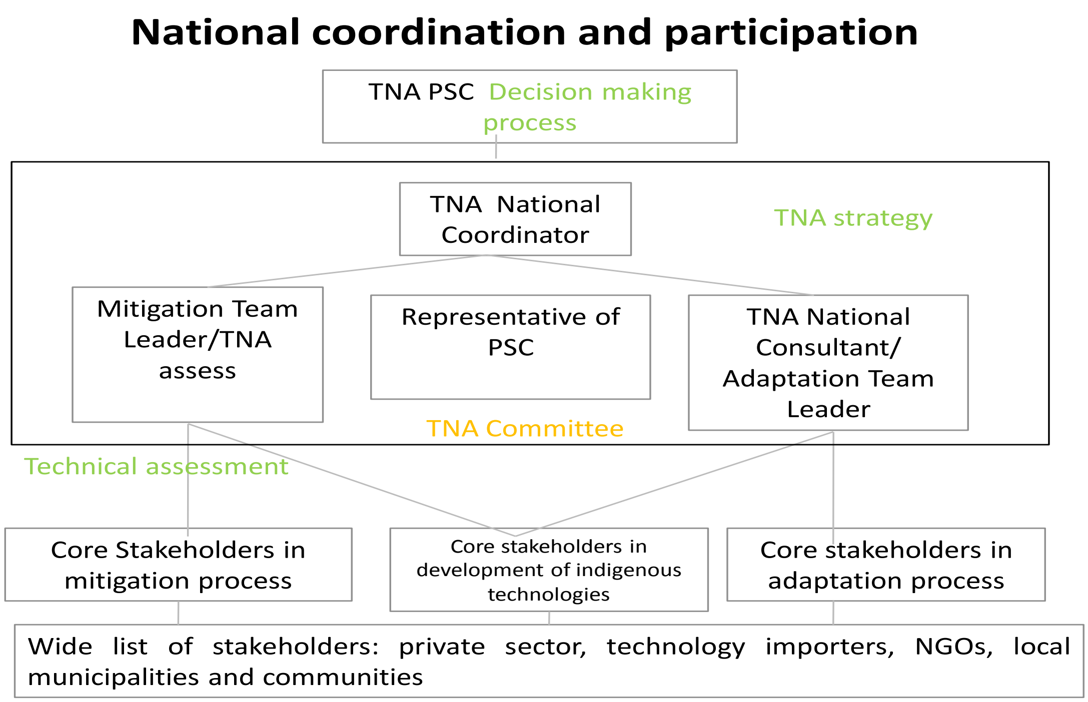

Fig. 1.1 - National coordination of TNA project

Adaptation and mitigation teams have been separately established for conducting the TNA process. The structure and organization of mitigation TNA process is provided in the Fig. 1.2

Georgia

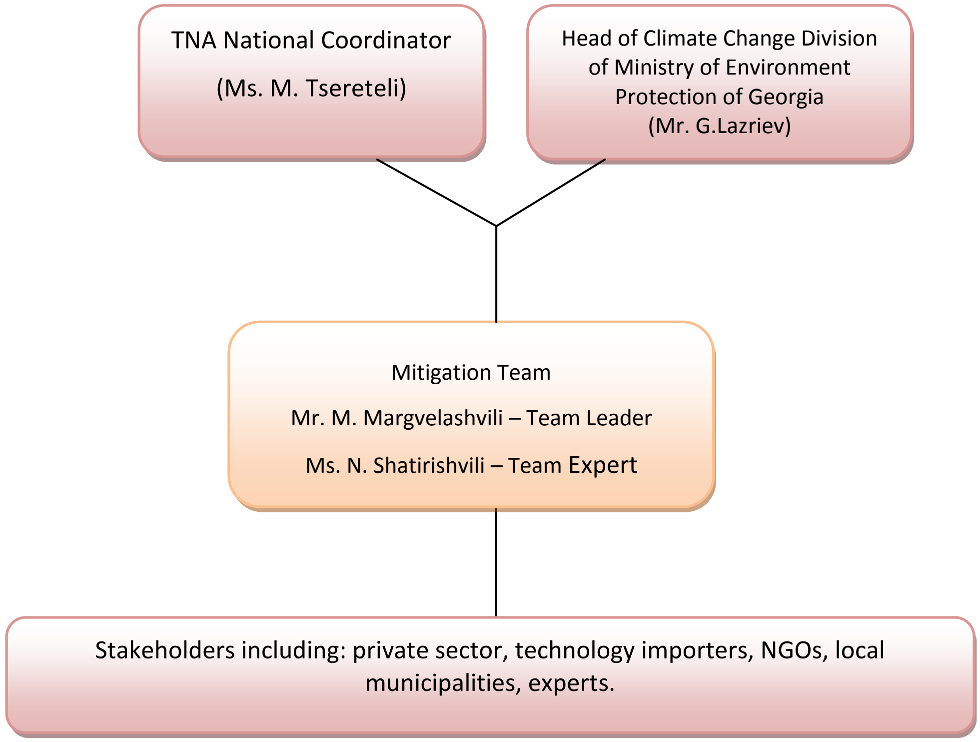

Fig. 1.2 - Implementation structure of mitigation section of TNA Georgia

Consultations with technical experts, officials and NGOs active in climate mitigation activities were used for

2.2 Stakeholder Engagement Process followed in Mitigation TNA

Since the mitigation team leader was engaged in January 2011 a broad stakeholder consultation process has been initiated involving technical experts and other stakeholders from different sub-sectors considered for mitigation. Due to limited time and resources available to the mitigation team an approach was taken to use the ongoing activities related to Climate Change mitigation technologies and policies, for stakeholder engagement and personal or group consultations. At the initial stage of sector selection and technology listing, the emphasis was shifted to individual interviews with technical experts to collect their feedback and to prepare common discussions at later stages. In parallel the desk study of various reports and studies of completed projects was conducted in order to review and summarize the main technical and economic parameters as well as compliance with country development priorities of various mitigation technologies. The information about TNA project and its potential outcomes was disseminated at various project meetings in order to solicit the input and the feedback from various potential stakeholders involved directly with the technologies relevant to TNA, for incorporation in the final assessment.

The PSC was another group of stakeholders dealing mainly with prioritization of sectors and selection of indicators for prioritization of priority sector and related technologies. Interpretation of criteria was a challenge for the PSC consultation process and for the technology selection process. TNA mitigation team has conducted consultations with each expert in order to ensure the common understanding of selection criteria. The intermediate results of technology selection were agreed with the PSC.

Synergies with ongoing Climate Change related project activities were utilized in order to achieve the maximum result:

In 2010 Tbilisi has joined the Covenant of Mayors and started development of an action plan - Tbilisi Sustainable Energy Action Plan (SEAP), to reduce carbon emissions beyond 20% by 2020. The work on SEAP development was going practically in parallel with the starting phase of TNA. The members of both adaptation and mitigation teams were involved in the process at varying level. For particular technologies the information generated for SEAP was used as an input for TNA process including sector and technology selection. In these cases the data from SEAP was further generalized to the rest of Georgia. Almost a third of Georgian population and the most of businesses are located in Tbilisi. Therefore the SEAP information is relevant to TNA process both by representing the major share of GHG emissions and potential mitigation activities. The political support and the willingness of the City Hall to engage in GHG reduction activities can play an important role in implementation of mitigation measures. A project on Energy Efficiency and Renewable Energy Use in residential buildings conducted by WEG under USAID NATELI project touched the issues of GHG reduction in major energy consumption sub-sector of residential block buildings. It considered broad spectrum of Energy Efficiency and Renewable Energy measures and information on costs and assessment of benefits for various technologies served as a material for sector and technology selection. The UNDP project on Removing Barriers for the Local Utilization of Renewable Energy Sources was devoted mostly to small hydro and geothermal energy development. Conclusions and opinions of experts involved in these projects have had a valuable effect on the results of this report.

The meetings and discussions with knowledge field experts and officials at different levels were used to identify potential projects, ongoing and planned studies that would have relevance to TNA and further technology implementation in Georgia. July 2011 workshop was used to communicate and agree the findings of the TNA to a wider group of stakeholders and to solicit their input.

List of stakeholders is provided in the Annex III.

Chapter 3

Sector and Subsector Prioritization

3.1 Sector Prioritization

The first step taken in TNA process was sector (and subsector) selection. 2006 IPCC Guidelines modified for the purpose of TNA process have been used for sector classification.

The following sectors were considered for prioritization:

- Energy supply and consumption (except for industrial sectors)
- Industry: energy consumption, industrial processes, and product use
- Agriculture, forestry, land use
- Waste
- Other

The relative importance of these sectors for mitigation and their relevance for TNA process was evaluated based on emissions inventory from the Georgia's Second National Communication on Climate Change. The greenhouse gas inventory of Second National Communication (SNC) of 2009 is based on the data of 2006. The evolution of emissions from key emitting sectors is depicted in the Fig.1.3 below.

Georgia

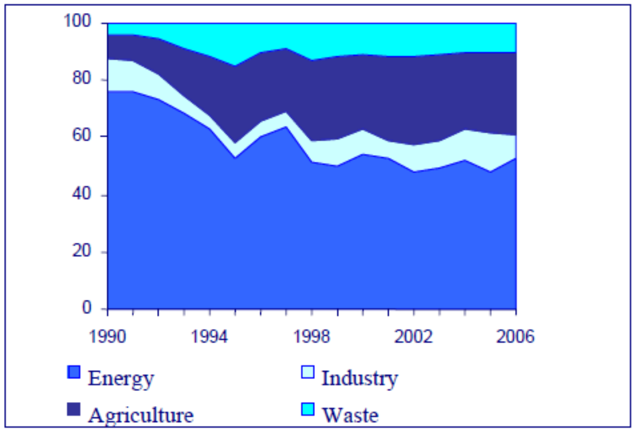

Fig. 1.3 - Share of sectors in National emissions (from SNC)

Highest emitting sectors were selected in order to identify the major emitting subsectors for further prioritization. Energy sector is by far the most emissive sector with the emissions coming from fugitive emissions, fuel combustion from energy industry and transport. Agriculture is the second most emissive sector with the major contribution coming from enteric fermentation. Thus **Energy and Agriculture sectors** were initially singled out as highest emissive sectors with the major share in GHG emissions of Georgia.

The evolution of GHG emissions from these sectors was assessed in consultation with various stakeholders and PSC as well as examination of country economic and energy information. Namely it was revealed that: Since 2006 there has been a significant improvement by reducing the fugitive emissions from energy sector. There has been also reduction in emissions from fuel combustion in energy sector relative to 2006. Emissions in transport sector have increased. It was assessed that agriculture and energy sector still comprise the key emitting sector with total share in emissions exceeding 75%. Review of available information about potential trends in country's economic development confirmed that these sectors will remain to be highest emission sectors most appropriate for TNA prioritization.

In spite of the work conducted on expected results of climate change in Georgia, there is no consensus on its most profound potential impacts on specific sectors and for the whole territory of Georgia. The common understanding is that the extreme weather conditions and catastrophic events will increase along with the growth of temperatures. This creates an additional linkage between mitigation and adaptation issues, since application of some mitigation measures (e.g. efficient construction, building weatherization) will provide also adaptation by reducing vulnerability to changing climatic conditions.

As a next step due to availability of information and Subsectors were further prioritized according to their respective costs and benefits by the mitigation team in consultation with the rest of TNA team and national stakeholders using a Multi Criteria Decision Analysis (MCA) framework. Benefits are divided into four categories: potential impact on greenhouse gas emissions, economic, social and environmental benefits. A simplified version of MCDA analysis was selected for selection of subsectors, where the priority criteria were given the scores 1 to 5. The final score was obtained by summing up the scores by each category.

The results assessment agreed with PSC are as follows:

Table 1.1 - MCA analysis for Subsector Prioritization

Subsector Emissions source	Economic priorities	Social priorities	Environmental Priorities	GHG reduction potential	Total
Energy: fuel combustion (residential, commercial, industrial sectors)	**5**	**5**	**4**	**5**	**19**
Energy: fuel combustion (transport)	**5**	**4**	**4**	**5**	**18**
Energy fuel combustion: (Energy Industries)	**4**	**3**	**4**	**3**	**14**
Agriculture Enteric fermentation	**1**	**2**	**1**	**4**	**8**

As a result of prioritization process Agriculture sector was excluded from further consideration due to its low priority as well as low perceived potential for introducing mitigation technologies. Energy sector was selected as a priority sector represented by subsectors of energy use in transport, in residential, commercial and public sector as primary sources of emissions to be taken to further steps of TNA.

3.2 Subsector and Technology Prioritization

Process followed in Subsector and Technology Prioritization

After identifying the energy sector as highest priority sector, TNA mitigation team proceeded to select the priority subsectors and relevant technology groups. There is a great number of mitigation technologies in selected sectors that might have high relevance to TNA process and/or be important for developing the future energy efficiency and renewable energy strategies and action plans. Therefore it was decided to group these potential technologies into subsectors and to conduct further analysis and prioritization by subsectors. Priority technologies were selected within each subsector and in-depth technical and economic assessment was conducted for these technologies. Finally the high priority technologies were selected for barrier analysis and development of Technology Action Plans. The process is depicted in the Fig. 1.4 below.

This process of subsector and technology selection is depicted on the Fig. 1.4

Georgia

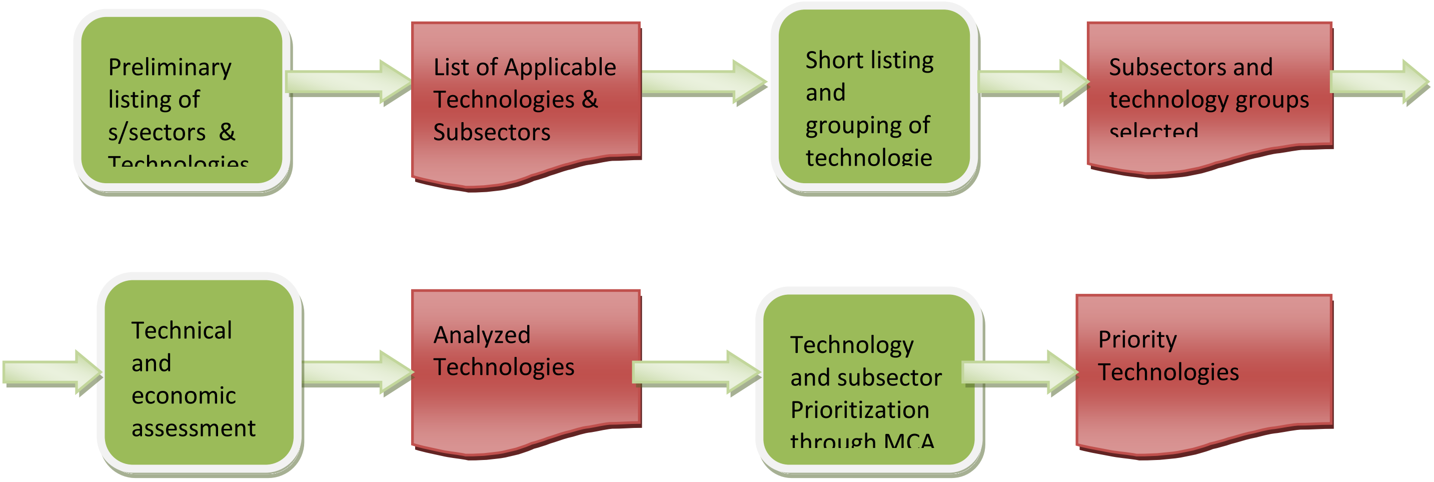

Fig. 1.4 - Process of subsector and technology prioritization

Subsector and technology prioritization

Substantial difficulty in TNA process was caused by low awareness and general lack of information on potential applicable technologies and deficit of reliable comprehensive or in-depth information on their costs and benefits in Georgia. The absence of government energy efficiency and renewable energy strategy or action plans in Georgia has hampered the development of information base and resulted in general low awareness on potential costs and benefits of applicable technologies. Mitigation team in consultation with the rest of TNA team decided to use the TNA process and its networking activities to complement the subsector and technology selection by a process of identification and listing of important technologies from all subsectors that had high relevance to climate change mitigation and might be potentially included in national energy efficiency and renewable energy action plans.

The Climatetechwiki site was used for initial listing of potentially interesting technologies. In addition to previous personal experience and expert input from various interviewed experts (Annex 4), information from ongoing projects in Georgia was considered. These included: Sustainable Energy Action Plan for Covenant of Mayors, SSP Strategic Planning for Georgian Energy Sector, USAID/NATELI –Energy Audits and pilot project in residential buildings of Tbilisi, etc.

The following preliminary listing of technologies and sub-sectors in Georgia with estimated higher climate change mitigation potential and applicability in Georgia was developed by mitigation team in consultation with stakeholders.

Table 1.2 - List of applicable technologies in Georgia selected after preliminary screening

- **Energy Supply**
  1. Hydropower
  2. Coal – pulverized bed combustion,
  3. Integrated gasification
  4. CHP
  5. Natural Gas Combined Cycle Plants
  6. Wind – onshore –large and small scale
  7. Coal mine/bed methane recovery
  8. Hydro – Pumped storage
  9. Solar power and solar heat
  10. Use of Geothermal water
- **Residential and Office buildings:**
  1. Insulation in buildings

2. Geothermal heat pumps for space heating and cooling and water heating
3. CHP – small scale
4. Building energy management systems
5. Use of air conditioning split systems for heating
6. Efficient lighting
7. Efficient construction

- **Transport**
  1. Biofuels
  2. CNG
  3. Electric vehicles +hybrids+Plug-in hybrids – electric scooters
  4. Regenerative breaking in trains and metro
  5. Electric public transport – tram, trolley, metro extension
- **Land and Forest management**

1. Forest management for mitigation (agreed not to consider in this round of TNA)

- **Waste**
  1. Methane capture at landfills
  2. Biogas for cooking & electricity
- **Biomass for energy supply**
  1. Efficient wood stoves
  2. Pellet, briquette and chip production
  3. Dry distillation of agriculture waste
- **Other**
  1. Wastewater treatment (Anaerobic biological digestion)
  2. Energy Storage – compressed air

This list includes the technologies from selected sectors. The list was compiled based on available reports from internet sources, personal inquiries and discussions with various stakeholders[1] involved in EE and RE activities, mainly in energy sector. Climatetechwiki site[2], was used as a systematic source of information on technologies and wherever necessary the own assessments or the results of completed projects were added.

These technologies from the above list of Table1.2 were recommended to the PSC as prime technologies for creation of a technology data base in support to innovation and technology development. Many of the technologies mentioned represent a group of technology options which have been separately discussed and analyzed (Cf. Chapter 5 and Annex II).

General remarks concerning technology selection depending on their stage of development: During the inquiry and data collection process the mitigation team came across several technology options that are at the early stage of their development and need further research. Without proper advice it was difficult to draw a professional opinion about these technologies and their prospects. This did not allow including them in the process.

In selecting the subsectors and technologies for further prioritization the period of time till 2020 was taken into consideration. The assumption was made that the acceptance and perception as well as market conditions for the technologies can be significantly changed over this period. An example is the introduction of electric three wheel scooters in Batumi area by municipal decision which before might be considered as culturally alien technology for Georgia. Therefore a special consideration is required for the technologies that are in pre-commercial stages of development.

[1] List of stakeholders consulted is presented in Annex 1
[2] www.climattechwiki.org

Technology short-listing for cost-benefit analysis

As a next step the technologies from Table 1.2 were shortlisted for inclusion in TNA and cost benefit (technical and economic) analysis. Non-energy sector technologies were excluded from the cost benefit analysis based on internal consultation of TNA team. Other energy sector technologies have been excluded based on the following considerations:

Hydropower - Importance of hydropower is increasing within the whole energy policy of the country and therefore does not require additional efforts in support, technology transfer and analysis. Large, medium and small hydro plants were considered to be the part of mainstream energy policy and not high priority for technology transfer since it is a well proven technology that provides more than 90% of Georgia's electricity generation. There is a potential for efficiency improvements, however this was also not considered as high priority because of uncertainty in electricity market as well as ownership issues (Cf. also comments below).

Coal – pulverized bed combustion, Integrated gasification combined cycle. This is efficient technology for coal burning including low grade brown coal presented in Georgian deposits in Tkibuli and Akhaltsikhe (potentially in Tkvarcheli). Coal mines are owned by a private corporation GIG and feasibility study is developed for a coal power plant. A combined cycle can be potentially implemented by using the existing condensing cycle power plants owned by the same company.

CCGP - Combined cycle gas plants are most likely extension of current thermal generation capacity taking into account the existing technologies. Combined cycle can be constructed based on one or more of existing condensing cycle steam turbine plants as well as two gas turbines.

Coal mine/bed methane recovery - Coal gasification attempts have been considered by GIG group and feasibility study was conducted. There is a regulatory issue to be resolved between allocating the methane from gasification to coal mine owners or to the licensee for oil & gas reserves on the same territory. However the technology is potentially applicable in Georgia on relatively small scale.

CHP - Combined heat and power plants were used in Georgia, but after destroying of the centralized heating system had shifted to only electricity generation and finally stopped. This is a promising efficient technology to be used in applications with large steam demanding industries.

Hydro – Pumped Storage - Pumped storage is a promising technology that can be effectively developed on a large scale using the Georgian hydropower potential and perspectives of creating a regional electricity interconnected grid and market. This technology needs robust practice of system planning and refined dispatch. It is being discussed in relation to Paravani HPP. However, the final decision is to be made based on actual feasibility.

The Energy industry subsector is of major importance in long term and the above technologies have to be thoroughly analyzed and promoted while developing the country's energy policy. However most of these technologies are well proven commercially available and their introduction is most likely to happen based on market studies and in business interests of corresponding large energy suppliers.

Industrial Energy consumption - Industrial energy consumption subsector was not considered as a high priority in this study since almost all major industries are privatized and the technologies in each industry and plants are specific. Therefore within the scope of current study it was not feasible to conduct a sufficient in-depth study to reveal technology needs and improvement potential, or to develop relevant mitigation measures that would be priority for the significant part of industry. This can be more effectively addressed through general awareness rising and will be largely driven by market and financial considerations in each particular business.

As a result of pre-selection and exclusion process the following subsectors/groups of technologies have been identified for further prioritization under TNA[3]:

[3] Ministry of Energy AND Natural Resources has expressed interest in the process and may still provide some information about potential technological improvements in electricity sector

- **Energy Efficiency in Residential and office buildings** including: Energy Efficient Construction, Thermal insulation in buildings. Efficient lighting. Heat pumps for space heating, cooling and water heating.
- **Transport** including: *Promotion of Public Transport systems in cities, Electric vehicles , hybrids, Plug-in hybrids, Electric Scooters, Use of Compressed Natural Gas in Passenger Vehicles, Bio-fuel Production*
- ***Renewable energy Technologies*** *including: Wind, Biomass, Solar and Geothermal technologies*

3.3 Current status of Technologies in Selected Subsectors

Out of Georgia's total primary energy supply (approximately 3.5 MTOE) 35-40% is coming from domestic renewable energy sources. Primarily this is hydropower that constitutes about 20-25% of total energy and fuel wood comprising 15-20% of energy supply. The rest of energy demand is covered by imported fossil fuel – primarily natural gas (about 40-45% of demand) and oil products (20-25%). [4]This factor also raises concerns over energy security due to high energy dependence of the country on external energy sources. Therefore energy security is one of highly important country development priorities. Diversification of external supplies and mobilization of all internal resources are needed to improve energy security of the country. Therefore development of mitigation technologies is at the same time inevitably related to increased energy security, economical and technological development of the country.

Georgia is almost fully electrified except very remote mountainous areas. Along with electrification there is an ongoing process of intensive gasification of Georgia's regions with the ambition to supply all urban and most of the rural population except remote locations where laying gas network would be very uneconomical. This trend leads to better energy supply to the regions but can also lead to increased GHG emissions and become an impediment for development of local renewable energy sources.

Below the current state of mitigation technology utilization in selected subsectors is briefly discussed:

Energy Subsector - Residential and Office buildings:

According to various assessments[5] energy consumption in buildings accounts to 40% of total energy consumption and is a major source of energy waste and excessive GHG emissions due mostly to high thermal losses during the heating season and increasingly cooling season. The following technologies can be considered for reducing the energy consumption and associated GHG emissions from building sector:

- Energy Efficient Construction

An intensive construction and living stock renovation process is currently going in Georgia. New residential buildings, offices, stores and hotels are being built very fast. At the same time in absence of it, it is important to introduce efficient construction practices and materials to reduce carbon footprint in the construction process and later in building lifetime.

- Thermal insulation in buildings.

Due to extremely poor thermal properties of the most of residential and office buildings in Georgia, this technology deserves relevant attention. However, cost effective ways of its implementation in existing and new buildings should be found. The assessments done under various donor programs show low return for its implementation.

- Heat pumps for space heating, cooling and water heating.

Efficient technology that can find many applications especially in combination with geothermal hot water. This technology deserves more detailed examination.

- Efficient lighting.

[4] Long-term Strategic Planning of Energy Sector using MARKAL model Project results (WEG, IRG/USAID).

[5]Survey of Current Construction Practices and Recommendation to Building Industry to Improve of Energy Efficiency in Georgia prepared by Yu.Matrosov, K. Melikidze, N. Verulava

Energy Problems of Residential Housing in Georgia by Giorgi Sadagashvili

This technology, although widely represented on the market, is not properly utilized, especially in residential sector and mostly in lower income population. There is a significant potential of disseminating this technology.

The above technologies can be considered as a part of building energy efficiency trend and should be implemented gradually based on the level of development of society, its energy awareness and technology advancement in construction business.

Energy Subsector – Transport

According to GHG inventory of SNC the transport sector is a major source of air pollution and GHG emissions in Georgia. Based on the SNC figures for 2006 the total annual CO_2 emissions from transport can be estimated to amount up to 1400Gg or 1.4 mln tons of CO_2 in 2010.

Several technologies have been considered for transport sector:

- *Promotion of Public Transport systems in cities*

This technology has been closely considered in SEAP of Tbilisi and is likely to be also incorporated in SEAPs of other major cities in Georgia who have recently also joined the Covenant of Mayors' process. A number of measures including improvement in municipal transport fleet, information boards etc. have shown first positive results in Tbilisi and probably will be replicated by other cities.

- *Electric vehicles*

Electric vehicles are partly under implementation as a promotion measure based on political decision. Not cost effective at this stage. Small scale electric vehicles may be an option for distribution courier services and also for demonstration purposes.

- *Use of Compressed Natural Gas in Passenger Vehicles*

Due to high gasoline prices this has become a cost effective measure in transport sector. Retrofit of existing vehicle fleet to use of double fuel (CNG retrofit) is going at fast pace.

- *Bio-fuel Production*

Bio-fuel production can be developed in Georgia on currently non-arable lands and can provide economic and environmental benefits. Previous studies have shown possibility of bio-ethanol production using the *Topinambur* plant. There is an ongoing activity in one of the universities to develop the production of bio-diesel.

Energy Subsector - Renewable Energy

Strong governmental supportive measures are applied to develop Georgia's vast hydro energy potential. Hydropower development technology is well tested in Georgia and there is quite adequate engineering and sector management capacity in order to properly develop hydroelectric resources. Therefore hydropower production technology was not considered for TNA process.

At the same time other renewable energy sources are lagging in development and require special efforts for dissemination and deployment of relevant technologies. Georgia is rich in unutilized solar, geothermal and wind energy potential. Technically achievable wind power potential is estimated at 5TWh annually and about 2GW of capacity. Average number of sunny days is around 280 and with the modern solar technologies it allows effective use all year round. Wood is currently used in unsustainable way leading to deforestation of certain localities. At the same time the remains of forestry and agriculture are practically not utilized. There is an important potential in increasing the efficiency of utilizing these resources. There are significant geothermal resources, mostly in West Georgia that can be successfully utilized for industrial and residential needs. Technologies in all these fields are briefly discussed below.

Gas prices in Georgia are below the regional prices due to mixing the in-kind payment for gas transit with the gas purchased from abroad this adds to the probability of gas switching for various uses. Therefore it can be expected that at least the part of energy demand that can be satisfied with renewable energy sources can switch to natural gas consumption and thus increase the CO_2 emissions.

- *Woody biomass for heat supply*

Georgia

Wood is the second most important domestic energy source in Georgia. Efficient use of biomass for heat supply has an extremely high importance for forest protection, and offset of potential emissions from using other energy sources.

- *Geothermal water for residential, agricultural and industrial use*

Abundant geothermal energy resource still needs utilization to provide its contribution and inclusion into the country's energy balance and economic development.

- *Solar energy for power and heat*

Solar energy widely used in many countries is still to be developed in Georgia. Although there has been a positive trend in Solar water heater technology dissemination, still according to expert assessment less than a percent of available solar potential is being used.

- *Wind power*

Development of wind power technology finds many obstacles in spite of good energy potential on various sites all over Georgia. Development of hydropower resources has outpaced this technology that can be of importance for energy supply as well as technological progress.

These technologies (groups)have to be taken to the next stage for more detailed examination.

Criteria for Technology and Subsector Prioritization

After selection of preferred technologies from each subsector, these technologies were prioritized and compared to each other based on the technical and economic feasibility and benefits in compliance with development priorities of the country. The collected information was analyzed and cost benefit analyses carried out for selected technology options. As a result the descriptions of technology options and technology fact sheets were compiled (Cf. Annex 2,). Economic analysis for the technologies and main assumptions can be found in Annex 1.

Technology costs were understood through economic performance of each technology estimated on the basis of economic evaluation or rigorous cost-benefit analysis. Benefits are divided into four categories: potential for CC mitigation, economic, social and environmental benefits. Table1. 4 depicts the factors within each cost or benefit category taken into account during the prioritization process

Table 1.3 - Criteria for assessing the benefits of mitigation technologies

TNA Criteria
Economic and financial feasibility
Potential for Greenhouse Gas Emission Reductions
▪ **GHG** reduction potential over 10 years
Economic Development Benefits
▪ Support for sustainable economic development ▪ Provision and maintenance of infrastructure, development of urban infrastructure ▪ Increase in productivity ▪ Energy Security ▪ Promotion of investment
Social Development Benefits
▪ Creation of employment and income generation opportunities ▪ Improvement of public health and quality of life ▪ Rural and regional development

▪ Improvement of local living conditions, including IDPs ▪ More targeted aid to socially vulnerable population
Environmental Benefits
▪ Avoidance of environment pollution ▪ Conservation and sustainable use of resources

The hierarchical representation of TNA criteria applied during technology prioritization process is given below in Fig. 1.5

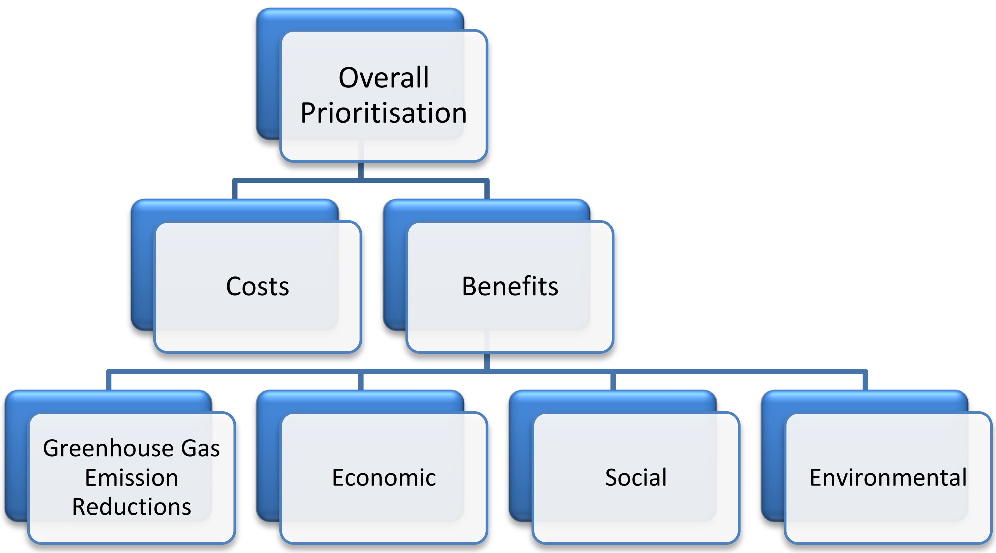

Fig. 1.5 - Hierarchical representation of cost and benefit of mitigation technologies

Different decision criteria were discussed within the TNA team and were assigned specific weights for MCA analysis and agreed with the PSC.

Table 1.4 - Weighting of criteria for technology options.

Economic feasibility (cost)	GHG mitigation	Economic development	Social development	Environment protection
15	20	25	20	20

Each preselected mitigation technology for each subsector has been scored on a scale of 1 to 100 according to prioritization criteria (costs and benefits), with 100 being the highest possible priority. The scores 0 or 100 were not assigned to any technologies since each of the selected technologies have zero or absolute maximum contribution. The overall score for a specific technology was obtained by summing weighted scores of each criteria. The final ranking represents a consensual position among the members of the TNA Mitigation Team and has been obtained through a series of facilitated discussions and consultations with various stakeholders.

Next section describes technology prioritization process within each selected subsector.

Chapter 4

Technology Prioritization for Building Subsector

There are good opportunities to improve energy efficiency of buildings in Georgia by using new technologies. These are market technologies in wide use in the EU and also in Ukraine, Moldova and Kazakhstan. There is big new construction activity in Tbilisi – more than 2 mln sq. meters of residential and commercial building space is being developed every year. Sealed glass units in windows with single plastic or metal frames, instead of unsealed double pane windows, heavy weight concrete in the external walls as well as decentralized heat supply systems, are being installed. These technologies can increase energy efficiency for buildings up to about 20%, but minimal thermal comfort still cannot be achieved. The next step is to change heavy weight concrete blocks to light weight concrete blocks and double-pane windows into sealed glass units and to a modern window with low-E coating, which together would improve energy efficiency up to about 40% and provide thermal comfort.

Moreover, for the construction sector in Georgia, new national construction standardization documents (codes) have not been developed and adopted yet. Existing building code is an old Soviet code which does not pay much attention to energy efficiency of the buildings. The primary importance during development and construction is given to structural stability, because the country is located in a seismically active zone. Moreover, there is no state obligation to follow existing code and the level of thermal resistance of new buildings is not controlled or regulated.

Energy efficiency level of existing buildings is far from EU standards as well. 60% of existing buildings are built during Soviet times and 13% are even older. Energy efficiency of these buildings could be increased through weatherization and thermal insulation of external walls. There are several pilot projects being implemented, however this practice is still of small scale.

Available information about technologies for increasing energy efficiency in building sector was compiled from Climatetechwiki, own ongoing and completed projects including WEG projects and reports available on the internet on energy efficiency in buildings. Technical and economic analysis was conducted and technology fact sheets were compiled. The technologies considered for prioritization are described in the Annex A1. Prioritization process was conducted by TNA mitigation team in consultation with stakeholders and the rest of TNA team and was finally approved by the PSC.

The following stakeholders were involved in discussion and prioritization of technologies: K. Melikidze, N. Lazashvili, T. Bolotashvili, T. Gogia, N. Kevkhishvili, etc.

The numerical values were obtained by assigning the scores by development priority criteria in the range of 1-100 to each technology and weighing the results according to the weights of Table 1.4..The assigned scores represent expert opinions of stakeholders and mitigation team, rather than results of rigorous calculations and analyses. The final scoring is presented in Table 1.5

Table 1.5 - Prioritization of Technologies for Mitigation – energy efficiency in buildings

Technology Options/ Criteria	Economic Feasibility	Benefits				Total Score	Priority
		GHG Mitigation	Economic	Social	Environment		
Efficient construction	10.5	16	22.5	16	16	81	1
Wall insulation	9	18	20	14	16	77	2

Weatherization	12	14	15	16	14	71	3
Efficient lighting	13.5	12	15	14	12	66.5	4
Heat pumps for heating/cooling	7.5	12	17.5	12	14	63	5

As a result – **Energy Efficient Construction** has been identified as the highest priority for Technology Transfer in the construction subsector. Introduction of this group of technologies entails implementation of principles of Integrated Building Design, development of efficient construction material production and supply, sustainable construction practices and will result in development of a new segment in real estate market. Energy efficient buildings will result in substantial reduction in energy consumption and therefore contribute to country's energy security, as detailed in Annex 1.5

Compatibility with country development priorities

Country social development priorities

The technology can improve peoples' living conditions and reduce their energy bills. This is also a step to adaptation to climate change where more extreme temperature regimes are expected

Country economic development priorities

Wider dissemination of this technology can support sustainable economic development of the country through increased economic activity, cost-saving for residents, job creation and increased budget revenues from economic activity. It also reduces dependency on imported natural gas and, therefore, increases energy security. With steadily increasing prices on imported natural gas this contributes to reduction in government expenditures.

Environmental development priorities

This technology is environmentally friendly compared to One of the main benefits of this technology is reducing of consumption of natural gas and therefore, improved quality of local air and CO_2 emissions reduction.

Chapter 5

Technology Prioritization for Transport

The main modes of transportation in Georgia are land and air transport. Land transport consists of a national network of roads and rail. Air transport has experienced steady growth with the country's expansion of its international and regional airports. Georgia is an important transit corridor from the Black Sea ports and Turkey to the neighboring countries. The goods transit is growing and the corresponding share of transit vehicles is increasing. Government has given a high importance to rehabilitation and construction of the road infrastructure. There is an intensive process of road rehabilitation and highway construction that will connect the extreme east and west points of the country with the high speed highway. This will resolve the problems of road infrastructure efficiency in the nearest years. Therefore the TNA process has focused mostly on the technologies for improved traffic management in the cities, emission reductions from vehicles and promotion of electric transport and public transport.

The number of passenger cars registered in Georgia as of June 2010 is 683 751 the corresponding number of vehicles per thousand persons is 156[6]. A significant share of these vehicles is old and high consumption vehicles. Most of the vehicles are concentrated in the cities and the biggest part - in the capital Tbilisi. The high concentration of vehicles is

[6] MSED- 2010 study "Level of Automibilization and Analysis of Vehicle Export-Import"

causing significant traffic jams, problems with parking, lower car speed and increased gas consumption. Combined with the high cost of gasoline for vehicles this increases the economic burden on vehicle owners and finally slows down the economic development. It also causes extensive air pollution and increased GHG emission levels.

Development of road infrastructure and promotion of electric transport is the recent government activities to support emission reductions in the transport sector. Tbilisi City Hall is adding a significant momentum to GHG reduction efforts by signing the Covenant of Mayors and developing the city Sustainable Energy Action Plan (SEAP)[7] to reduce carbon emissions beyond 20% by 2020. Main directions in transport sector identified in this document are: a. Rehabilitation and development of transport infrastructure, b. Increase the share of public transport within total passenger turnover, and c. Decrease the mobility of private cars and encourage low emission cars by means of various restrictions and incentives.

In TNA preparation and in decision making process a number of parameters necessary in MCA were analyzed and generalized based on previous studies including SEAP[8]. In addition our own inquiries, data collection and analyses were conducted by TNA team to supplement the SEAP actions.

In order to generalize the action plan for Tbilisi transport sector to country level the following cities were considered: Batumi (123 500 citizens.), Kutaisi (192 500), Zugdidi (175 000), Rustavi (119 500) and Marneuli (126 300). These cities are more likely to contribute to GHG mitigation from transport sector due to relatively high number of inhabitants and presence of public transport (PT).

Main calculations were made in relevant excel spreadsheet models, the transport and public transport intensity in the cities was estimated based on the population figures. Special coefficients were applied to each of the above cities to reflect urban development and applicability of specific measures selected for Tbilisi. Activities that could be generalized with reasonable assumptions were included, while activities specific to concrete location were not taken into consideration.

Prioritization of available technologies was conducted by TNA mitigation team in consultation with the following stakeholders: S. Mestvirishvili, O. Shatberashvili, I. Shekriladze, A. Beroshvili, G.Papuashvili, M. Salukvadze.. The summary information on various technology options, their costs and benefits was presented as described in Annex A3.

The numerical values were obtained by assigning the scores by development priority criteria in the range of 1-100 to each technology and weighing the results according to Table 1.4. The final scoring is are presented in Table 1.6

Table 1.6 - Prioritization of mitigation technologies for the Georgian transport subsector

N	Criteria	Economic Feasibility	Benefits				Total Score
	Technology Options		GHG	Economic	Social	Environment	
1	Natural gas switching of passenger vehicles	13.5	16	20	14	16	79.5
2	Private cars discouragement actions	13.5	10	15	8	10	56.5
3	Improvement of PT service	6	6	10	10	6	38
4	Public transport popularization campaign	6	8	7.5	8	8	37.5
5	Bio-fuel	8.25	8	12.5	10	10	48.75
6	Electric cars	6.75	18	17.5	12	16	70.25
7	Improvement of transport management system	7.5	12	15	14	12	60.5

[7] Sustainable Energy Action Plan, City of Tbilisi, 2011

[8] Georgian Sustainable Urban Transport Project Interim Report 2 – ADB, Tbilisi City Hall 2010.

As it can be seen in the table, the leading technology is natural gas switching of passenger vehicles. This measure turned to be the most cost effective, providing economic, environmental and social benefits as well. The analysis showed that among other possible technologies in transport sector this technology has greater CO_2 reduction potential and is more feasible to be implemented. It increases natural gas consumption but reduces consumption of gasoline. However, the energy security is not much affected since the vehicles have dual fuel and can immediately switch to gasoline consumption as a backup fuel.

Electric public transport is considered to be the second best technology to be implemented in Georgia. Own hydroelectric potential provides ground for the development in this direction. This measure provides high reduction in local air pollution in the cities and cuts GHG gas emissions. At the same time it is specific to certain locations and requires high capital expenditures. Therefore it can be developed only with strong municipal support.

Electric cars are the third technology that requires substantial development of own specific infrastructure as well as general electricity distribution system. Due to its high cost and necessity of sufficient charging stations we assume that this measure will hardly be widely implemented. However, even today Georgian government shows interest towards electric cars and plans to import a certain number in near future.

The fourth technology is Improvement of public transport encouragement and management system. This measure provides high social value due to improvement of comfort of transport. This in turn, raises popularity of PT, so number of private cars will decrease as well as GHG emissions.

ADDED NOTE: As it is described above, CNG switching of vehicles has been identified during the TNA process as the highest priority in transport sector. Later developments confirmed the conclusion and intensive process of CNG switching of high mobility and high consumption vehicles started. The process is mainly driven by economic profitability and has reached the scale where the need for additional promotion through technology transfer does not seem necessary. The most important measures recommended by experts and the mitigation team have been realized. Therefore the relevance for TNA process of this technology was reconsidered and it was replaced by a candidate technology from Renewable energy subsector.

Chapter 6

Technology Prioritization for Renewable Energy

Hydro power is the single most developed and best supported type of renewable energy of Georgia. At the same time other renewable energy technologies are lagging in development and require special efforts for dissemination and deployment. Georgia is rich in unutilized solar, geothermal and wind energy potential[9]. Technically achievable wind power potential is estimated at 5TWh annually and about 2GW of capacity. Average number of sunny days is around 280 and with the modern solar technologies it allows effective use all year round. Wood is currently used in unsustainable way leading to deforestation of certain localities. At the same time the remains of forestry and agriculture are practically not utilized. There is an important potential in increasing the efficiency of utilizing these resources. There are significant geothermal resources, mostly in West Georgia that can be successfully utilized for industrial and residential needs.

Technologies in all these fields are analyzed and prioritized below.

6.1. Technology Option – Solar Energy

Only a negligible share of solar energy potential is utilized in Georgia. The prices for solar collector systems are high and there is a need for developing of this market. Solar water heating systems are mostly installed by commercial

[9]WEG 2008.

entities, few high income residents and donor funded pilot projects. With some exceptions, the PV systems are used only in remote areas where there is no electricity grid e.g. in remote mountainous villages and monasteries of border guard posts.

There are several technologies of solar energy relevant for consideration under TNA described in brief in the Table 1.7 below:

Table 1.7 - Technologies for Solar energy

#	Technology options:	Relevance to TNA
1	Solar PV panels for electricity	PV is used for feeding DC current to feed stand alone devices. The PV panels can be used in power stations, in buildings (integrated or mounted), in transport, in standalone devices, in rural electrification and solar roadway lighting. The technology is pollution free and can to some extent substitute electricity generated from other sources. However, in Georgian case electricity is mainly generated by cheap hydro, therefore expensive PV systems are less favorable.
2	Solar Water heaters for hot water supply	It is estimated that in Georgian conditions such SWH system can substitute traditional fuel expenditure up to 80% on average annually. Taking into account high lifetime of this system in long-run it can be profiTable1. investment. This technology is pollution free and gives possibility to sufficiently cut utility bills. Wide application of this technology can reduce country dependency on imported natural gas. SWH system applicable for urban areas costs on average 3000 GEL (1800$) while SWH system suiTable1. for rural area is twice cheaper, 1500GEL (900$). With presence of financing option this technology is profiTable1. investment and can be widely used in Georgia.
3	Solar collectors for hot water and space heating	This system is much more complex and expensive than SWH. It suggests using solar hot water for space heating. However, taking into account that in winter the weather is dominantly cloudy this system will not be able to fully substitute gas expenditures. The price of the system is so high that payback is larger than the lifetime of the system itself. Moreover, such systems usually require much space and in urban area it can be problematic.

The numerical values for prioritization were obtained by assigning the scores by development priority criteria in the range of 1-100 to each technology and weighing the results according to Table 1.4.. The results of prioritization scoring are presented in Table 1.8

Table 1.8 - Prioritization of Technologies for Mitigation – Solar energy

N	Technology Options/Criteria	Economic Feasibility	Benefits				Total Score
			GHG	Economic	Social	Environment	
1	Solar PV panels for electricity	6	16	15	9	14	60

2	Solar Water heaters for hot water supply	10.5	16	20	13	16	75.5
3	Solar collectors for hot water and space heating	7.5	16	13.75	10	17	64.25

As a result of preliminary prioritization the technology of **solar water heaters** was selected for further technical and economic analysis

Main vendors of SWH systems in Georgia were inquired and average price for closed and open SWH systems was calculated, 3000 and 1500 GEL respectively. Price of electric and gas heaters ranges between 150-450GEl. With savings in electricity or natural gas, solar water heaters pay for themselves within 6-20 years. And solar water heaters last between 15 and 40 years--the same as conventional systems--so after that initial payback period is up, zero energy cost essentially means having free hot water for years to come.

As it was suggested by experts, a closed system is mostly suitable for urban areas while an open system can operate well in rural areas. Economic calculations show that to compare to traditional way of water heating (gas or electricity), the open system is economically the optimal decision. However, in rural areas, residents usually use biomass to heat water. As for closed system, in long-run it is economically reasonable technology when compared to electricity, however when compared to natural gas its payback exceed lifetime. It worth noting though that gas is subsidized and its price does not represent all costs fully.

Under moderate estimations, market will consist of 60 000 systems in 10 years. However, if barriers are overcome successfully, this number can be significantly higher.

Compatibility with country development priorities

Country social development priorities

The technology can directly benefit individual households through the installation of solar collectors which will result in energy savings and lower expenditures

Country economic development priorities

Wider dissemination of this technology can support sustainable economic development of the country through increased economic activity, cost-saving for residents, job creation and increased budget revenues from economic activity. It also reduces dependency on imported natural gas and, therefore, increases energy security.

Environmental development priorities

Implementation of this technology brings economic, social and environmental benefits. One of the main benefits of this technology is reducing of consumption of natural gas and therefore, improved quality of local air and CO_2 emissions reduction.

Moreover, with steadily increasing prices on imported natural gas this contributes to reduction in government expenditures. In rural areas where people are likely to switch to natural gas this can be a good alternative for water heating.

Development of market of solar water heaters will cause job creation and establishment of different businesses, which are tax payers. Development of this sector will bring sufficient benefits and can increase budget revenues; however, at this stage it needs policy support.

Potential reduction in CO_2 emissions is presented in Table 1.9

Table 1.9 - Potential CO2 reduction

Main outcome	Total	
Potential market in 10 years	60 000	
Effective consumer number f. 10 years	36 000	
Potential 10 year CO2 saving	325	Thousand tons

As can be seen from the table, development of SWH technology can bring substantial reduction in emissions. Assuming that the technology will be deployed gradually over 10 years period it can save 0.32mln tons of CO_2 emissions. Of course the estimation is very rough and in case barriers are overcome successfully it can reduce CO_2 emissions even more.

For successful development there is a need for two main ingredients: abundance to stimulate innovation and competition to drive efficiency. Favorable environment (information support, regulations, tax subsidies, etc) can play as a push, after which the sector can grow by inertia.

6.2 Technology Option - Wind Power

Wind power is a technology to be promoted in Georgia mostly due to its technological benefit. There may be selected areas where the wind power would be more feasible than conventional hydro. However, in general it is considered to be more expensive than hydro power. At the same time currently there is no market in country for wind power development.

There are several options of wind power technology that were considered for TNA purposes. These are small scale off-grid, medium and large scale grid connected wind turbines. Summarized information is given in the Table 1.10 below.

Table 1.10 - Prioritization of Technologies for Mitigation – wind energy

#	Technology options:	Relevance to TNA	Priority
1	Small scale off-grid	This technology is mainly used in remote areas where there is no grid electricity. Due to little applicability this technology option has little GHG mitigation potential and therefore is not a priority for TNA	3
2	Medium scale grid connected	This technology option can be applied by businesses when the wind power site is located close to the consumption center. Freedom from transmission and distribution charges may render such solutions economical in certain cases. However such an application will necessarily have a limited extent.	2
3	Large Scale grid connected	This is a most economical option due to lower cost per installed capacity and higher potential for wind energy utilization due to installation of bigger turbines. Economies of scale may result in this technology being competitive with wide spread hydro power plants and may be able to justify the investment in road and transmission infrastructure	1

Therefore Large scale grid-connected wind power will be considered as a prime candidate wind power

Georgia

Economic parameters of chosen technology option were calculated in special model and the results are given in Table 1.11 below

Table 1.11 - Economic parameters of chosen technology option

#	Site	Total capacity	Capacity factor	Turbine size MW	Capital Cost (€/kW)	O & M Costs (€c/kWh)	Annual Output (GWh)	RR	10 Year Emissions reduction (thd T CO2)
1	Samgori	60	0.23	3.00	1100	0.5	120.9	8.3%	411
2	Skra	99	0.24	3.00	1200	0.5	208.1	7.8%	708
3	Kutaisi	99	0.24	3.00	1200	0.5	208.1	7.8%	708
4	Chorokhi	30	0.25	3.00	1250	0.5	65.7	7.8%	223
5	Sabueti	600	0.38	3.00	1300	0.6	1997.3	12.3 %	6391
6	Tskhratskaro	100	0.28	3.00	1300	0.6	245.3	8.6%	834
	TOTAL	992					2845.4		9,275

Calculations are made in separate excel spreadsheet.

One can see that the economic benefit of wind power is rather weak. The return on investment is between 8-12% which is below commercially available interest rates in Georgia.

Compatibility with country development priorities

- Wind power is a new technology for Georgia. Its introduction will pose higher requirements on maintenance and operation personnel. Therefore this will have a positive social benefit on technical knowledge improvement.
- For a small country like Georgia it will be difficult to jump-start the production of own wind power equipment. Therefore it will be imported. However, site and foundation preparation as well as electric installation and connection works will provide employment opportunities and contribute to country's overall business activity.
- Wind power in some locations can be competitive with small hydro power and therefore can add to economic competitiveness of the country.

- In certain locations wind turbines may have less environmental impacts than alternative hydro plants. Therefore they may be able to deliver environmental advantage as well.
- Additional wind power has a potential to contribute to country's energy security or export potential. This benefit needs to be analyzed in a wider context of energy sector development scenario.

6.3 Technology Option – Geothermal Hot Water

Georgia is rich in geothermal water resources. There are approximately 206 wells and 4 springs of geothermal hot water (GHW) with temperatures between 30 and 110^0 Celsius located in 44 deposits in Georgia. About 80% of this geothermal potential is located in West Georgia. The total theoretical thermal capacity of all geothermal sources at T0-250C was estimated at 300 MW of thermal capacity. Total achievable potential is estimated at 30% or 100MW of thermal capacity[10]. The temperatures of geothermal deposits are not very high and are mostly suitablefor heating and hot water supply rather than for power generation.

Technology options considered for inclusion in TNA assessment are summarized in the Table 1.12 below.

Table 1.12 - Technologies for Geothermal hot water utilization

#	Technology options:	Relevance to TNA	Priority
1	Space heating with geothermal water	Two studies have been conducted on the use of geothermal water for space heating. The study of Zugdidi central heating from Zugdidi-Tsaishi deposit has shown need for high investment and insufficient returns from such a project. The study of Energy Efficiency Alternatives in Residential Sector of Tbilisi has analyzed two technology options and shown that use of GHW is not economical to compare with natural gas. In both cases seasonality of demand for space heating does not allow fully utilizing geothermal energy potential. Therefore this option was considered as low priority for TNA.	**3**
2	Geothermal water for hot water supply	This technology option can be applied by businesses when the wind power site is located close to the consumption center. Freedom from transmission and distribution charges may render such solutions economical in certain cases. However such an application will necessarily have a limited extent.	**1**
3	Geothermal water use in agriculture & food industry	A system of agriculture complexes can be developed around the geothermal wells in rural regions. Potential use of geothermal energy can include the use for soil heating, fishery, paltry farms, fruit and tea drying etc. This might be a good candidate for challenging a pilot project. However it requires creation of unique	**2**

[10]N. Tsertsvadze, G. Buachidze, O. Vardigoreli "Thermal Waters of Georgia", Tbilisi, 1998

		and complex land, business and geothermal well ownership structure together with good business skills.	
4	Geothermal water for power generation	There is a discussion of using geothermal water for power generation in Georgia. This can be more realistic in Western Georgia where the geothermal energy potential is higher, though the geothermal water temperatures are still not sufficiently high (90^{0}C). This option requires further technical and economic study however has low relevance to TNA, mostly due to low potential of GHG mitigation.	**4**

As a result of technology selection the highest priority is assigned to use of geothermal water for residential hot water supply.

The following measures were identified as necessary for utilization of GHW potential in Tbilisi

1. **Commercialization of geothermal water distribution system** including
    a. Installation of metering & disconnection outside apartments
    b. Introduction of sound commercial procedures and policies
    c. Proper marketing, promotion and pricing strategies
    d. License conditions requiring development of resource (for new licenses)
2. **Use of heat exchangers** in low elevation high pressure wells to get rid of hydrogen sulfide access to apartments
3. **Install Geothermal Circulation Systems (GCS)** in the Lisi area to assure sustainable operation of geothermal wells

Number of studies and ongoing projects has prepared the ground for improvements in geothermal water supply and are intended to deliver practical results. E.g. installation of metering and disconnection system inside the building is intended under ongoing UNDP project[2]. However, it does not include connection to customers' internal piping. Installation of heat exchangers for hot water supply can become a part of future residential energy efficiency pilot project under NATELI project.

An attempt was made by the mitigation team to derive the costs of suggested measures based on previous studies (Annex 2). It is likely that 5 million USD investments in the system will allow improving the well productivity and assuring their sustainable long term operation; commercialize the distribution system and expand customer base to provide reliable service to the total of 10 thousand customers with reasonable economic benefit of the project. The ongoing replacement of internal piping for existing customers, can improve the potential economic performance.

Furthermore, farming is being developed and the complex is under construction at Lisi Lake. Negotiations are conducted with LLC "Lisi Lake" for supplying a large healing-recreational and residential complex around the lake, with full geothermal heating.

6.4 Technology Option – Biomass

Many countries are shifting the domestic heat supply from gas and electricity to renewable sources, among which the wood is most commonly used in the developing countries. Wood is a renewable source although its misuse can carry grave implications for the environment in general and for the forests in particular.

In Georgia the majority of population living in rural areas is heating their houses by fuel wood. Due to insufficient control over wood cutting, in many locations wood fuel can be obtained for cheap and in a way leading to deforestation. Annual wood felling for firewood is estimated by experts at 2.5 mln m^3.This is estimated to be above sustainability level by 0.5mln m^3. Excessive and poorly managed wood harvesting leads to deforestation of many localities and finally - to landslides, land erosion, loss of fresh water springs and biodiversity degradation and deficit of heating fuel.

Although fuel wood is the main source of heating in the most of rural areas, the wood stoves do not effectively provide sufficient heat. The efficiency of the most widely used wood stoves is 25-30% and moreover, they are often not safe. The decisive factor for choosing a stove is its initial cost. Although people may know about possibility of buying better stoves, but they prefer to minimize upfront costs. The inefficiency of stoves is further aggravated by poor quality of installation and interior weatherization, low awareness of consumers.

Wood logs are easily available from woods, while more efficient fuel types, such as pellets, chips and briquettes are not produced in Georgia on a commercial basis yet. The residues of wood industry as well as agricultural waste that could serve as a material for such more efficient fuels remain largely unused and only contaminate environment. The same happens in the cities where the residues of tree trimming are not utilized properly and are simply disposed off at the landfills.

Along with the increased deficit of wood as a fuel there is an ongoing process of gasification of Georgia's regions with the possibility of switching to natural gas for heating. The only limiting factor is the cost of gas to be paid by rural population. However, in baseline scenario it is expected that substantial number of households will switch to partial or full gas heating.

Unsustainable wood felling and the expected switching to gas for heating can cause substantial emissions in the coming years, unless the appropriate measures are taken to make the use of wood more affordable and available.

The potential of switching to gas and therefore the baseline estimation of its probability crucially depends on the economics of gas consumption and wood supply, which is quite sensitive to the cost of wood and gas. Therefore subsidized gas price can strongly affect the decision in favor of its use and corresponding increase of emissions.

The economic analysis including comparison of leveled costs of these technologies has been conducted in special spreadsheet files (Cf. Annex A2).

Some efforts have been done through several donor projects to encourage the use of these more efficient stoves. E.g. energy efficiency center, “Rural Communities’ Development Agency”, “Bioenergia” and others were trying to promote manufacturing and use of relatively more efficient stoves in different parts of Georgia.

Therefore, a high efficiency wood stove with modern design and combustion efficiency around 80% has been chosen as a primary candidate technology.

The comparison of lifecycle levelized cost of these fuels provides the grounds for comparison of these technologies and is presented in Annex A 2.4

6.5 Technology Prioritization for Woody Biomass

The technologies discussed above have been compared based on the scores according to TNA selection criteria. The numerical values were obtained by assigning the scores by development priority criteria in the range of 1-100 to each technology and weighing the results according to Table 1.4

Table 1.13 - Prioritization of mitigation technologies for energy efficiency in Georgia on a scale of 1 to 100

N	Technology Options/Criteria	Economic Feasibility	Benefits				Total Score	Priority
			GHG	Economic	Social	Environment		
1	Efficient wood stove for rural heating/cooking	13.5	14	17.5	20	18	83	**1**
2	High tech premium wood stove	7.5	6	12.5	8	10	44	**5**
3	Pellet production and burning	6	6	15	6	10	43	
4	Briquettes production and burning	12	15	17.5	10	14	68.5	**4**

5	Wood chips boiler	7.5	6	12.5	6	12	44	**3**
6	Dry fermentation	9	16	20	16	12	73	**2**

As it can be seen from the Table1.12the leading technology is efficient wood stoves (EWS) with 80% efficiency. These stoves can be cost-effective at reasonable price. Middle-income families can easily afford such stoves, however, a low-income families may need financial assistance mechanisms to purchase such stoves. Necessary measures are discussed in factsheet and woody biomass combustion report. This technology is included in priority technologies. As discussed in the Annex 2.4 it can save up to 0.5 cubic meters of wood annually through sustainable use of domestic biomass. Dissemination of this technology will support economic activity in the regions and contribute to energy security of the country as well as safety of population.
Stakeholders participating in discussion: R. Gamisonia, A. Bitsazdze, N. Lazashvili, N. Mgebrishvili, T. Kandelaki, G. Abulashvili, A. Geladze, G. Sopadze.

6.6 Technology Prioritization for Renewable Energy

As a result of previous analyses and studies, the comprehensive description of suggested renewable energy technologies was compiled in Technology Fact sheets prepared for the selected technologies. The weighting was developed by a mitigation team in consultation with the rest of TNA team and the final scores were agreed with the project steering committee and stakeholders.

Table 1.14- Prioritization of Technologies for Mitigation

No.	Technology Options/Criteria	Economic Feasibility	Benefits				Total Score
			GHG	Economic	Social	Environment	
1	Wind energy	6	12	17.5	6	14	55.5
2	Solar water heater	10.5	16	20	12	16	74.5
3	Biomass	13.5	14	17.5	20	18	83
4	Geothermal hot water	6	6	12.5	8	16	48.5

Therefore, the efficient biomass combustion was selected as a highest priority technology followed by the Solar Water heater technology. The final selection and scoring was conducted by TNA mitigation team in consultation with the following stakeholders: R. Arveladze, G. Abulashvili, G. Lazriev, A. Ramishvili, K. Dzodzuashvili, P. Janelidze, A. Zedginidze.

As a final result of subsector and technology selection process, subsectors and technologies were selected for further analysis and TAP development.

Table 1.15 – List of subsectors and technologies

Sub-Sector	Sub-subsector	Technology
Energy (Supply)	Renewable Energy	Efficient Wood Stoves
		Solar Water Heaters
Energy (Demand)	Residential and Office Buildings	Efficient construction

Chapter 7

Summary/Conclusions

Georgia

Several conclusions of the TNA process are in order for mentioning here:

- Energy sector and agriculture sectors are the most important emitters of Greenhouse gases in Georgia.
- Energy sector has been selected as most relevant for TNA. Three leading subsectors/groups of technologies for climate change mitigation include:
    - Energy consumption in residential and office buildings
    - Transport sector including various technologies in public and individual transport systems
    - Renewable Energy supply
- Energy consumption in residential and office buildings is a major source of GHG emissions and the subsector with important mitigation potential. Application of efficient construction technologies including integrated building design, energy efficient materials and construction practices, can limit further and is related to substantial technology.
- Transport is another most important source of emissions however since the technology transfer in transport sector successfully addressed through other ongoing activities this sector was not taken for TAP development.
- Fuel wood is a second most important indigenous energy source. There is a need to develop a strategy in this field in conjunction with forestry reform. Efficiency of fuel wood use is low and needs immediate attention in order to reduce unsustainable wood cutting for fuel. Introduction of Manufacturing and use of high Efficiency residential wood stoves; can help in improvement of fuel wood utilization and limit switching to natural gas consumption and increase of GHG emissions in near future. There is a need for state strategy in energy covering all energy types including fuel wood along with other types of energy.
- Three technologies recommended for TAP development are:
    - Manufacturing and use of high Efficiency residential wood stoves;
    - Efficient construction technologies including integrated building design, energy efficient materials and construction practices,
    - Solar water heaters for residential and commercial use. The results have been discussed and are endorsed by the Project Steering Committee.

    These technologies are related to a wide spectrum of economic social and political factors. It is understood that barrier analysis and development of Technology Action Plans for these selected technologies will reflect the need for technology actions for the whole groups of technologies in chosen subsectors.
- There is a need to develop a comprehensive technology data base for consumer and policy maker decision making.
- R & D institutions and their activities need to be developed in order to support local technology and know-how development.
- The above activities need to be conducted in the framework of developing a National Innovation System for technological advancement of the country.

Part II

Technology Action Plans

Executive summary

In accordance with TNA/TAP methodology the technologies selected in the Part I of this report are further analysed to develop market maps, conduct barrier analyses, develop enabling environment and derive the concrete Technology action plans for their deployment and dissemination. The interaction with stakeholders was also used to develop and suggest concrete pilot project ideas. Georgia is in early stage of formulating its policies towards climate change mitigation technologies, the most important barriers are generic rather than specific to each technology in different subsector. Therefore it was chosen to conduct the market analyses and develop TAPs for the highest priority technologies.

Three technologies from energy sector selected for the further analysis were:

- High efficiency wood stoves
- Solar water heaters

Efficient construction technology

Although the number of selected technologies is not big, it is understood that by covering the wide range of sectors and regulatory or policy issues the conducted analysis fairly represents the needs for further development of innovation system in Georgia.

The market map for High efficiency wood stoves (EWS) has few core actors including producers, dealers and consumers, however it requires high quality financial and technology services to be developed and is heavily dependent on the market environment, mostly availability and price of fuel wood and availability and price of natural gas. The natural gas is relatively cheap in Georgia and gasification is intensively being carried out in the regions of Georgia, thus threatening continued utilization of renewable fuel wood for energy. On the other hand although the fuel wood is the second most important indigenous energy source in Georgia, there is no state policy document for this fuel. Forestry reform provides mixed signals for the use of wood as a fuel.

The barrier analysis has revealed that lack of information and awareness is the most important barrier for implementation of EWS technology. This concerns awareness and information at policy, consumer manufacturer and general market levels. There is a need to develop and communicate the information to various stakeholders on importance of fuel wood for country's energy balance as well as information on efficient combustion, heat management, and designs of efficient stoves.

Second important barrier is financial barrier for manufacturers and consumers' short term vision preventing from investment in longer term durable benefits. Thirdly, technological barrier namely need for proper adaptation of the technology to specific region conditions, and lack of R & D for testing certification and standardization prevents spreading of EWSs technology and start of wide scale manufacturing.

Recommended policies and measures for overcoming the barriers to EWS technology are:

- Development of state strategy for woody fuel use
- Government should support innovation and R & D institutions in RE technologies.
- Standardization and certification
- Establishment of State agency for EE & RE development
- Cheap and business friendly special EE & RE financing sources
- Proper energy pricing and accounting for externalities
- Better donor coordination with local conditions is needed.

The second selected technology – Efficient construction has a much more complicated market map with several related markets and big number of market participants. These include architects and designers, developers, construction companies, efficient material suppliers, general real estate market, buyers etc. Introduction of efficient construction methods and practices is related to introducing awareness and know how to each of these segments. These stakeholders are operating in an environment defined by financial services, relevant construction standards and norms, to be supported by adequate measurement and certification capacity of R & D labs and institutions and influenced by energy prices and general economic situation.

Barrier analysis involving a group of stakeholders has shown that information barrier is a key barrier for this technology. Insufficient information and knowledge of architects, designers and constructors as well as developers and consumers does not allow the technology to develop and lack of adequate factual information at policy level does not support creation of enabling and creation of supportive policy and regulatory environment which is the second most important barrier.

The measures and policies to overcome this barrier include:

- Development of training and educational programs for specialists.
- Outreach campaigns and better coordination of donor programs
- Development of efficient R&D institutions with material testing and certification, building certification
- Sharing best world experience and practices
- Government needs to support innovation in RE and EE technologies.
- Introduction of building standards, certification and building passports that can be used on mandatory or voluntary basis
- Government support and dedicated EE & RE state institution
- .State strategy and vision in EE & RE technologies supported by relevant legislation.

The third selected technology – Solar Water Heaters has a more advanced market than EWSs: importer/sellers, importer/assemblers, local manufacturers, installers and consumers. Sometimes some of these functions are combined within one entity. Local manufacturing and assembly needs to be promoted in order the overcome the main barrier which is relatively high cost of the equipment.

The main factors of business enabling environment are: taxation regimes and import duties, energy prices and availability, cost of capital and interest rates on financial market, consumer awareness and preferences, government economic strategies and policies, R & D base for technology deployment and support, Donor projects and programs, general business environment. Use of SWH can be influenced by energy prices and stability of water supply.

Among the barriers the most important ones are financial and information barriers. High price of the equipment relative to population incomes and lack of reliable information about the potential benefits of technology for the consumer and for economy prevent its development.

The recommended measures for overcoming these barriers are:

Development of state strategy and vision in favor of climate technologies,

- Adoption of EE & RE legislation and establishment of state agency in charge of RE and EE development to support creating and dissemination of information to market participants.
- Establishment of efficient R&D institutions for technology testing and certification. R & D will provide feasibility studies, and develop manuals instructions and guidance on installation, technical characteristics, etc.
- Better coordinated and planned Donor programs with pronounced information component.
- Introduction of tax benefits and cheap financing schemes etc.

Based on barrier analyses, technology action plans have been developed for each of the mentioned technologies. The policies and measures are laid out with their associated timeframes and costs. The EWS and solar heaters are considered as market technologies that might be accelerated immediately, while the Efficient Construction technology requires more substantial time for know-how and skills development and therefore is considered as medium term technology.

These TAPs share some of the main measures and policies, including development of R & D institutes, setting up a State Agency for EE and RE, Introduction of tax benefits and cheap financing schemes etc. These measures require more state policy and institutional development. Therefore an essential part of TAPs is continued participation of Donor agencies, since the state is not yet prepared for leading the development of climate change mitigation technologies. An emphasis should be placed on developing the state functionality in this direction.

Chapter 1

Energy Sector - Efficient Wood Stoves

1.1 Preliminary Targets for Deployment and Diffusion of EWS

There is no accurate data available on the total number of wood stoves in use as well as on the blend of their types used by population. Inquiries have indicated that in highland relatively cold areas there is a prevalence of medium efficiency stoves used for cooking and heating, while in the relatively warm regions most of the stoves are low efficiency (25-30%). The expert estimate achieved by consensus at the stakeholder meetings indicates 30-40% of medium efficiency stoves and 60-70% of low efficiency stoves. The ambitious prime target of EWS technology deployment and dissemination should be elimination of majority low efficiency wood stoves and part of medium efficiency stoves and replacement them with the highly efficient models adapted to the local conditions and requirements. The preliminary target for efficient wood stove dissemination is also to eliminate the unsustainable portion of wood cutting for fuel equivalent to 0.5 mln cubic meters of wood. This is equivalent to about 100 thousand EWS deployed however due to competing trend of gasification this amount may not be achievable in first 10 years.

Therefore as a more realistic the preliminary target for Intermediate period was chosen is to overcome the information, technology and financial barriers and start large scale manufacturing of efficient wood stoves and to achieve the level of first 20 thousand efficient wood stoves deployed in the first five years of TAP implementation. This number would rise in subsequent years due to removed barriers.

1.2 Market Characterization for Efficient Wood Stoves

The Efficient Wood Stoves (EWS) are not produced on a wide scale in Georgia. The highest efficiency stove available on the market is the so called "Svanetian" stove that combines heating with cooking oven and sometimes water heating. These stoves are lacking lining of the combustion chamber, proper air intake controls and secondary combustion chamber. Typical efficiency of this stove is around 45%. Most widespread type of wood stoves on the market is the cheap low efficiency tin stoves that serve for a few years and have efficiency of 25-30%. The prices for such stoves vary depending on the season size and existence of oven compartment, but normally are in the range of $23-35compared to $180-210[11]for more durable and efficient Svanetian stoves. The prices for high efficiency stoves are in the same range as Svanetian stoves. The wood stoves are sold by retailers at construction materials and appliances markets.

There are several small scale craftsmen, who produce small numbers of high efficiency stoves mostly from used material and sell themselves. The prices of these efficient stoves are not high compared to Svanetian stoves, but lack of awareness as well as operation habits prevent from spreading of this technology. There are no specialized cook stoves on the market.

The inquiry with stakeholders working in this field shows that among operating stoves about 40% are Svanetian type used mostly in colder regions of Georgia. The other 60% are inefficient cheap stoves. The share of high efficiency stoves with efficiencies above 70% is negligible.

[11]Own market survey and inquiry with stakeholders

Georgia

The market for efficient wood stoves is undeveloped. There are few customers and suppliers aware of the high efficiency technology in wood combustion. The few producers of efficient stoves mostly sell their product directly to customers; therefore even trader sector of the market is very weak. The map of EWS market is presented in the Fig. 2.1

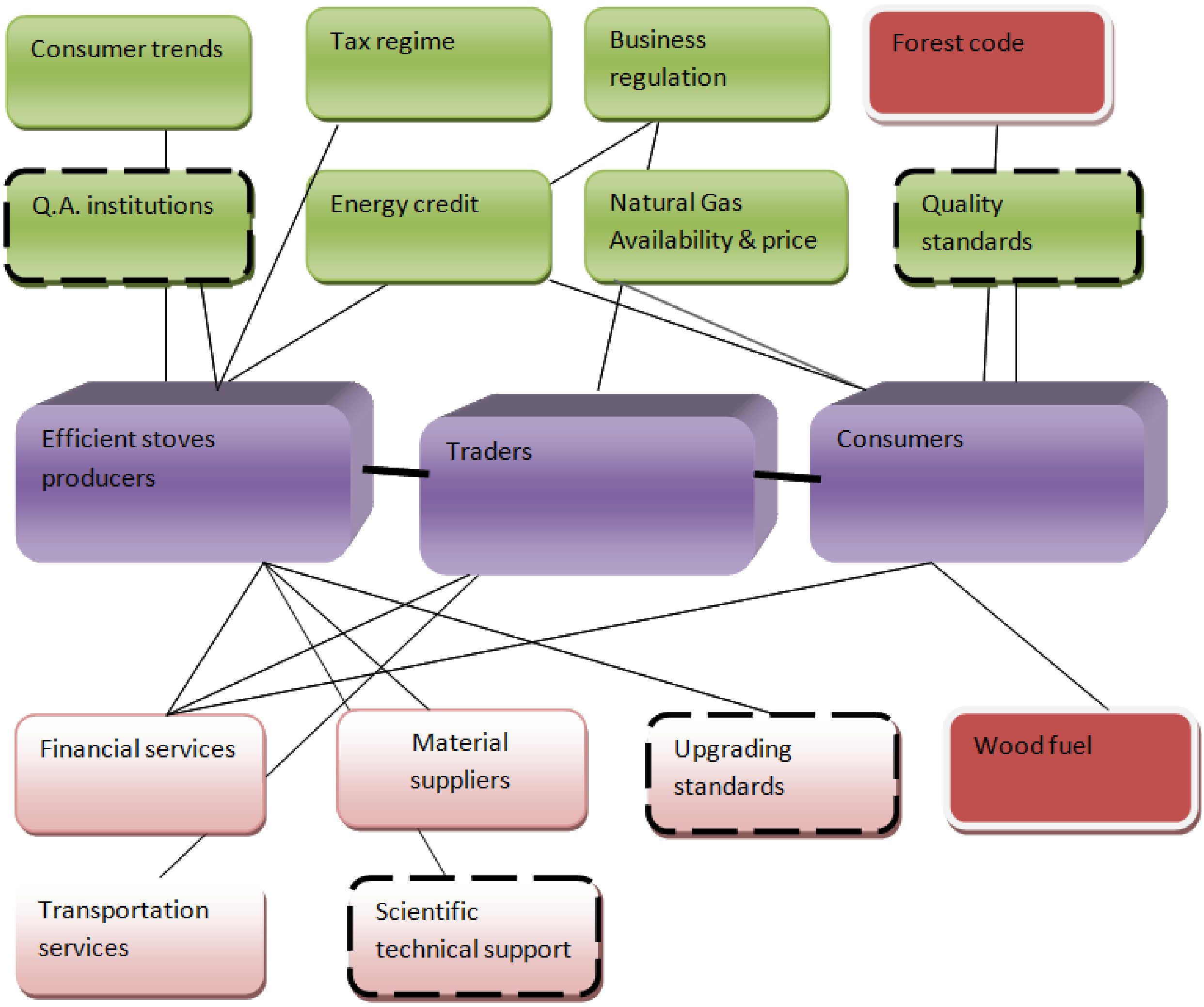

Fig. 2.1 - Market Map for Efficient Wood Stoves

Factors determining environment in the market are colored in green, while additional services for efficient market operation are colored in pink. The market chain participants are colored in purple. Boxes in dashes represent institution/services that are needed for efficient operation of the market but currently are absent. Additionally, there are two factors(colored in red)that belong to wood market, however, they indirectly affect market for efficient wood stoves as well.

It was assessed that for proper functioning the market requires financial services to be provided to potential producers and consumers as well as reliable material supply. Most important factor for EWS is the market for fuel wood and its prices which is largely defined by the forestry legislation. Development of the EWS technology also depends on gasification process and price of natural gas as well as availability of reliable information about technology standards and its performance. The presented market map was used for Barrier analysis for the technology.

The materials used for efficient wood stoves are not specific and can be found on the general market for metal and construction materials. At the same time proper deployment of the technology would require technical R & D advice and support for design adaptation to regional climate conditions/habitual and cultural preferences would be also helpful.

The environment for EWS market is also defined by factors: material prices, availability of cheap financing market, consumer preferences, government economic strategies and policies, R & D base for technology deployment and support, Donor projects and programs, general business environment.

In order to assess the barriers for EWS technology one needs to compare the current market with the desired situation. The anticipated picture of efficient wood stove market looks as follows:

- Local manufacturing of parts or complete EWSs on a wide scale
- Availability of information for EWS and their classification for ease of consumer choice
- Available financing for startup of manufacturing and purchase of SWHs
- Government support through various instruments including taxation, subsidies, information, education etc.
- Government promotion and possibly mandatory installation on new buildings
- Settled and unsubsidized wood and gas markets

1.3 Barrier Analysis for Efficient Wood Stoves

Main Barrier Categories

As a result of brainstorming at stakeholder meeting conducted in WEG office and own analysis the following categories of barriers have been identified as relevant to deployment and dissemination of efficient woodstove (EWS) technology:

1.3.1 Economic and financial

High cost of capital

Scarcity of cheap capital hampers the development of new technologies in Georgia. Banks are issuing the loans at high interest rate and only under firm collateral guarantee. There are few if any cases of project financing based on business plans. Therefore the risk is high for the entrepreneurs to take the loans and not to be able to repay the interest. This increases the risk and cost of startup for manufacturers.

This barrier is not appropriate for analysis since it reflects the macroeconomic reality in the country and cannot be properly addressed through technology actions specifically designed to support the efficient wood burning technology. On the other hand it can be removed within a pilot project through grant facility in order to demonstrate economic viability of EWS business.

Financing barrier

On consumer side, the cost of efficient wood stoves seems to be high for most of the rural dwellers. The expected price of about 300 GEL (about $185)is about 10% of their annual income and therefore not easy to spare even in case of knowledge of its benefits.

On production side, financing of new production technology is problematic for small workshops that are currently manufacturing the stoves. The needed additional finances to increase the capacity and introduce new material and design may be unaffordable for these small workshops.

There is a practice of consumer loans that might support the purchase of efficient wood stoves by end users; however this has been only extended to high price certified western stoves.

Inappropriate financial incentives and disincentives

There are no state incentives for development of climate technologies neither economic, nor financial nor organizational and informational. However there are no disincentives as well.

Neglect of externalities: Negative externalities (pollution, environmental damage) from conventional technology are not considered in pricing; positive impacts of climate technologies are not valued. Correspondingly, there is no mechanism for accounting for environmental benefits that might result from application of efficient technologies and highly efficient wood stoves in particular.

Gas is supplied to residents at below regional prices and as a result there is no strong incentive to move to more efficient wood burning technologies. Due to gas price being similar to wood burning price, the rural or semi-rural residents may switch to gas as a source for heating. Such a scenario needs to be considered as baseline in assessment of environmental benefits of introducing EWSs.

1.3.2 Market failure/imperfection

Underdeveloped market

There is an underdeveloped small market with all its wee problems due low demand. Because of weak market, economies of scale and sufficient experience, it is hard to achieve the efficient wood stove manufacturing and use. Low consumer demand, limited or difficult access to the international market makes distribution and sales costly. Stoves are sold in big regional centers or in cities and in rural areas where they may be most needed they are unavailable.

Efficient woodstoves are not available or distributed in regions and villages where they might be purchased by households. There are no distribution channels in place.

Well-established and cheaper alternatives

Technology is not easily available and visible in the market to allow the customer choice. The market is dominated by low efficiency cheap wood stoves and medium efficiency relatively expensive stoves. Moreover, the established view on the market is that the so called "Svanetian" stove of medium efficiency is the best possible design for wood stoves.

Lack of successful reference projects in country

There have been several donor projects distributing the efficient wood stoves, however their scale is indecisive and there was insufficient attention paid to adaptation to local conditions and needs. As a result the success is quite low on the country level.

1.3.3 Policy, legal and regulatory

No legal and regulatory support

Government interest and attention to climate technologies beyond hydropower has been limited up to now. Government vision, strategy and action plan as well as supportive laws and bylaws for climate mitigation technologies including energy efficiency and renewable energy technologies still need to be developed. There is no government entity tasked with development of the above concepts and documents.

Although many of the climate technologies have significant positive impact on country's development priorities, this impact is not properly valued and accounted for. Externalities for traditional technologies are not incorporated and the environmental and sustainable development benefits of the climate technologies are not accounted for.

Government's liberal approach to market economy has resulted in abolishing standardization and certification in various fields. Therefore additional effort will be needed in order to accommodate the needs for standardization, design certification and quality control of EWSs within the government policies of open market.

Although fuel wood is the second most important indigenous energy resource in the country, a comprehensive strategy and vision of its use still need to be developed. The ongoing forest reform is supposed to define a more clear vision of expected availability and prices of the fuel wood and other types of woody fuel in medium and long term. Absence of such a vision hampers the investment in efficient wood combustion technologies by producers as well as customers.

1.3.4 Network failures

Weak connectivity between actors favoring the new technology

Stakeholders in EWS technology are dispersed and poorly organized. Donor projects are lacking coordination with the government authorities as well as with each other. Experiences of various projects are not analyzed and accounted for.

There is insufficient cooperation between industry and R&D institutions that would allow easier deployment of EWS technology.

These tasks naturally must be undertaken by state agency in charge of climate technology development once such an entity will be created.

1.3.5 Institutional and organizational capacity

Need for state agency for EE and RE development

There is a need for a government agency that would take the issue of efficient wood stoves to policy level and incorporate it in energy planning. Currently the government is mostly preoccupied with high scale energy projects and has no resources allocated to support most of small scale climate technologies. There is no government agency in charge of energy efficiency and renewable energy development. The functions of the Ministry of energy and natural resources in this respect are mostly declarative and no mechanisms for their implementation are in place. Therefore there is no material government support for deployment and dissemination of EWS technologies.

Donor projects are not properly coordinated and aligned to the interests of regional development or other development priorities of the country. There is a lack for institutions to promote and enhance market by information outreach, promotion and lobbying. The commercial market players like ESCOs are not developed.

These issues also might be taken by government agency for EE and RE development.

Lack of institutions to support technical standards

There was limited attention and appreciation of R&D role in technology adaptation and deployment. Few existing R&D organizations and facilities (mainly Georgian Technical University) are either not mobilized or not properly equipped. Lack of programs in efficient woodstove (as well as other climate technologies') adaptation prevents the development of technical standards that would serve as benchmarks and support market development.

1.3.6 Human skills

There is a good base of theoretical engineering knowledge in Georgian Technical University. However, practical skills and knowledge necessary for market adaptation need to be developed further. There is a need for domestic consultants knowledgeable in modern designs and operation principles of EWSs that would train local manufacturers and advice promotion agencies.

There is a lack of entrepreneurial approach in the market. Relatively low profitability and underdeveloped market leads to perception of low returns. In case of introduction of efficient wood burning technology there will be sufficient capacity for production and distribution.

1.3.7 Social, cultural and behavioral

Consumer preferences and social biases

Consumers in highland locations are accustomed to sound of relatively more efficient woodstoves and use them regularly. On the other hand in relatively low, warmer locations the woodstoves are not traditionally a part of interior. Therefore, the size and exterior appearance of stoves have to be attractive.

Short term interests

Prevalence of short term interests in decision making. Together with funds' availability, short sited attitude is traditionally an obstacle, for investment in relatively more expensive but more cost effective technology.

New product

Due to inadequate information manufacturers do not have the information about possibility of improvements in efficiency of their product. Low awareness is combined with traditional attitude of insufficient attention to technical information, details of efficiency and observance of technical guidelines.

Required discount rates are even higher for customers who have a strong preference for the money they have today over the same amount of money tomorrow; in particular, private manufacturers and low income population have a short economic horizon, while utilities have a longer horizon;

1.3.8 Information and awareness

There is poor dissemination of information to technology users as well as producers on potential product, its benefits, costs, financing sources, potential project developers etc.

The donor projects conducted by various NGOs are not sufficient for market turnaround. There is no adequate R & D support and there is a need for more substantial specialized market development agency or a dedicated decisive project to create sufficient awareness and expectation of the new technology.

The manufacturers of wood stoves as well as consumers are mostly unaware of the potential for improvements in design to achieve efficient combustion.

There is little attention paid to installation and building weatherization that can add to efficiency of wood energy utilization. Designs and drawings of various efficient wood stoves that might be adequate to the specific needs of different regions are not readily available and need to be adapted to local conditions.

The population is not properly informed about the basic principles of efficient utilization of wood fuel, including the basics of combustion, heat transfer, living space weatherization etc.

1.3.9 Technical

Technology adaptation

Technical problems are mostly related to adaptation of EWS technologyto local conditions and choosing the right standards appropriate for different regions, taking into account local preferences (preferred use, fuel, seasonality, type of installation, etc.).
Even traditional size of wood logs or woody waste can be an obstacle for the use of efficient stoves. The small size burners have higher efficiency; however the logs are traditionally cut in big sizes. Therefore a change may be needed to tradition of fuel wood cutting or to change the design of stoves so that they accommodate the larger wood logs and other waste. The alternative solutions can be to introduce cutting devices that would help to cut own tree cuttings into smaller sizes.

Developing adequate design of efficient stoves

Some woodstoves due to their large size do not conform to interior, require too much place. In other cases people prefer to have the stoves next to the walls. To address these issues there is a need to analyze local conditions and suggest most appropriate designs.

Research and Development

Lack of R &D activities in this field resulted in lack of adequate standards, certification, and quality control, as well as low awareness of manufacturers and consumers of the opportunities provided by efficient wood stoves.

1.4 Logical Problem Analysis for EWS Barriers

From the above list of barriers three key barriers were selected based on stakeholder discussion and brainstorming of mitigation team: information and awareness barrier, market adaptation and financial barrier. For each of these key barriers the logic problem analysis was conducted.

1.4.1 Information and Awareness Barrier

Fig. 2.2 below represents the analysis LPA of information barrier

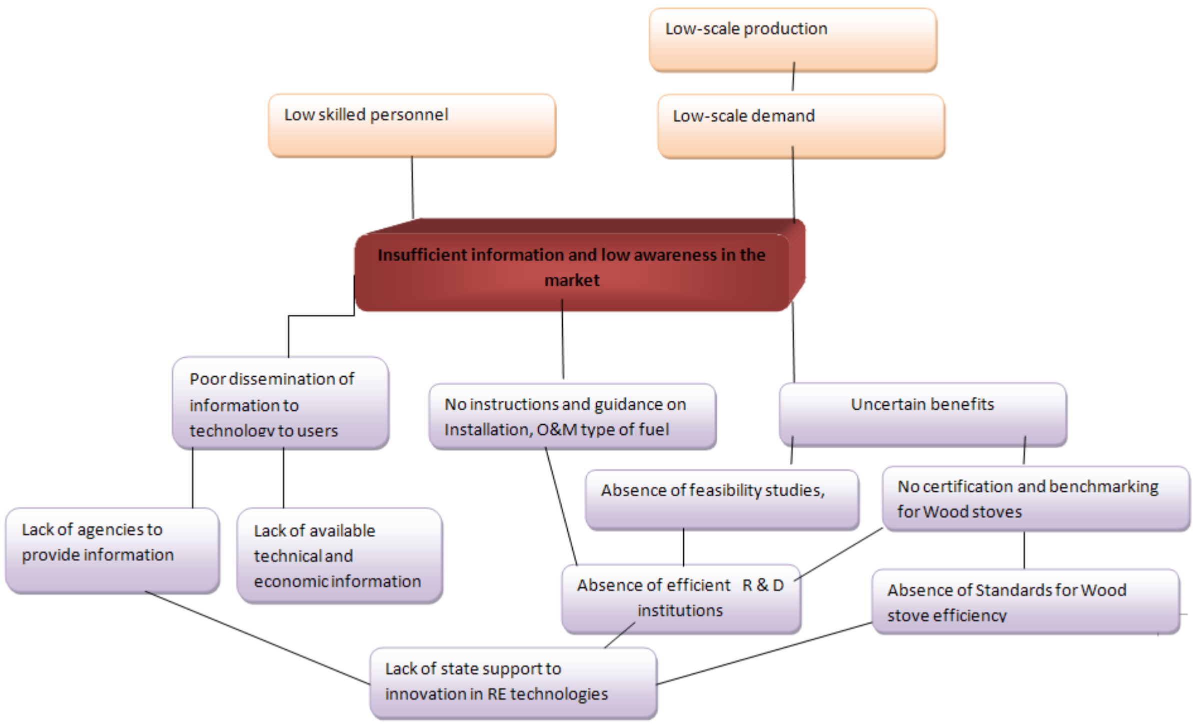

Fig. 2.2 - LPA of information barrier

Lack of information and low awareness is one of the most important barriers preventing demand and supply growth in the market. As a consequence inefficient stoves dominate the rural heating with all negative effects described before.

Manufacturers are not aware of the real efficiency of their product. The consumers do not know what the necessary attributes of high efficiency stove are. The field visit to stove vendors showed that the stoves sold in the market are lacking basic features necessary for efficient combustion including air inflow control, insulation of combustion chamber, air preheating etc. Most of the stove manufacturers are small craft shops with limited technical ability to improve the efficiency of their stoves. Moreover, there is no testing lab, university research program or other capability to determine the actual efficiency of stoves.

There is very limited knowledge information on efficient wood burning stoves used in other countries. The results of several implemented donor projects remain largely unused. There is no dedicated institution or agency that would be systematically working on spreading this knowledge among producers and consumers.

R & D is needed to conduct feasibility studies, and develop instructions and guidance on installation, O&M etc. At present these activities are not conducted. There are certain R&D institutions, like EE and RE laboratory at Georgian Technical University. However, it does not have a program or agenda devoted to development of efficient wood burning technologies in Georgia. Ideally such an entity would be involved in testing and adapting different types of efficient stoves and proposing standards as well as certification of concrete product. Government needs to support R&D institutions and/or donor programs for above tasks as well as to disseminate the developed information. This would allow both producers and consumers to have sufficient information on this technology for decision making.

Market assessment feasibility study and development of a business case might be important first steps to motivate and provide incentive for innovation. From the other side instruction and guidance on installation and O&M are mostly needed for consumers to make them better understand the technology and its exploitation process. Correct installation and O&M could increase efficiency of the stove and its lifetime.

The root cause of this barrier is as follows: since there is lack of state support to innovation in climate technologies there are few agencies to provide information, no efficient and active R&D institutions, no standards for wood stove efficiency and as a result there is poor dissemination of information to technology producers and users. Moreover, without efficient R&D institutions there are no feasibility studies and no certification and benchmarking for wood stoves. As a result benefits of efficient wood stoves are not evaluated fully and are uncertain.

1.4.2 Financial Barrier

The Fig. 2.3 below represents the LPA of financial barrier

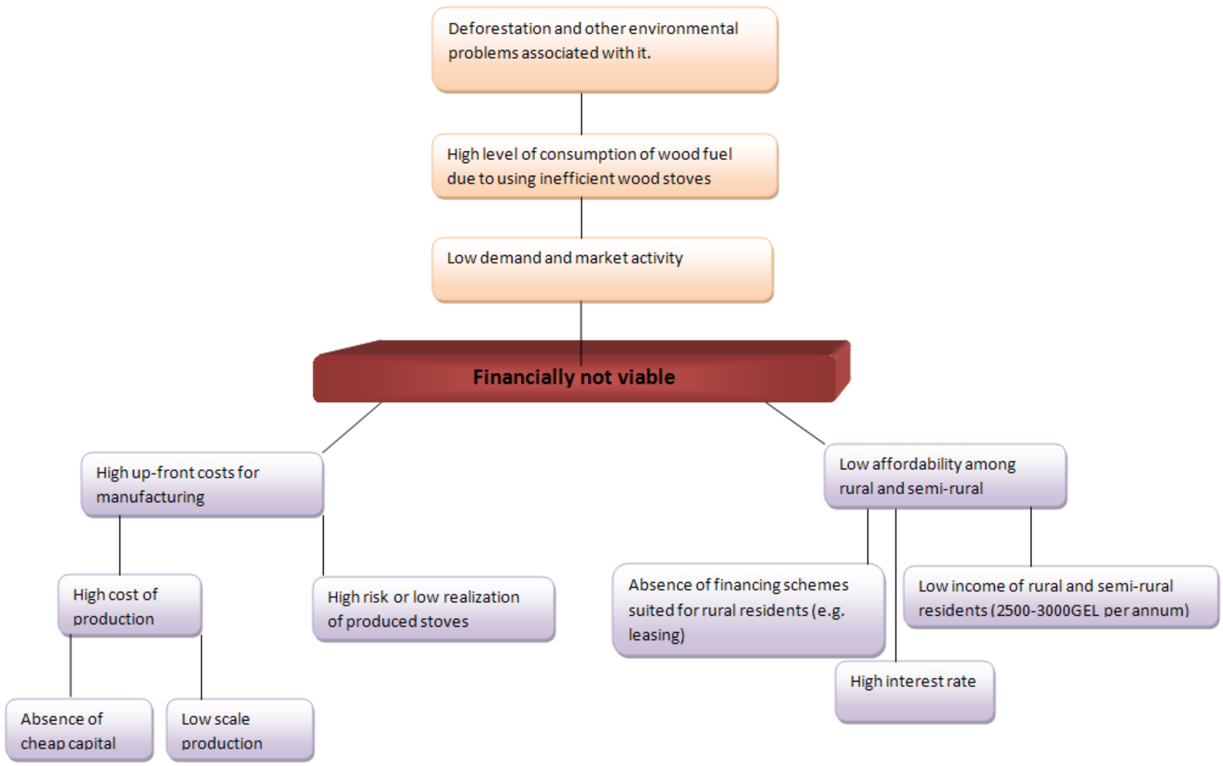

Fig. 2.3 - LPA of Financial Barrier

Affordability of EWSs for many rural consumers is another major barrier. The financial obstacle for consumers derives from low income of rural households combined with absence of cheap lending. Rural residents are mostly the low-income people earning $1200-1800annually. Taking into account all other expenses of rural consumer, price of an efficient stove, $150-180l, is a relatively big investment which the majority are not willing to pay. There are no banking services in villages to provide consumer loans, besides; the high interest rates make existing lending mechanisms unattractive for rural consumers.

Low demand results in a high market risk of low realization of produced stoves.

Relatively high cost of production results also from low scale of production, high market risk of sales, absence of special cheap financing schemes and high interest rates in the market. Georgian banks are reluctant to provide project financing, thus making starting investment even more difficult and risky for entrepreneurs.

These factors lead to high up-front cost of manufacturing from one side and low affordability by rural and semi-rural residents from the other. This gap constitutes the essence of financial barrier and prevents deployment and dissemination of efficient wood stove technology.

Certification and testing is needed in order to make the new technology eligible for donor supported sustainable energy financing schemes.

1.4.3 Technology Adaptation

The Fig. 2.4 below represents the LPA of technical barrier

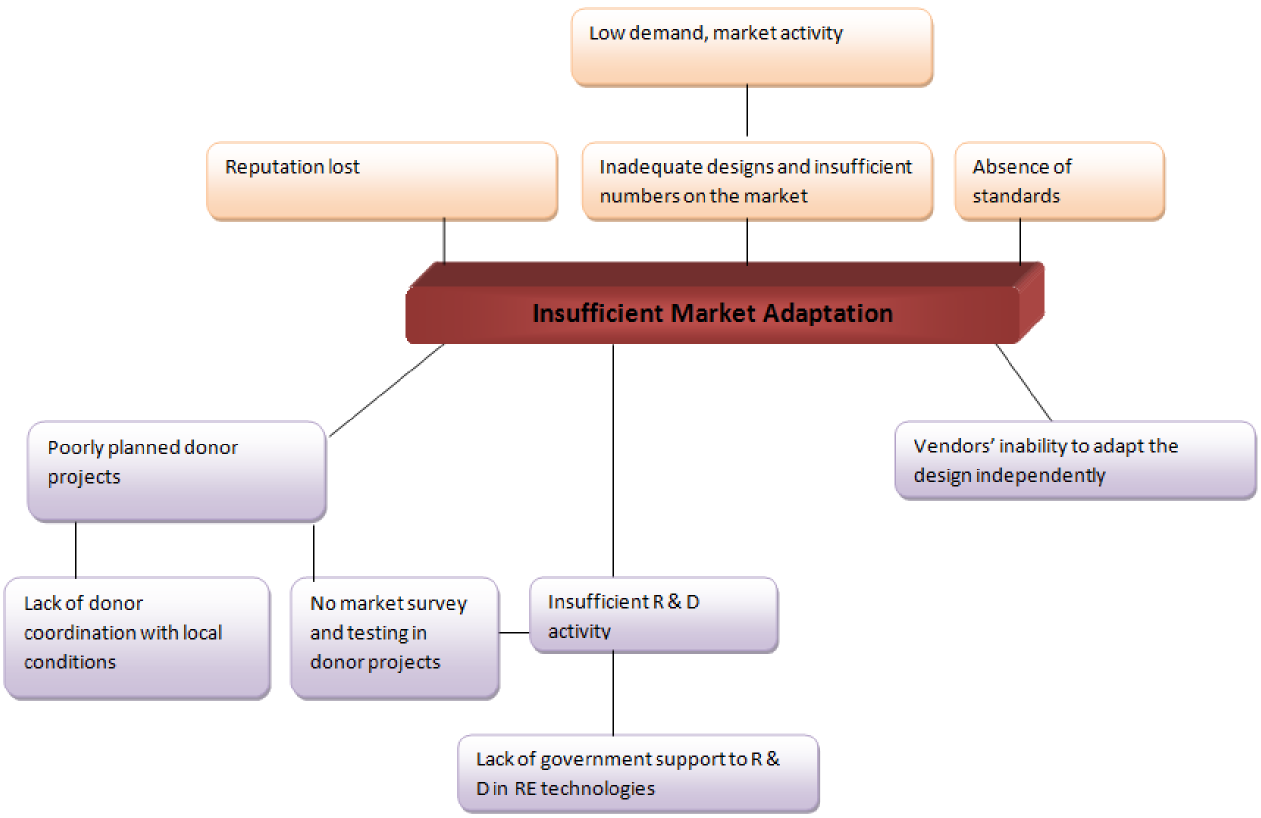

Fig. 2.4 - LPA of Technical Barrier

Another key barrier for EWS technology deployment and dissemination is a technical barrier related to insufficient market adaptation. Technology is not being adjusted to local conditions and consumer preferences. Insufficient consideration of consumer preferences while suggesting the efficient stoves has impacted negatively the outcome of some donor funded projects. As a result, the reputation of efficient stoves has suffered in some of the regions – even with relatively cold climate[i].

There is a need to adapt the design of EWSs to fuel types available in different parts of Georgia, including, agricultural waste, cuttings from vineyards in the east or laurel cuttings in the west. Consumer preferences of cooking versus heating and/or combined use, as well as preferences for size exterior design and place of installation have to be considered and taken into account.

The dissemination of EWS might be accelerated by establishing the recognizable standards of design and efficiency adapted to different parts of the country. Certification of the EWSs to these standards would help the producers to keep up with the parameters and gain consumer confidence and acceptation of the new product.

Lack of government support to innovation in new RE technologies causes insufficient development of R&D institutions that should conduct the research and establish standards for subsequent certification of the stoves. This problem was discussed also under description of Information Barrier.

As a result of absence of standards and effective R&D institutions that would provide training and information support, most of the potential manufacturers/vendors remain ignorant of the opportunities in efficiency improvements and are unable to adapt the designs to local conditions independently. This is the result of low skilled personnel and individual producers. There is certain design of efficient stove on the market, but its characteristics do not fully meet the local conditions. For instance, rural resident would prefer efficient stove to be able to operate with different size of wood logs and even with wood waste. At this stage, the most popular efficient stove "svanetian" does not possess this ability.

Another important aspect is the lack of donor coordination with local conditions. Usually donor projects do not have commercial interests and therefore are lacking consumer focus. Technology which is insufficiently adapted to local conditions causes consumer dissatisfaction with the new technology and blocks its dissemination. Donor projects need to be coordinated with each other and experience shared across the donor community and involved NGOs. This can be achieved by better coordination from state agencies and involvement of local authorities who know better the local conditions.

1.5 Overcoming Barriers

1.5.1 Information Barrier

In order to overcome the barriers and create enabling environment for the chosen technology the following measures need to be taken and the following goals achieved:

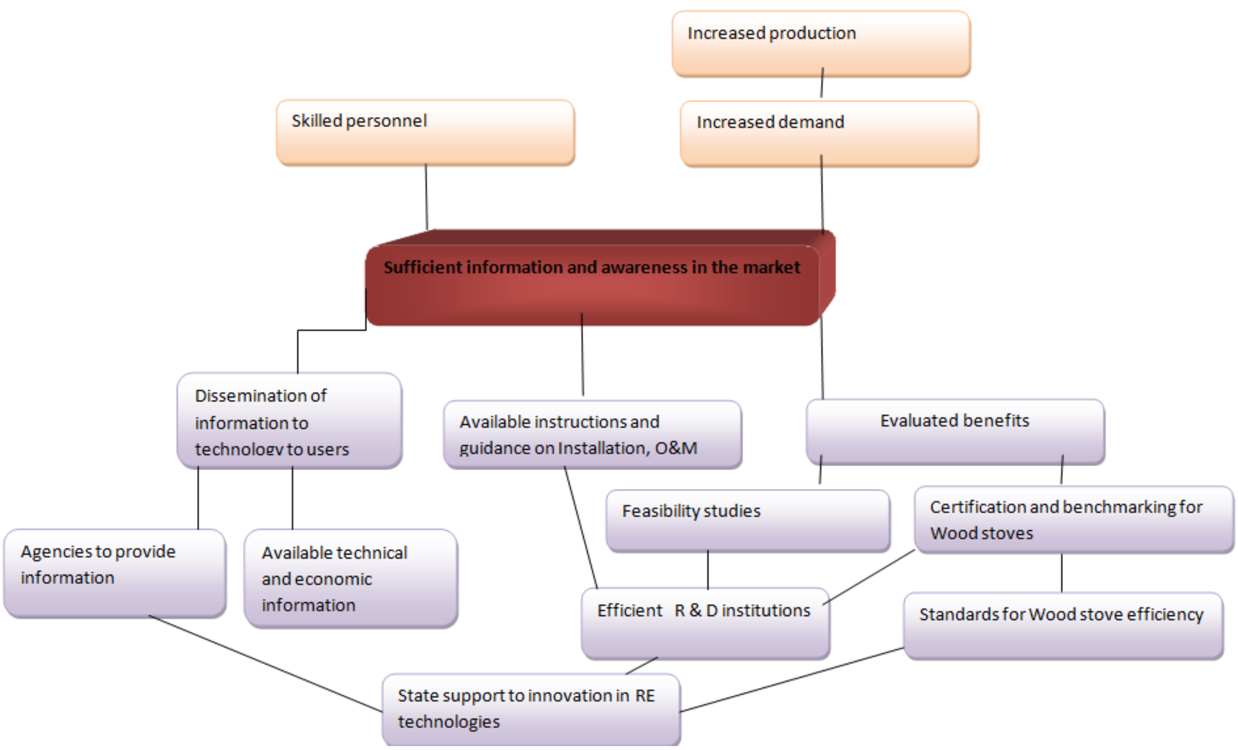

Fig. 2.5 - Overcoming information barrier

Information barriers could be overcome if the following measures are implemented.

- Stable and sound state strategy for woody fuel use needs to be developed and harmonized with forestry reform to define long term conditions for the efficient use of this energy resource in regional context. This would create long term basis for decision by potential producers to invest and consumers to make their choice between EWS and other means for heating
- State should support innovation in RE technologies. It should assist/ establish and fund if necessary R&D institution working not only on efficient wood stoves but on renewable energy and energy efficient

technologies in general. Such an entity would provide the information and technology support support to producers and consumers.

- R&D institutions need improvements to become more efficient (coordination, financing, technical equipment, etc). Such institution should provide market and its participants with necessary information on technology, such as feasibility studies, instruction and guidance on installation and O&M, as well as certification of existing stoves, test results to verify whether they correspond to standards. These institutions could also conduct training activities for producers' personnel.
- Standards for wood stove efficiency are to be developed and approved. Such standards could be set by standardization agency and serve for benchmarking of wood stove performance. The standards shall not be mandatory but would provide the reference information and benchmarks for consumer choice
- Agencies providing information (EE & RE state agency) should be established, or the existing agencies should be stimulated to widely disseminate the information about efficient use of fuel wood including the efficient stoves, weatherization, heat exchange basics etc. The mission of such agencies is to disseminate existing information provided by R&D institutions, to adapt it for ordinary users and make it easily available. Agency could distribute leaflets, books, brochures, conduct small seminars and trainings on O&M develop a website, etc.

  As a result of these measures the demand and production will increase with more qualified and knowledgeable personnel and consumers.

1.5.2 Financial Barrier

The ways of improving financial viability of efficient wood burning stove technology are presented in the Fig. 2.6 below:

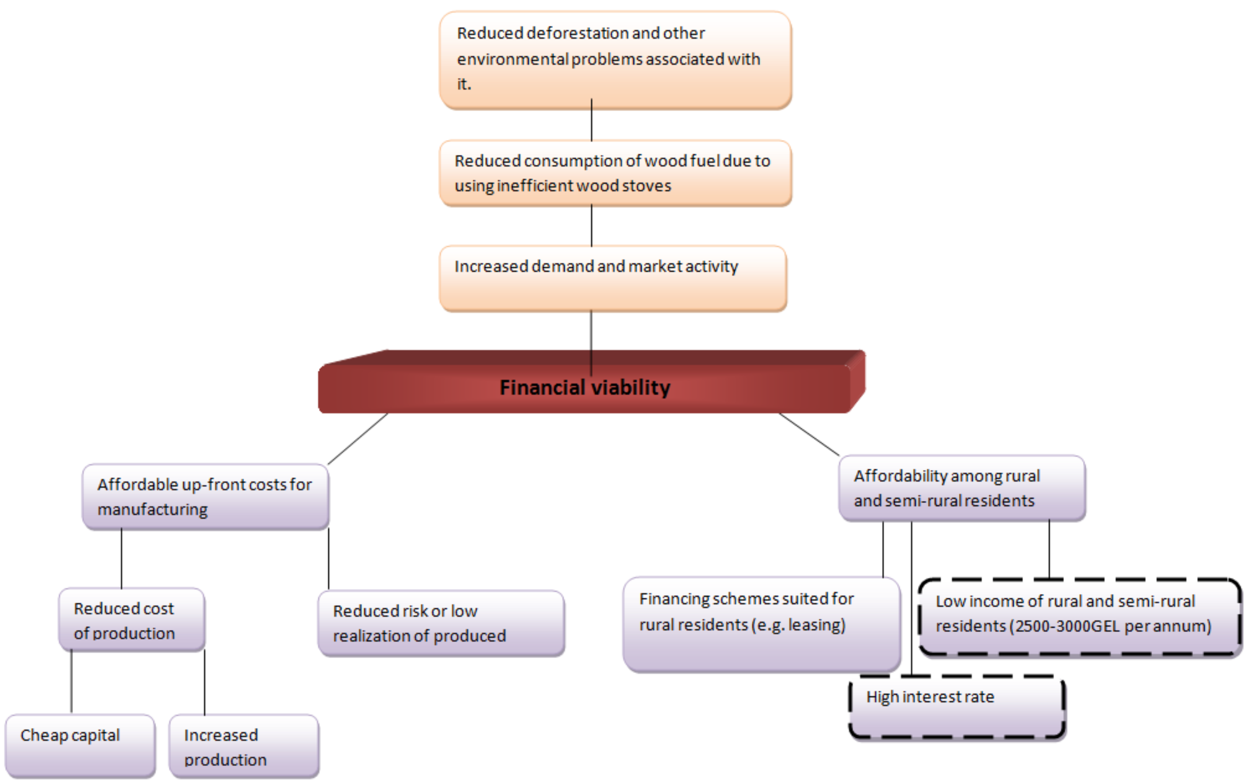

Fig. 2.6 - Overcoming financial barrier

Financial barrier could be overcome if the following measures would be implemented

- Larger scale production that can be achieved by overcoming of information barrier contributes to reduced cost of production; however, presence of cheap capital is also necessary to reduce cost of production. Cheap capital can be achieved through simplified scheme of obtaining a loan (no collateral), special lower interest rate for starting businesses of efficient technologies, etc.
- In order to take the risk of large scale production the manufacturers need to be assured in sufficient sales. This can be achieved through financial support and promotion of EWSs
- Special financial schemes should exist for rural residents, such as for instance, leasing and low interest loans . Such schemes will give possibility for rural residents with small income to smooth their expenditure associated with purchasing of new efficient stove. This would help increase affordability and ultimately adoption of EWSs even on the background of low income that cannot be changed in the framework of this program.

High interest rate and low income of rural residents are rather external factors and can be hardly changed through technology action plan.

Positive externalities of overcoming the information barrier is the increased production which contributes to reduced cost of production and increased demand which lowers risk of low realization of produced stoves.

Overcoming of financial barrier leads to increased demand for efficient stoves and market activity. This means lower consumption of wood fuel and will help to tackle environmental problems associated with deforestation.

1.5.3 Technology Barrier

Technology barrier can be overcome as shown below in Fig. 2.7

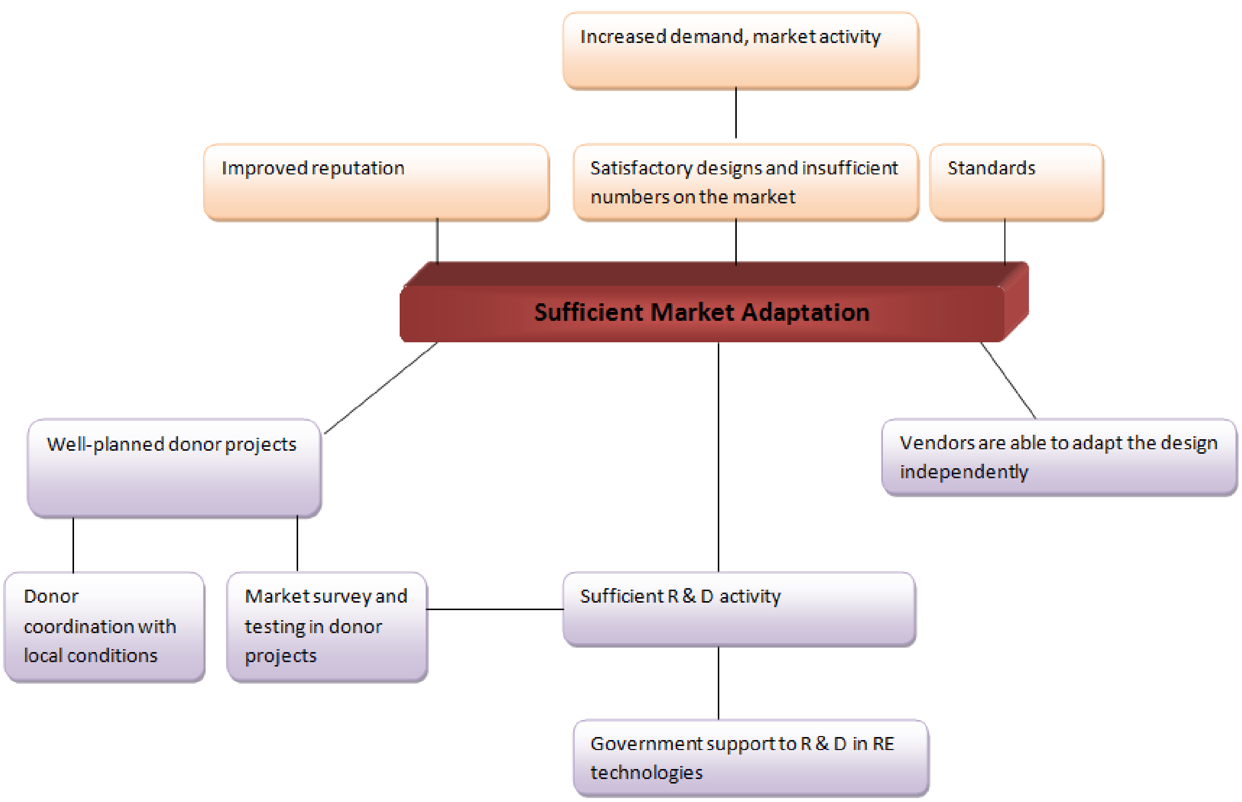

Fig. 2.7 - Overcoming market adaptation barrier

In order to overcome market adaptation barrier the following measures are needed:

- Government support to R&D in renewable technologies is needed. It will stimulate R&D activity to develop recommendations for particular regions in Georgia and to develop documentation including: general information on efficient wood use, characteristics of particular wood stoves, recommendations and guides for installation and operation of efficient wood stoves. Conduct testing and certification of various efficient stoves, support manufacturers in improving their design etc... With existing standards and certification procedures vendors will have incentives and ability to adapt the design of efficient stove independently, in conformance with consumers' needs and preferences.
- Better coordination of donor projects with local conditions is needed. Survey of local preferences and follow up monitoring should be made an essential part of these projects in order to enable choosing the right set of designs for various regions. Communities through better interaction with local governments. The projects should be aimed at bringing the technology and knowledge of its proper use. More emphasis should be placed on sustainability of the results. Closer coordination with local communities and local governments is an important factor for success.

Market and consumer preference surveys need to be conducted in each potential region that would reveal the local fuel and consumer preferences and help in adapting the design. Such surveys should be also used for two way communication to inform the consumers about the heat management and principles of operation of efficient wood stoves once the barrier is overcome it will gradually recover the reputation of efficient stoves since satisfactory design and functions of efficient stoves will be developed and implemented. All these together will lead to increased demand and market activity. `

1.6 Technology Action Plans for the selected technologies

Based on the above barrier analyses the attempt was made to develop more concrete measures that would support the deployment and dissemination of selected technologies. Efficient wood stove is a short-term technology that can be immediately introduced to the market. However, the market for efficient wood stoves is to be developed to make the technology more affordable and available for consumers.

Tables 2.1- below summarize the technology action plan for EWS technology.

Georgia

Table 2.1 - TAP for efficient wood stoves

Measure	Priority	Objective	Implementing Agency	How should they do it?	Time scale	Monitoring, reporting and verification	Estimated costs
1	2	3	4	5	6	7	8
Stakeholder Network							
Arrange networking between Donors, NGOs, Local authorities, community representatives	1	Specify the problems & issues and develop action program	NGOs Donors	government supported workshops	1-2 years	Number of workshops, reports	$20K
Networking of local authorities and communities with experts and suppliers	2	Assure dissemination of EWSs and feedback from users	State EE & RE agency (to be established)	regular feedback from municipalities	2-4 years	communications and comments from regions	no cost
Arrange consumer networking and information exchange	2	Facilitate information exchange and market activity	NGO project	websites and forums	1 year	number of posts, participants, user activity	$10K
Policies and Measures							
Information campaign	1	Increase the awareness of policymakers and public on efficient combustion	Donors/NGOs	TV, press, internet, high level lobbying	1-2 years	number of publications and broadcasts	$80K
Establish standards and classification	1	Standardize the commodity for easy market penetration and create material for lobbying and information campaign	R & D institutions under donor funding	design review and field testing	1-5 years	Defined standards	$80K
Establish the Efficient Wood Burning State Program	2	Lead and coordinate the deployment and dissemination of the new technology	State & Donors with NGOs	Within the general RE strategy	1-3 years	Program activities, initiated projects, etc.	TBD - consists of other activities
Develop state strategy for fuel wood use as a part of EE and RE strategy	1	Create supportive environment for EWS market	State with donor TA	Targeted project with participation of stakeholders and wide publicity	1-2 years	State strategy adopted	$80K
Develop and adopt RE Law	2	Create supportive environment for SWH business	Donors & State agencies	Through participatory law drafting and lobbying program	1-2 years	Law adopted	$100

Georgia

1	2	3	4	5	6	7	8
Establish R & D centers including hardware, personnel and programs	1	Assure expert support to vendors, consumers, develop cost benefit analyses	State, Educational & research institutions	Technology Centers (Techno-Parks)	2 years	Technology reviews, feasibility analyses, equipment testing and classification, guidebooks and training courses	$200K
Organizational & Behavioral change							
Establish EE & RE state agency	1	Coordinate implementation of RE strategy and action plans	State with donor TA	Through innovation system support programs	2 years	Agency endorsed by parliament/governmen t	NA
Introduce wood stove program for R & D (GTU lab, Technology Center)	1	Provide consultancy service for the Efficient Wood Burning Program and stakeholders	State and R &D institutions	In the framework	1-3 years	program activity report	$70K
Market, system support, financial services							
Cheap loans & Revolving funds	1	support market penetration of SWHs	Donors	Special credit lines and revolving funds	1-3 years	amount of subsidies	TBD
Tax breaks and subsidies	2	Make technology more affordable	Government & Donors	To reduce tax payments either through providing subsidies or through temporary reduction in tax payments	2-3 years	amount of tax breaks	TBD
Grants	2	Support producers of efficient stoves and make them more competitive on the market	Government & Donors	provide grants to producers of efficient stoves to make such stoves more affordable	2-3 years	amount of tax breaks and effect on technology penetration	TBD
Skills training & Education							
Guidelines and training material for consumers	1	increase awareness of consumers	R & D institutions under donor funding	involve world experience	1-2 years	information material available in Georgian	$40K
Local authorities & communities	2	Informing about efficient wood burning	State agency	leaflets, booklets, school programs	2-4 years	amount of educational material	$50K
International Cooperation & IPR							
Connection of international and local engineers & experts	1	Introduce state of the art technology knowledge	donors/state/ EE & RE agency	TA program	1 year	program activity report	$50

The expense figures are rough cost estimates to be made more precise at the stage of more detailed task planning

Chapter 2

Energy Sector - Efficient Construction Technology

2.1 Preliminary Targets for Efficient Construction Technology

The preliminary targets for the sustainable construction technology is set based on the current rate of new construction of 2mln sqm annually and estimated energy savings of 50% achievable per square meter of new construction [12]. The share of sustainable construction in new buildings was evaluated by mitigation team in consultation with stakeholders to achieve 60% of all new buildings constructed annually by the end of 10 years. The share of sustainable buildings in current construction is negligible and was estimated as 1% of all square footage constructed annually. Based on this assumption it was derived that in case of implementation of necessary measures for promotion of efficient construction technologies 6.1 mln sqm of new efficient buildings shall be constructed in ten years providing the saving in CO_2 emissions of 90 thousand tons.

2.2 Market Map for Efficient Construction Technology

Efficient (sustainable) construction includes the following elements of green construction:

- Use of renewable for heating, cooling and electricity;
- Improvements to the building envelope, including materials, natural ventilation and day lighting; and
- Improvements to building services, including heating, mechanical ventilation and air-conditioning.

When considering the sources of CO2 emissions from buildings, the -called 'life cycle CO2 emissions' of building should be taken into consideration, such as emissions related to production of building materials, as well as downstream waste disposal from construction and renovation of buildings. Technologies and measures which are aimed at reducing the use of energy in buildings could have several advantages, such as lower energy bills, increasing comfort of living or working, and reduced impact on the environment, including reduction of CO2 emissions13.

Below we concentrate on sustainable new construction technologies, since the refurbishment of old buildings is related to more or less known simple techniques and technologies that require less effort on technology transfer. Also as a first step we consider improved energy efficiency with application of Green Building principles considered as a higher and more refined goal for next stage of development.

Construction sector includes both private and public subsectors. Private subsector includes construction of commercial and residential buildings built for by private companies or households. Public sector construction comprises municipal, governmental agency and other public buildings or residential buildings ordered and financed by government for internally displaced persons (IDPs), military and other categories of civil servants. In both cases the final decision on procuring a particular type of building or apartment with certain level of energy efficiency is made by the client - being it a private (developer - for apartment buildings or other business for commercial building) or public (ministry, municipality or other government agency) entity.

Fig. 2.8 represents the generic market map for efficient construction sector

This is a complex system including several markets:

[12] Survey of Current Construction Practices and Recommendation to Building Industry to Improve of Energy Efficiency in Georgia prepared by Yu.Matrosov, K. Melikidze, N. Verulava - USAID/Winrock International 2008

[13] http://climatetechwiki.org/technology/energy-savings-buildings

- Market for land and (including old buildings to be demolished)
- Residential real estate market for apartments and individual houses
- Construction material market

The below market map shows the scheme for efficient construction technology in residential subsector. Developers are the key actors on the construction market. Developers acquire the land for new construction and order from architects the design projects of new buildings. After approval/permitting procedures in relevant municipal services, they subsequently hire construction companies to build the buildings according to provided design. The Construction Companies in turn should possess EE and RE technologies and efficient construction technologies in order to implement the principles of sustainable construction. Developers in the process of construction raise money from buyers, who agree to pay upfront for future apartments. Realtors are an additional link between developers and residential or small commercial buyers. They are the most advanced information agents who possess information about the market demand and preferences and in turn can spread out the information to customers about new product on the real estate market. Developers can also contact buyers directly without realtors. Developers are oriented towards consumers' preferences and needs, to be able to sell more new buildings. On the other hand some developers may choose to promote the new market segment of efficient construction as it had already been the case for a few buildings.

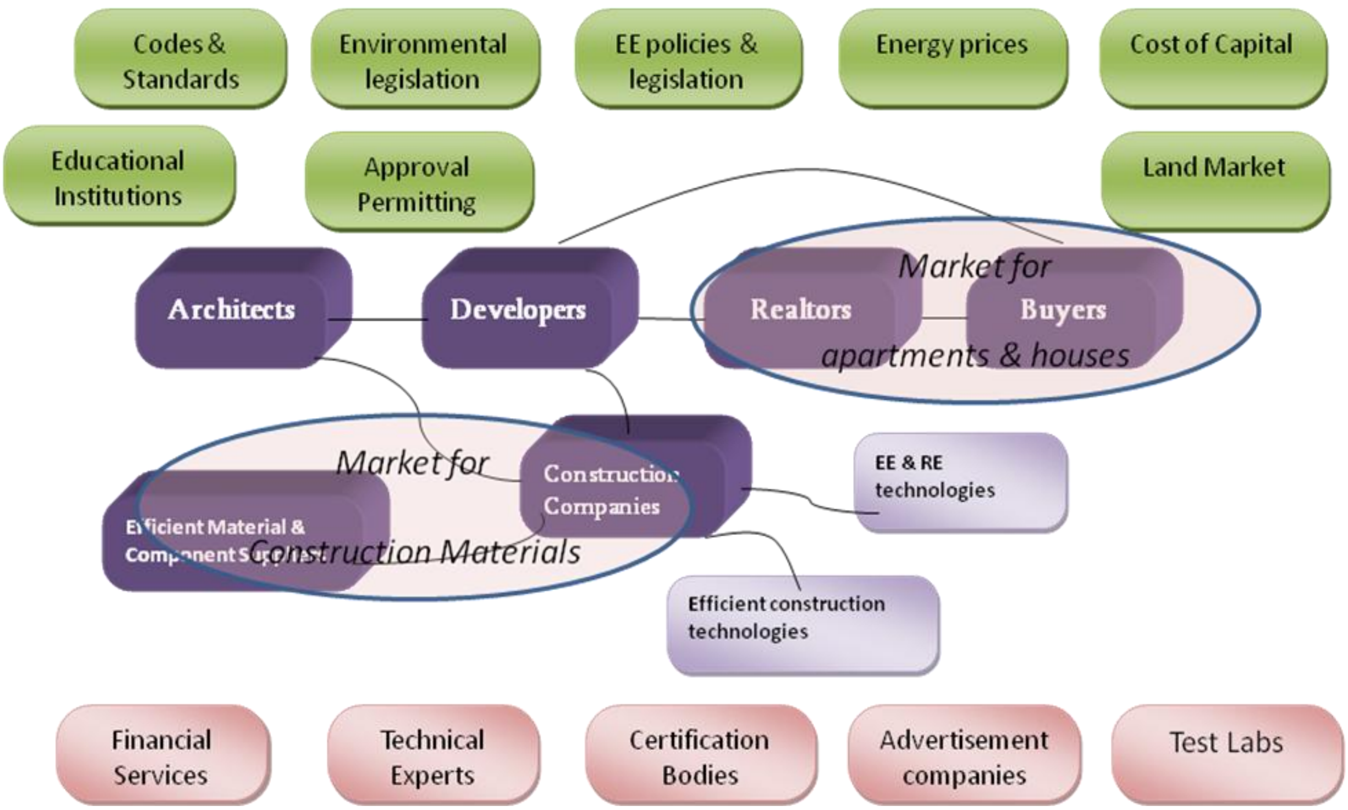

Fig. 2.8 - Market map for efficient construction technology

The above market map endures some modifications in case of public sector construction, when public entity chooses to build a new building. In this case the Developer, Realtor and Buyer are combined in one public entity that, through a tender procedure, has to order the design, and involve a construction company. All other chain links work in the same way as in private construction market. In case of public sector construction, it is the preferences of and, in general, the attitude of public entities to efficient sustainable construction that define the requirements. There are no mandatory requirements or construction standards in place that would mandate the specific parameters of building energy efficiency or serve for benchmarking in case of voluntary construction of efficient buildings.

Georgia

The services for this market include:

- Financial services for consumers to buy new more efficient living space, for developers - to finance new construction, for construction companies - to acquire new technologies and equipment for efficient construction and material vendors, to develop production or import of relevant efficient material;

- Public outreach for promotion of new technologies and high quality construction can be done through various advertising companies and media. Service of advertisement companies is actively used by developers, realtors and construction companies. These companies could promote construction companies that use efficient construction methods. Financial services are useful both for developers and buyers;

- There should be sufficient number of qualified technical experts, test labs and R & D institutions that would be able to support the development of efficient construction material production by testing and recommending improvements to technological processes for adaptation to local conditions. Technical experts can assist both construction companies and architects with implementing know-how, new efficient technologies, conduct consultations, etc. There are some local experts and potential test labs. Some of them conduct testing of building materials (lad at Georgian Technical University), but their coordination with construction companies and developers need to be improved.

- Certification body and test labs should develop building passports indicating major energy characteristics of buildings, issue certificates indicating green buildings, buildings with modern and efficient materials. There are no certification bodies at the moments to provide independent information to customers on actual qualities of buildings for sale.

The environment for the market of efficient construction technologies is defined by the following key factors:

- General economic situation and cost of capital reflecting the risks of investing in long term assets.

- Tax regimes, customs duties and potential subsidies that might support the deployment and dissemination of efficient construction technologies.

- Prices for traditional energy that can substantially affect the customer preferences of efficient construction.

- Construction codes and standards are essential for efficient construction development; however, at this time there is no obligatory code or standards in construction sector. The existing code is a soviet time construction code and it is outdated for the time being. However, even this code is not obligatory for construction companies. Therefore there are no acting minimum standards on energy performance of buildings. Attempts to introduce such standards have failed due to not covering the interests of various stakeholders.

- Environmental legislation and EE and RE policies and regulation are needed to ensure efficient construction. Environmental legislation could control CO_2 emissions of new built buildings, correspondence of new buildings with environment, etc. EE and RE policies could ensure energy efficiency of new buildings making them more comfortable and less energy consumers, saving residents' money and improving country's energy security. State strategies and action plans for energy efficiency and renewable energy development that might provide state policies in support of efficient construction and that are largely absent now except the recent trend for major cities (starting with Tbilisi and followed by Rustavi, Kutaisi and Batumi) to join the covenant of mayors in support of sustainable development of those cities.

- Land market defines the cost of the land plots for new construction and affects the final cost of the buildings.

- Permitting and approval procedures conducted by municipal services compliance with the safety, exterior and architectural design compliance, as well as other parameters of the prospective buildings. Energy qualities of the buildings are not in the list of criteria for decision making so far.

- Energy prices affect construction market both from buyers' side and from Construction Company's side. Energy and fuel prices affect costs of construction. Energy prices also affect buyers' decision since high energy prices can convince buyers to require energy efficient buildings.

- Undergraduate and graduate courses should provide education of architects and constructors in principles and practices of sustainable design and construction of buildings. There are some episodic small courses that need to be developed further in comprehensive education for specialists in sustainable construction.

2.3 Barrier Analysis for Efficient Construction Technology

2.3.1 Economic and financial barriers

Financial barriers

Higher costs for technology and materials require higher expenses in construction and design phase. Therefore financial barriers appear:

- Shortage of financial resources significantly hinders the implementation of modern technologies
- High cost of capital makes borrowing expensive
- Customers may not be willing to finance upfront the construction with the new technology the same way as they do for ordinary construction

Economic barriers

For successful implementation of a technology it is necessary to ensure economical and cost effectiveness for each participant in the market chain. This concerns developers who should be sure about sufficient returns and concerns buyers who need to be sure about worthiness of potential additional investment in their dwelling, as well as construction companies who will invest in equipment and people skills. Therefore the following economic barriers apply:

- Unclear benefit for the consumers due to lack of realistic feasibility studies and cost-benefit analyses
- Unclear economic benefit for developers and
- Unclear economic benefit for construction companies who should benefit from development of a new market segment

2.3.2 Policy, legal and regulatory

Insufficient legal and regulatory framework

- Due to absence of EE and RE legislation and action plans, there is no direct state support for energy-efficient construction
- Liberal approach of the government has prevented introduction of mandatory norms and standards for energy performance of buildings
- Existing legislation is missing a technical part that has a knock-on effect on the construction sector development
- Absence of economic instruments (taxes, subsidies), information or other policy instruments in support of climate technologies
- Conflicting interests and opposition on political arena by incumbents of traditional technologies.

Undeveloped normative base

- No building energy performance standards accustomed to Georgian conditions either mandatory or benchmarking
- No obligatory requirements for compliance with any standards of energy performance of buildings
- No requirements to report energy performance of buildings (energy passport not mandatory)

2.3.3 Network failures

- Insufficient coordination between proponents of sustainable construction various donor programs and government institutions resulting in insufficient involvement of government agencies
- Insufficient cooperation between industries and R&D institutions
- Lack of stakeholders' consultation culture
- Insufficient coordination between proponents of sustainable construction technologies (architects, developers, material producers etc.)

2.3.4 Institutional and organizational capacity

- Lack of government institutions to consider the issues of sustainable and energy efficient construction and to take them to the policy level
- Lack of institutions to collect, analyze and disseminate the current and reliable information on sustainable construction, materials etc.
- Insufficient involvement and effectiveness of R&D institutions to support the development of efficient construction technologies (R&D facilities missing, lack of capacity for R&D, lack of appreciation of R&D role in technology adaptation)
- Lack or inefficiency of test labs for certification of materials and buildings

2.3.5 Human skills

- Lack of trained experts knowledgeable in modern efficient construction
    - Architects/Designers
    - Constructors/Builders
- Lack of domestic consultants in efficient construction methods for construction companies and developers
- Lack of skilled personnel to apply efficient construction technologies and deal with efficient construction materials
- Insufficient awareness of consumers on potential for improvements in construction practices and the resulting effects on energy expenditures
- Lack of decision makers with needed vision and perspective to promote the sustainable construction practices.

2.3.6 Information and awareness

- Lack of sound feasibility studies and cost/benefit analyses for buyers of apartments resulting in uncertainties in the benefits of sustainable construction
- Poor dissemination of information to technology users (on products, benefits, costs, financing sources, potential project developers etc.)
- Lack of agencies or agencies ill-equipped to provide information
- Insufficient knowledge and trust in technologies increases risk perception and results in higher requirements to payback for investment in new technologies
- Insufficient information on properties and technology of use of efficient construction materials for construction companies and developers
- Efficient construction materials represent the subject of intensive deliberations due to their valuable qualities like energy efficiency and ecologically friendly, though absence of sufficient information results into lack of demand on the market for the mentioned products
- Emphasis on visual appearance and ignorance of construction quality as well as energy performance of buildings while assessing their value
- No established benchmarks for energy performance of buildings

2.3.7 Technology barrier

- No tradition and practice of sustainable design in place
- No practice of application of new efficient construction technologies

- Lack or high price of efficient materials, need of import or producing of more efficient materials
- Insufficiently equipped test labs
- Absence of evaluation tools for ready constructions
- No recognized parameters and standards for energy performance of buildings. Introduction of such parameters would be a great asset for brokers and developers
- Poor qualification of Design and Construction Companies
- Uncertainty of new technologies may raise consumer concern about the safety and soundness of new buildings

2.3.8 Other Barriers

- Diversity of climate zones may lead to fragmenting the market and therefore making the introduction of sustainable construction technologies more difficult, are not considered in designing process, implying that different approaches need to be applied in different zones with the consideration of climatic conditions
- Unpopularity of energy-efficiency, resulting into a low level and inferior quality of the construction process
- Energy efficiency does not represent an up-to date topic, though the higher the energy expense the more acute is this topic
- Ineffective construction quality control mechanisms

2.3.9 Cultural & behavioral

- Short term interest and high required return on investment by customers. Major focus is made on initial construction expenses, which results in low quality and cheap construction.; Buyers may prefer to invest in less efficient cheaper houses rather than invest in more expensive ones that would provide future savings on energy bills
- New types of buildings and materials may be difficult to get accustomed to.

2.3.10 Market competition

- There is a competition from the traditional construction that has cheaper prices due to economy of scale and established methods and technologies
- There is a limited market of efficient construction materials and technologies not allowing price reduction through economy of scale and established operation.

Logical Problem Analysis for Efficient Construction Technology

From the above list of barriers two key barriers were selected as the most important for further analysis and action planning: a. information and awareness barrier; b. policy and regulatory barrier. This choice was made by mitigation team having in mind several unsuccessful attempts to introduce efficiency standards and building codes and numerous discussions with stakeholders indicating the low awareness among policymakers and general public as a barrier for market penetration and policy support of Efficient Construction Technology. For each of these key barriers the logic problem analysis has been conducted.

2.4 Overcoming barriers

2.4.1 Information Barrier

The LPA diagram for information barrier is presented below in Fig. 2.9

Insufficient information and awareness of market participants and policymakers is one of the key barriers of efficient construction market. As a result there is low awareness and demand from buyers and low qualification and preparedness of suppliers that leads to absence of market signals and poor market development. Another consequence of the information barrier is low awareness and preparedness of policymakers for supportive decisions and as a result there is no enabling legal and regulatory framework and no institution support to a new technology.

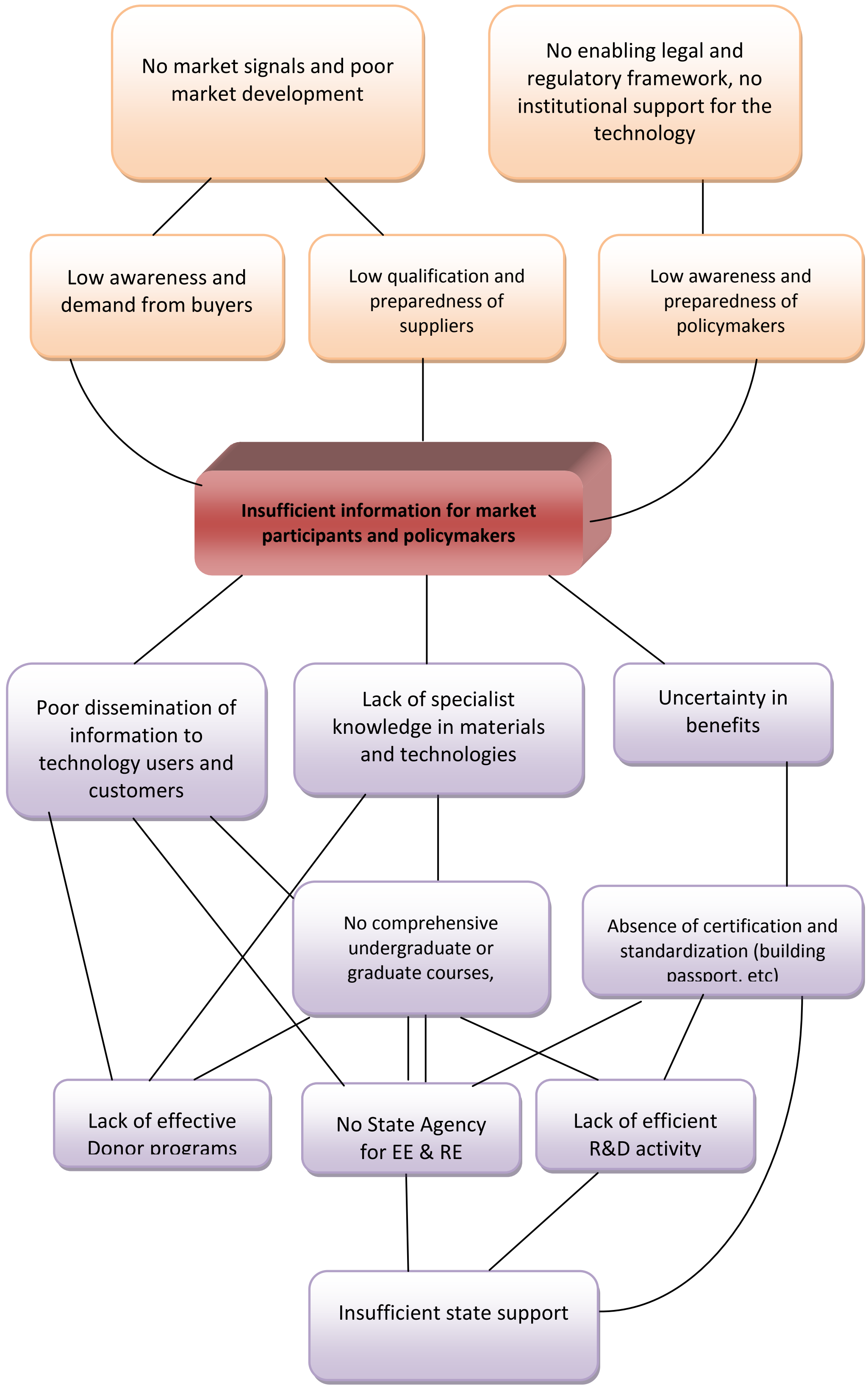

Fig. 2.9 - LPA of information barrier

Georgia

LPA was conducted by mitigation team and involved consultations with architects, NGOs& experts (Cf. Stakeholder list)

Information barrier itself has the reasons that need to be analyzed and addressed:

Insufficient state support: This is one of the main causes of the information barrier. Without state support through dedicated EE & RE agency there is deficiency in provision of information to market participants. Absence of certification and standardization is also a manifestation of insufficient state support. Certification and standardization could be conducted by state agency or by independent organization. Insufficient state support also leads to lack of efficient R&D institutions. There are a few R&D institutions, for example, testing laboratory at Georgian Technical University where currently some construction materials can be tested. However, coordination between this laboratory and design and construction companies is either absent or inefficient. Ideally such an entity should be involved in testing and adapting different types of efficient construction materials and proposing standards as well as certification of concrete products. R & D is needed to conduct feasibility studies, and develop instructions and guidance on installation, technical characteristics, etc. At present these activities are not conducted.

Lack of effective donor programs: Donor programs are supposed to demonstrate new product and help its implementation. The donor programs in general suffer from coordination with each other and with the state as well as insufficient attention to monitoring, experience analysis, sharing and outreach.

There is a need for donor programs to support development of comprehensive undergraduate or graduate courses or other training courses and scholarships that could be potentially financed by donor projects. As a result there is insufficient awareness and knowledge of efficient construction materials, integrated design methods and sustainable construction practices.

Lack of R & D and specialist knowledge :Due to insufficient R & D activity there are few specialists and architects with sufficient knowledge of modern efficient materials, construction and design technologies. This also affects the possibility of graduate or training courses that could otherwise provide knowledge and raise awareness on efficient construction materials. Due to the lack of consultants, education courses and studies, benefits of using efficient construction materials are not well known and recognized by market participants and decision makers. Uncertain benefits reduce demand for efficient construction materials and efficient buildings.

As a result of this barrier there is low awareness among buyers that leads to low demand. On the other side there is low preparedness and qualification among suppliers that leads to poor market development. Absence of enabling legal framework and institutional support for technology can be explained by low awareness and preparedness of policymakers. All these effects can be eliminated once information barrier is overcome.

2.4.2 Policy and Regulatory Barrier

The LPA diagram for information barrier is presented below in Fig. 2.10

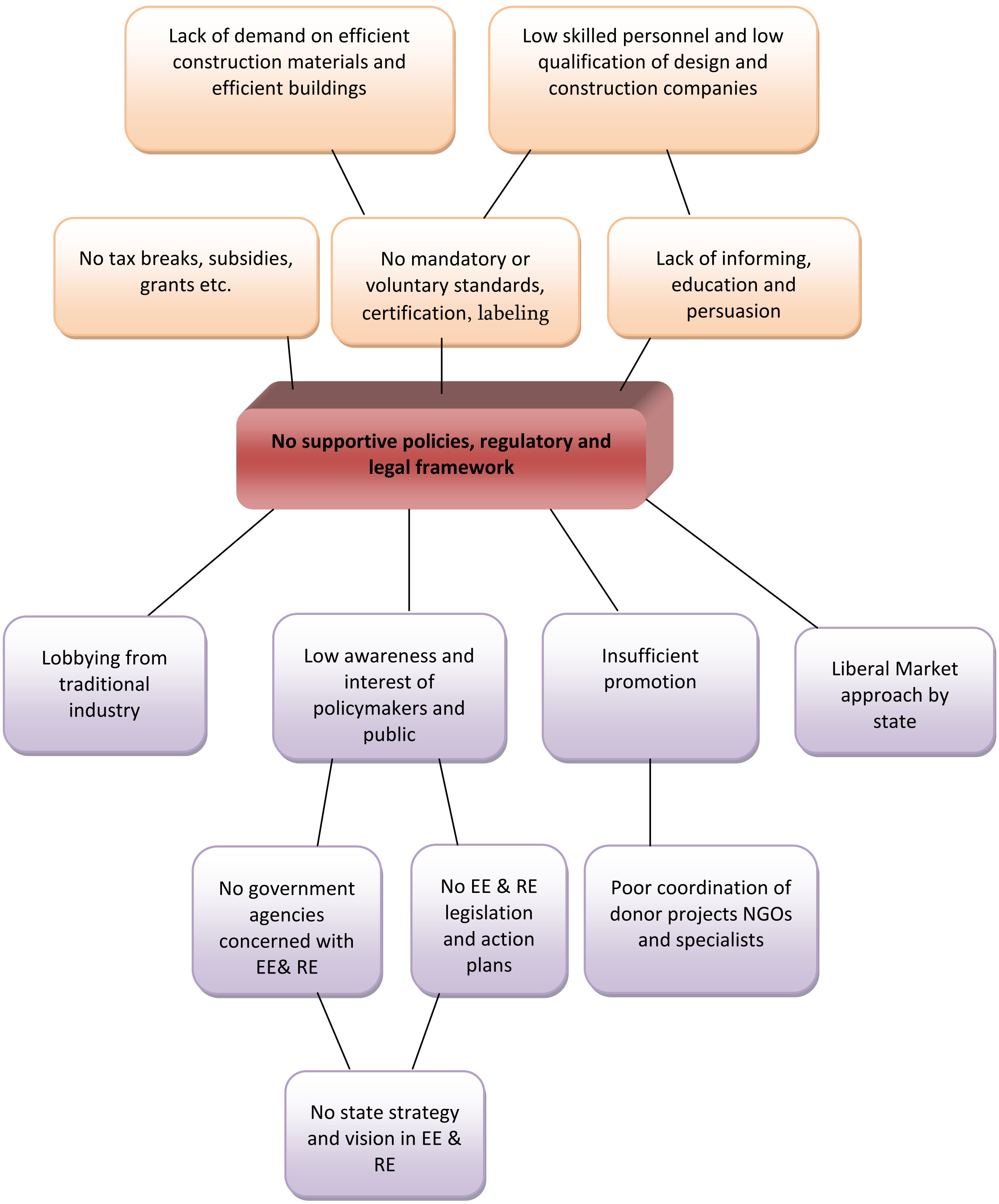

Fig. 2.10 - LPA diagram for policy and regulatory barrier

Georgia

Absence of supportive policies and legal framework is another key barrier of efficient construction market. It entails absence of tax breaks, subsidies and grants, absence of voluntary or mandatory standards, certification, labeling and lack of information in the market. This all results in low skilled personnel and low qualification of design and construction companies and low awareness demand on efficient construction materials and buildings.

The preceding reasons of legal and regulatory barrier are as follows:

Absence of state strategy and vision in EE & RE: EE & RE strategy is necessary not only for efficient construction market development but also for development of other renewable and efficient technologies like efficient wood stove, solar water heater, etc. Without state strategy in EE & RE there is no EE & RE legislation and action plans, no government agencies concerned with EE & RE and no support to research and development in EE and RE technologies. As a result there is low awareness and interest of policymakers for decision making and consequently public. These factors are applicable not only for efficient construction but for other RE and EE technologies as well, therefore, tackling with them is important and could benefit several markets simultaneously.

Poor coordination of donor projects NGOs and specialists. Poorly coordinated projects may dampen reputation of efficient construction. As a rule the projects financed beforehand by donor organization are not so oriented on future sales and quality of the product. They are less oriented on public needs and preferences than the developers. This leads to insufficient coordination of donor projects with specialists and the implemented projects do not stimulate efficient construction market development. This is followed by insufficient promotion and sometimes even the demotion of efficient construction.

Liberal Market approach by state: This element can hardly be changed through TAP since it represents the general state approach to any market. However, absence of construction codes and norms even on voluntary basis can be affected through TAP suggesting the development of at least voluntary codes and norms.

Lobbying from traditional industry: In case government develops construction code and forces construction companies to use efficient materials the expenses of construction companies will supposedly rise. Construction companies are afraid of a risk of future low sales and are lobbying against any construction codes or norms. Since majority of consumers demand efficient buildings and mostly assess buildings only by visual design, location and price, construction companies are oriented to satisfy only these needs and are not willing to increase energy efficiency of constructed buildings.

The regulatory barrier is manifested in absence of tax breaks, subsidies and state grants that could stimulate development of sustainable construction technology. Regulatory barrier leads to absence of informing, education and persuasion as well as to absence of certification and standards. This leads to lack of needed qualification of design and construction companies. Moreover, low demand for efficient construction materials and efficient buildings can also be explained by absence of regulatory framework.

All these important effects can be eliminated if regulatory barrier is overcome.

Overcoming barriers

The actions needed in order to overcome the most critical barriers and create an enabling framework for technology development are given below.

2.4.3 Overcoming Information barrier

The measures needed for overcoming the information barrier can be visualized as shown in Fig. 2.11 below.

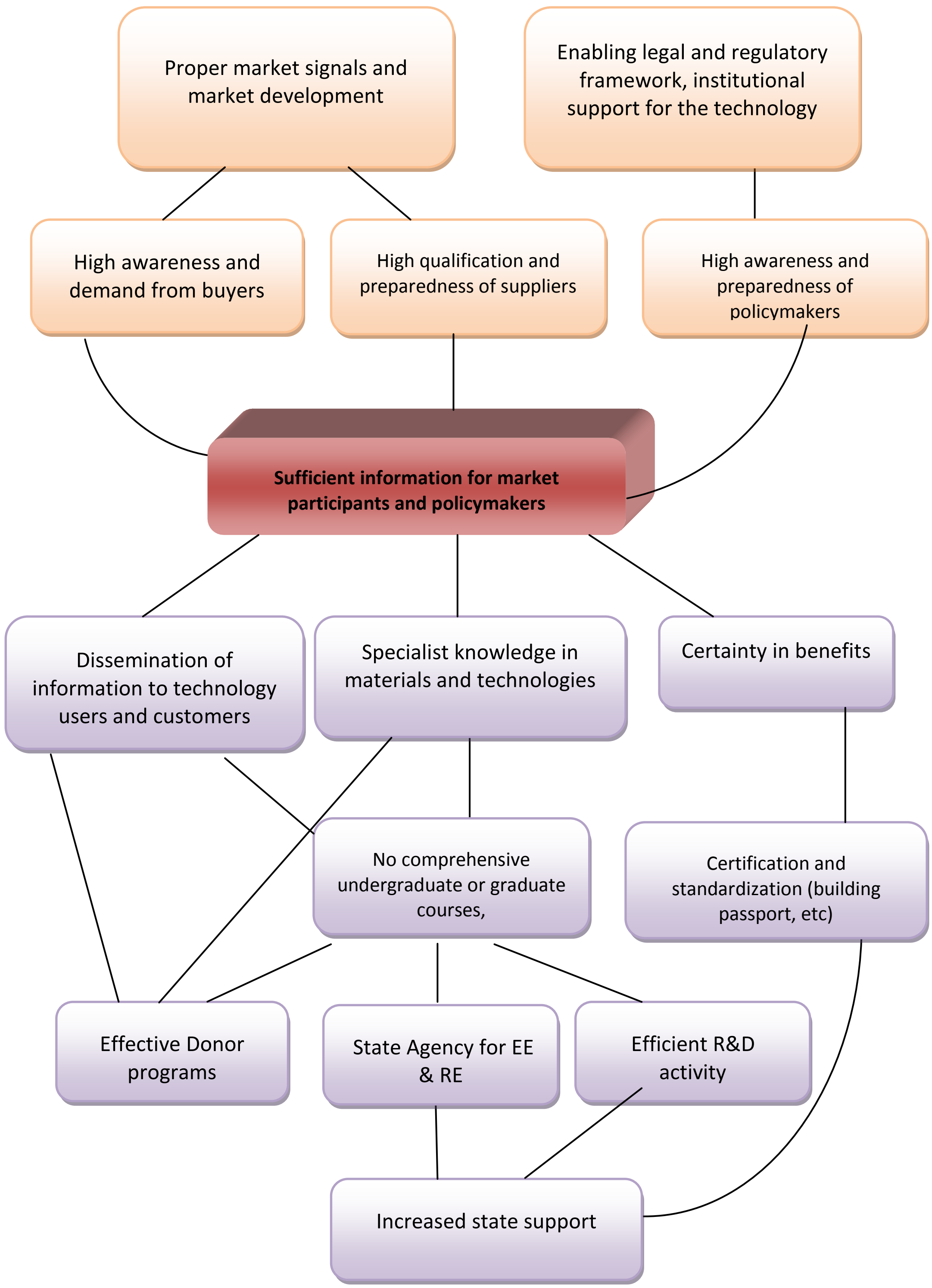

Fig. 2.11 - Overcoming of information barrier.

Georgia

Information barriers could be overcome if the following measures are implemented:

- Government support to innovation in RE and EE technologies. This activity should be conducted through a special state agency for sustainable energy. It would assists/establish R&D institution working on efficient construction materials, RE & EE. State would establish certification and standardization procedures conducted by government or independent organizations. The State should also support collection and dissemination of information and coordinate the donor projects with ongoing activities in the field of EE & RE. As a result the availability of information, specialist knowledge and efficiency of information use would increase leading to qualified specialist base, informed policymakers and consumers providing proper market signals.
- Efficient R&D institutions with the lab-testing should be developed. Their task would be to test different construction materials, provide recommendation on their use and technical characteristics, conduct feasibility studies, inspect the buildings and certify their energy performance, etc. These entities would produce knowledgeable specialists and would serve for setting the standards and certification practices. Standardization and certification will provide more certainty to consumers and assure their informed decision making. The information and knowledge provided by such institutions would provide information base for, development of materials industry, construction and design know-how.
- The better planned and coordinated Donor programs shall provide support to more relevant and practical information for decisions by consumers and entrepreneurs, bring in the international knowledge and experience, support the special undergraduate and graduate courses and training programs for designers, and other specialists in construction industry thus assuring the specialist base.
- Training and education for specialists. There should be established comprehensive undergraduate or graduate courses as well as scholarships to introduce the seed technology knowledge. This will help to increase skill level of personnel and therefore, quality of efficient construction. Additionally, enhance workforce through relevant retraining to increase the competitiveness of the local staff
- Designers, construction workers and manufacturers of efficient construction material should share foreign experience and knowledge that will help to upgrading their skills

Overcoming the information barrier can bring sizeable benefits to efficient construction market. First it increases qualification and preparedness of suppliers and awareness and demand from buyers. This all contributes to market development. Moreover, overcoming of information barrier will contribute to awareness raise and preparedness of policy makers who will be better prepared to develop the supportive legislation and establish necessary institutions. This can contribute to creation of enabling legal and regulatory framework and institutional support for the technology.

2.4.4 Overcoming Policy and Regulatory Barrier

The measures needed for overcoming the policy and regulatory barrier can be visualized, as shown in Fig. 2.12

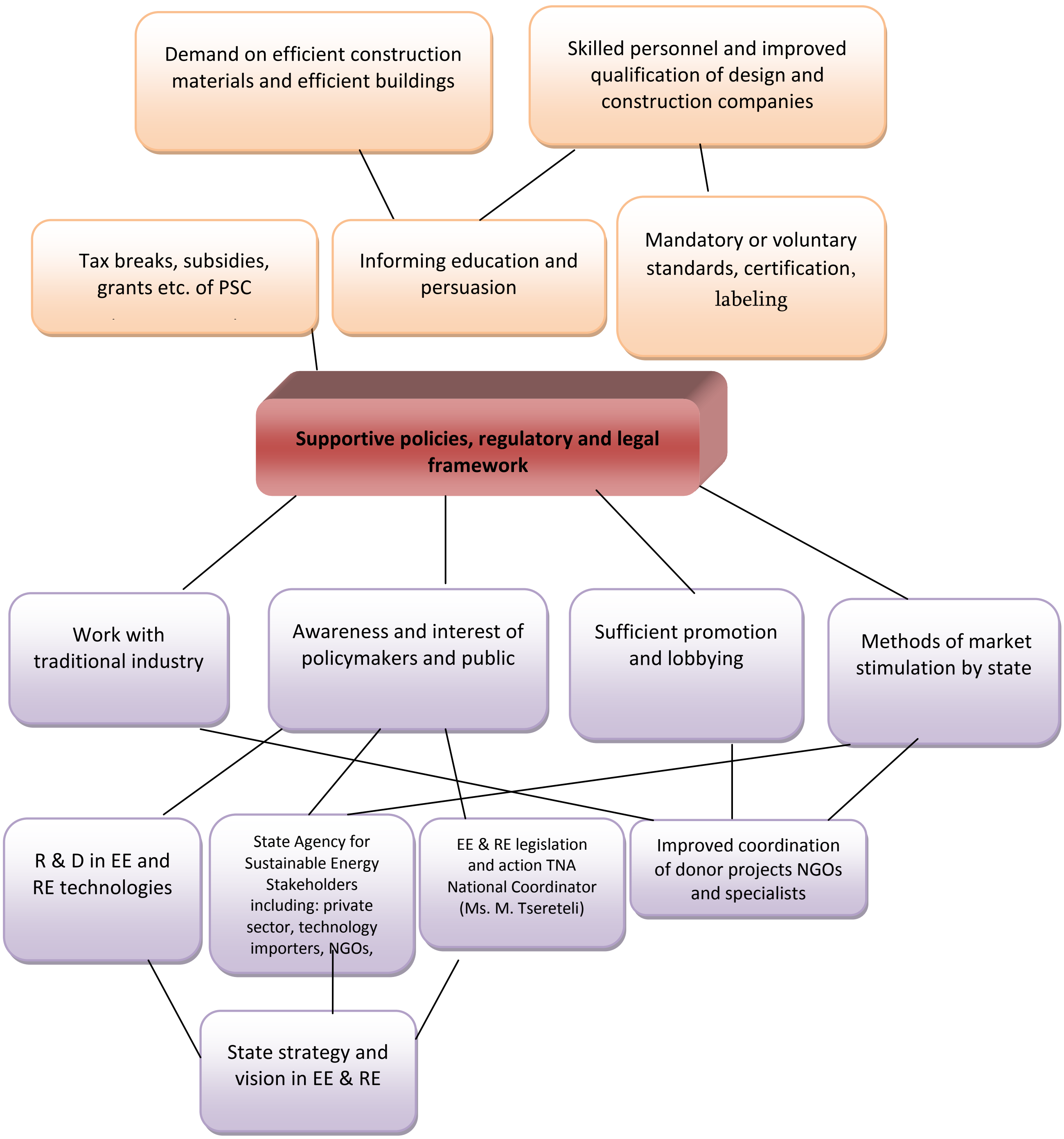

Fig. 2.12 - Overcoming of policy and regulatory barrier

The presence of a Legal Framework is pivotal in terms of regulating the compulsory compliance with the requirements aimed at ensuring a high quality construction product. For the effective market operation there is a necessity of governmental support through introduction of a Legal Framework regulating the compliance with the required standards aimed at ensuring of high quality constructions as well as energy performance of buildings.

Policy and regulatory barrier can be overcome through the following measures:

- State strategy and vision in EE & RE technologies should be developed. Essential parts of this strategy should be a new approach to EE and RE legislation, taking into account all externalities and long term sustainability interests of the country. Establishment of Agency for Sustainable Energy, assistance to existing R&D in EE and Re technologies and increased concern of government agencies with EE and RE technologies. Work is needed with traditional industry to help them upgrade and develop a new market niche of efficient construction. Market stimulation mechanisms should be developed and applied. This will help overcome the existing opposition and establish the supportive legal and policy framework
- Support from the Donor Organizations for enactment of a Legal Framework. Donor programs should be well coordinated with local specialists and have a common vision based on close situation analysis.This shall result in improved promotion and lobbying with government as well as industry.
- Liberal market approach by the state hardly can be changed through action plan, however, construction codes and norm are to be developed and implemented at least on voluntary basis to provide additional market information and open up the new market segment of efficient construction.

Overcoming of policy and regulatory barrier can bring following benefits to efficient construction market:

- Encouraging the energy-efficient construction through tax incentives, subsidies and grants
- Implementation of mandatory or voluntary standards, certification and labeling, building energy passports. This will help to control quality of buildings as well as provide information on level of energy efficiency in the building which in turn will raise demand for efficient buildings
- Qualification of design and construction companies will be improved as well as skill level of its personnel.

2.5 Technology Action Plans for the selected technologies

Based on the above barrier analyses the attempt was made to develop more concrete measures that would support the deployment and dissemination of selected technologies SWH is short-term technology that is already available on the market, however, needs information and financial support to be developed on a wider scale.

Tables 2.2 below summarize the technology action plans for SWH technology

Georgia

Table 2.2 - TAP for efficient construction

Measure	Priority	Objective	Implementing agency	How should they do it?	Time scale	Monitoring, reporting and verification for measure	Estimated costs
1	2	3	4	5	6	7	8
Stakeholder Network							
Coordination between market participants of sustainable construction technologies (architects, developers, efficient material producers, construction companies and buyers)	1	Increase market activity and information flow between market participants identify main obstacles	Donors, NGOs	Stakeholder workshops smart, comprehensive pilot projects	1-2 years	Pilot projects implemented, workshops and joint activities conducted	$200K
Develop R & D activity, provide reliable information about technologies and adapt technologies	2	Induce cooperation between industry and R&D institutions	Government, industry	Research grants, R&D development	2-4 years	Assessments of current construction practices, measurements of thermal resistance etc.	
Networking between donors, NGOs, R&D and public (government and municipal) institutions	1	To increase efficiency of donor programs and awareness of decision makers and arrive at supporting policies	Donor projects	Workshops and pilot project events	1-3 years	number of workshops & joint events	included in previous activities
Coordination between proponents of sustainable construction technologies (architects, developers, material producers, construction companies and buyers)	1	Promotion of legal framework development	stakeholders	Stakeholder workshops smart, comprehensive pilot projects	1-2 years	number of workshops & joint events	included in previous activities
Policies and Measures							
Information campaign	1	Mobilize stakeholders and public opinion, inform and alert policymakers. Promote awareness on energy saving in buildings and efficient construction benefits	Donors, NGOs	Mass media, demo projects, advocating, lobbying	1-2 Yeas	number of publications, workshops, TV casts	$100k
Develop state strategy and vision for EE and RE technologies develop EE & RE legislation	1	To create supportive environment for SWH business development	State with donor TA	Targeted project with participation of stakeholders and wide publicity	1-2 years	State strategy and law adopted	$150k
Introduce building performance measurement and passportization practice	1	To increase awareness and promote demand for efficient buildings	State/donors/ R & D institutions/ Specialist NGOs	On demand measurements of thermal qualities and energy performance	1-4 years	Number of apartment and building passports	$100k

Georgia

1	2	3	4	5	6	7	8
Develop construction codes and norms	2	Increase quality of new modern buildings	Ministry of Economic Development, experts	Based on State strategy and through Technical Assistance	2-3 years	Construction code adopted	$150k
Develop the strategy and measures for efficient material industry support	3	Improve competitiveness and widen products and services	State EE & RE agency	Introduce tax breaks and other measures based on economic development strategy	2-3 years	number and quality of supporting policies and measures	$100K
Conduct smart pilot projects	2	Promote awareness, test the technologies, test local materials, develop efficient construction techniques	Donor supported pilot projects	Donor programs and tender procedures with strong information and development component	1-3 years	amount of efficient building space	$500K
Organizational & Behavioral change							
Establish EE & RE state agency	1	Coordinate implementation of RE strategy and action plans	State with donor TA	Through innovation system support programs	2 years	Agency endorsed by parliament/government	NA
Market, system support, financial services							
Preferential rates for efficient housing mortgage loans	3	Support energy security and	State subsidy	Based on state economic development and EE &RE strategy	3-5 years	Amount of loans issued	TBD
Credit lines for efficient material production development	3	Support efficient material industry development	EE & RE agency /donors	Based on efficient construction development strategy	1-4 years	Amount of credits issued	TBD
Skills training & Education							
Train Architects	1	Develop efficient housing designs and efficient material use	Architectural university programs, state with donor support	International Scholarships, Modern university programs	1-5 years	Number of western trained architects and modern programs in universities	$300K
Educate school children and parents	2	increase environment and energy awareness	Ministry of Education supported by State EE & RE agency	develop school programs	2-3 years	number of school programs and handbooks	$50k

The expense figures are rough cost estimates to be made more precise at the stage of more detailed task planning

Chapter 3

Energy Sector - Solar Water Heaters

3.1 Preliminary targets for Solar Water Heater Technology

The preliminary targets for the Solar Water Heater technology were set based on own previous studies by mitigation team [5] and the analysis conducted in Part 1 and detailed in Annex 1 of the report. The mitigation team made an initial estimate of the potential market for SWHs as 60 thousand SWHs to be installed over 10 years period, out of which 50000 are SWHs for residential consumers and 10000 for organizations and businesses. The market size was roughly evaluated based on available information on the number of residents, availability of insolated roof space for SWH installation, price of SWHs, alternative means for water heating and economic comparison of competing alternatives. The initial estimate was confirmed at common and individual meetings with stakeholders. The target for emissions reductions has been derived based on the above market estimates to be about 300 thousand tons of CO_2 emissions over the 10 year period. This estimate assumes current gas prices and can be substantially increased if the gas price will be increased to regional levels.

Development of SWH manufacturing and assembly business might promote internal economic activity, improve foreign trade balance and improve energy security. However the government has to develop the strategy that would assign proper value to these factors and provide incentives for these business activities.

3.2 Market for Solar Water Heater Technology

Solar Water Heaters (SWH) are not produced on a commercial scale in Georgia. Though there are several small scale manufacturers, currently different types of SWH are mostly imported from abroad, mainly from China and Germany. There is a small donor project importing solar collectors from Germany and assembling the SWHs with local tanks and other components. There have been undertaken some attempts to organize local manufacture of cheaper solar collectors that had minor commercial success. One non-profit organization is currently assembling solar collectors from imported parts and adding about 70% of final product in local parts (tanks and fittings) and local labor. However this is a small scale local project without significant impact on the market.

The prices vary significantly, depending on size and type, as well as country of origin of the equipment. Pressurized closed systems are almost twice more expensive than open systems (appropriate in rural areas). European systems are much more expensive than their Chinese analogs, though it is believed that the quality is also higher.

Solar water systems are sold by two main types of companies – technical companies who are also the installers of the systems and Importers/sellers who hire the installers or arrange the connection of consumers with installation crews. The companies that import SWHs and sell them, often also perform their installation and post-sale support.

SWHs on domestic market are beyond the availability for a great majority of population. The share of residential use of SWHs is very little and is limited to high income families mostly having individual private houses and partly motivated by prestige of a new technology. Most SWH systems in Georgia are bought by commercial entities, mostly hotels and hospitals, having high consumption of hot water. Other typical examples of SWHs use are the installations in kindergartens, schools and hospitals done under donor programs and use in remote monasteries where there is no gas and/or reliable electricity supply. On the other hand, based on statistical data for Georgia, the main consumer of energy is the residential sector. Moreover, this sector is less energy efficient compared to the commercial sector. Improvement in energy consumption pattern in the residential sector can strongly contribute to, economic development and energy security of the country.

There are no cheaper affordable options present in the market. There is certain market inertia and entrepreneurial inactivity that does not allow fast dissemination of new technologies to all potential market segments and first of all to the residential sector.

Georgia

The market map for solar water heater technology is given below in Fig. 2.13

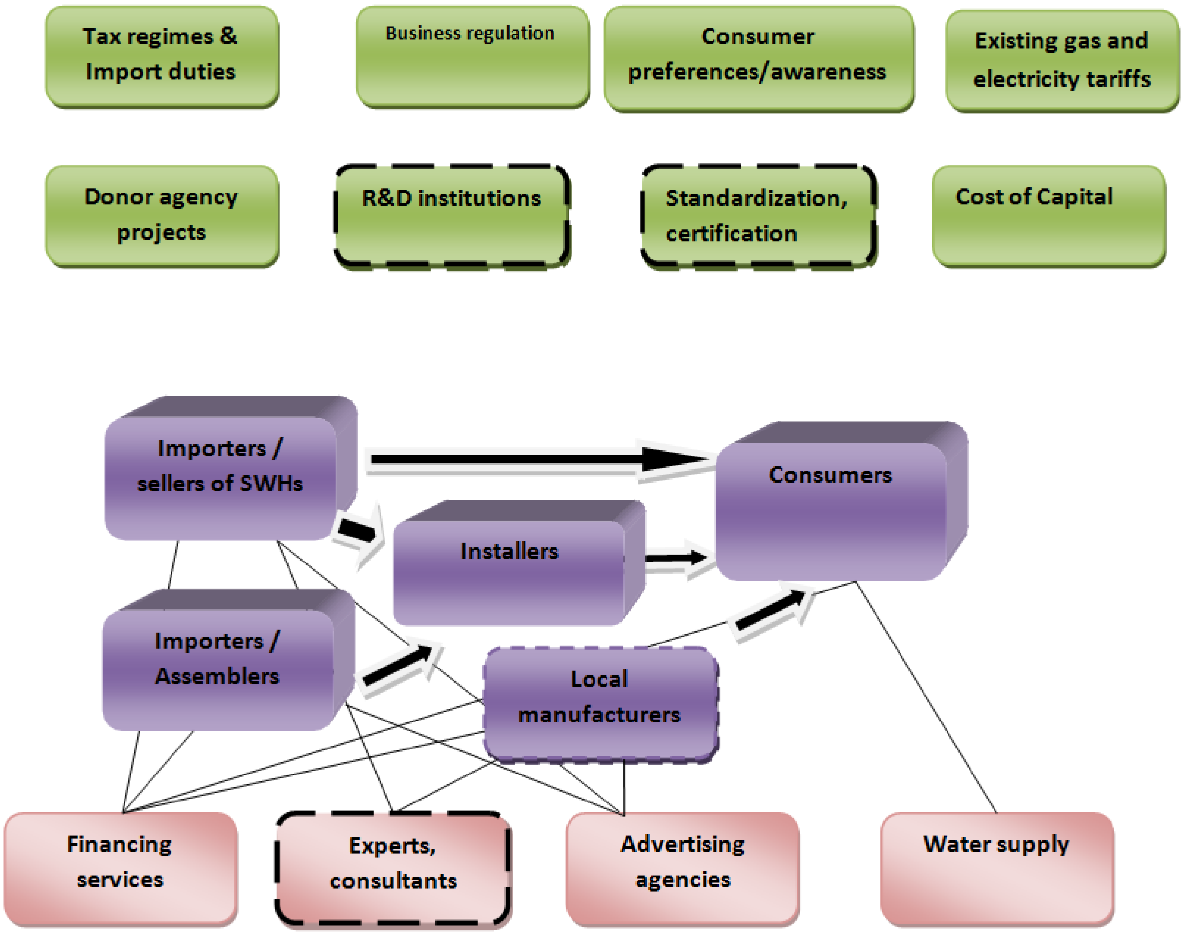

Fig. 2.13 - Market map for Solar Water Heater technology

Solar water heaters have to compete with traditional means of water heating including gas and electricity. Water heating with electricity is more expensive, therefore more and more residents in gasified locations are switching to gas heating.

There are five potential core actors in SWH market: importer/sellers, importer/assemblers, local manufacturers, installers and consumers. Sometimes some of these functions are combined within one entity. Local manufacturers hardly exist but for future we should not exclude the possibility of wider local production of solar water heaters and/or their components.

Solar water heater market requires the following main services: Financial, advertising, water supply and independent consultancy for consumers. In general the independent consultancy service for choosing the right solar water heaters is not available and vendors can promote their own product without sufficient consideration of customers' actual needs. This kind of service seems important especially at the early stages of SWH market development, before sufficient information about costs, benefits and operation of SWHs becomes widely available. Water supply is an important factor for solar water heater use. Continuity and typical pressures of water supply may define the customer choice while selecting the type of solar water heaters. There are limited dedicated financing opportunities for SWHs except EBRD funded Energy Credit facility. However, even in this case the lending rates are not much different from general finance market rates. Advertising agencies are active and well developed, so once there will be strong market signal it will be easy to spread the information.

The environment for solar water heater market is defined by the following main factors: taxation regimes and import duties, energy prices and availability, cost of capital and interest rates on financial market, consumer awareness and preferences, government economic strategies and policies, R & D base for technology deployment and support, Donor projects and programs, general business environment.

In order to operate efficiently, linkages between market actors should be strengthened and cooperation facilitated. For instance, there is a laboratory for testing the energy efficient and renewable technologies where SWHs could be tested, their benefits could be estimated and then widely demonstrated to public. However, this possibility is not effectively used and accordingly, the link between seller and Q.A institution on the picture is dashed.

Traditional options for water heating are fuel wood, electricity and gas. Therefore the economy of solar water heater installation depends on the prices of traditional energy carriers.

There is a need for solar water heaters to become more "democratic" equipment that would be affordable for the significant part of the population and thus would contribute significantly to the energy balance.

In order to assess the barriers for SWH technology one needs to compare the current market with the desired situation. The anticipated picture of solar water heater market looks as follows:

- Intensive import and installation of solar water heaters in all sectors
- Local manufacturing of parts or complete collectors
- Availability of information for SWH selection and installation
- Cheap solar water heating equipment
- Cheap Bank loans for installation
- Government support through various instruments including taxation, subsidies, information, education etc.
- Government promotion and possibly mandatory installation on new buildings

3.3 Barriers for SWH technology

3.3.1 Economic and financial

Long payback period

Economy of solar water heaters strongly depends on the mode of operation, its proper sizing relative to hot water demand and cost of the systems. It is defined by the degree of utilization of available solar energy all year round, as well as the cost of water heating by traditional energy sources- i.e. electricity, gas and wood.

The cost/benefit analysis of SWHs shows that at the current prices of equipment the economy of SWHs is not very attractive compared to heating of water with gas. Substituting electricity with solar energy would be more cost efficient with payback periods around 5-7 years, but even in this case switching to gas is more economical and less capital intensive. In order to compete with gas heating, the solar water heaters need to be cheaper for the consumers. Since it is not economical, the demand is low and import is low-scale, concentrated on commercial sector. In most of the residential applications the economic value of decision to install the solar water heaters is just marginal.

With the combination of adequate pricing and correct choice of operation regimes cost efficiency of the SWH systems still can be achieved.

High cost of capital

Cheap capital is not available due to high perceived risk by financial institutions. Banks are issuing loans at high interest rate and mostly only under firm collateral guarantee. There are very few cases of project financing based on business plans. This increases the risk for the entrepreneurs because there is no adequate analysis of business plans and risk sharing by banks.

This barrier is not appropriate for analysis since it reflects general economic environment and cannot be changed specifically for the needs of considered technology. However, this can be overcome on a small scale through limited cheap financing for pilot project.

Financing barrier

High up-front costs of SWHs compared with average income levels of households result in low affordability for great majority of urban and rural residents even if the technology was cost effective. There are certain support schemes like Energy Credit operating under e.g. EBRD loan and BP grant, though due to high interest rates this credit line is not sufficiently effective in promotion of the SWH technology. There are consumer loans that might be developed further to address this problem, though the high interest rate for consumer loans make this option less attractive, especially having in mind the long payback period of SWH investment.

Inappropriate financial incentives

Externalities like environmental, economic, or energy security benefits in comparison with traditional energy sources are not properly accounted for and are not reflected in government support schemes for climate technologies and SWHs in particular. There are no tax breaks or other budget incentives to support the renewable energy technologies and SWH in particular. Although until 2005 there was the tax exemption on renewable energy technologies. However, since 2006 the tax exemption was abolished. This hampers development of the technology that has a number of valuable benefits for country's development priorities.

Development of SWH manufacturing and assembly business might promote internal economic activity, improve foreign trade balance and improve energy security. However the government has to develop the strategy that would assign proper value to these factors and provide incentives for these business activities.

3.3.2 Market failure/imperfection

Currently most of SWH installations are done in commercial or public sector, while residential market is not developed. This is partly due to low income of residents. However, there is a possibility to introduce some cheaper, more affordable equipment.

In China the prices for cheap SWH systems start at around $200[14]. This would be affordable for a wider variety of consumers and would contribute to the development of wider market.

Small underdeveloped market and its limitations affect the overhead costs and increase the price of the equipment. There is underdeveloped competition in market. Entrance of new players seems to be limited.

3.3.3 Policy, legal and regulatory

Insufficient legal and regulatory framework

Government interest to climate technologies has been limited to the hydropower development up to now. Government vision, strategy and action plans for Energy Efficiency and Renewable energy as well as supportive laws and bylaws still need to be developed.

Although many of the climate technologies have significant positive impact on country development priorities, this impact is not properly accounted for. Environmental, social and economic externalities of RE development are not accounted and reflected in policies and regulations.

There are no strategies, laws or action plans addressing the specifics of on RE and EE development.

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http://www.alibaba.com/countrysearch/TR/solar-water-heater_3.html

Government's liberal approach to market economy has resulted in elimination of standardization and certification processes in various fields. This makes difficult to create and disseminate recognizable and standardized information about the properties of various equipment that might increase the consumer interest and facilitate decision making.

There is a lack of coherent economic policies and strategies that would incorporate properly the potential benefits offered by for renewable energy sources and SWHs in particular.

3.3.4 Network failures

There have been several donor projects and attempts to promote climate technologies by NGOs and various donor projects. However, there is still insufficient interaction and dialogue with policy making bodies and decision makers to allow constructive discussion of potential benefits and barriers to be overcome in order to achieve these benefits.

There is insufficient cooperation between the environmental NGOs and engineering R&D institutions that would result in more justified argumentation and allow convincing the decision makers.

Donor projects are not properly coordinating with each other and aligned to have a common vision to reinforce the mutual effect.

Culture of consultation with stakeholders is also missing. There is no way for users of particular equipment to share their experience on the benefits and failures of their equipment.

3.3.5 Institutional and organizational capacity

Need for Government agency in charge of EE & RE. Government is mostly preoccupied with high scale projects and has no resources allocated to support most of small scale climate technologies. There is no government agency in charge of energy efficiency and renewable energy development. Functions of the Ministry of energy and natural resources in this respect are not properly articulated and there are no action mechanisms in place. Therefore there is no material government support to deployment and dissemination of SWH technology. There is a need for a government agency that would take the RE issues to policy level and incorporate them in energy strategy. Other side of the activity for such an agency would be the generation and dissemination of relevant RE & EE information, coordination of donor projects, support of R&D for technology deployment etc.

Need for consultancy services. There is a lack for institutions to promote and enhance market by information outreach, promotion and lobbying. The commercial market players like ESCOs, which would provide qualified consultancy services and would share the performance risk for solar water heaters are not developed.

Limited R&D activity. R&D facilities (mainly Georgian Technical University) are ineffective or not properly equipped. There was limited attention and appreciation of R&D role in technology adaptation and deployment. Lack of programs in SWH adaptation prevents the development of technical standards that would serve as benchmarks and support market development.

Small size of local companies – The companies involved with solar water heater import, sale and installation are mostly small size companies without significant financial and technical resource who would take a risk of widening their operations in the field of SWHs.

3.3.6 Human skills

There is a good base of theoretical engineering knowledge mostly in Georgian Technical University, however the practical knowledge and attitude needed for market adaptation of SWHs needs to be developed.

There is insufficient entrepreneurial attitude to developing the market of solar water heaters which is partly due to lack of technical and operational information. Relatively low profitability and underdeveloped market leads to lack of competition and supply constraints.

There is insufficient economic consideration by consumers as well as vendors. The consumer decisions are often made basing on prestige or simple interest in a new technology rather than economic reasoning and calculations.

3.3.7 Social, cultural and behavioral

In general the SWH technology enjoys positive public perception; however the final decisions for purchase of the equipment are hampered by its high cost and uncertain benefits.

High discount rates of consumers (mentioned under 'Economic and financial') short sited attitude is traditionally an obstacle together with funds availability for investment for dissemination of relatively more expensive but more cost effective technology.

There is a believe among policymakers that RE technologies necessarily require budget subsidies and spending that imposes additional burden on public money and hampers economic development according to free market principles. There is a need for comprehensive economic analyses that would show the total effect of RE technology development on the economy as well as country's budget.

3.3.8 Information and awareness

There is insufficient information about actual benefits of the Solar Water Heaters among the consumers. Lack of realistic cost-benefit analyses that would serve as reference for decision making hinders the dissemination of technology.

Due to inadequate information even manufacturers do not have relevant information on possibility of improvements in efficiency of their products. Low awareness is combined with traditional attitude of insufficient attention to technical information, details of efficiency and observance of technical guidelines. This obstacle shall be taken into account while developing the TAP and pilot project for EWS deployment and dissemination.

Due to uncertainty in benefits of SWHs the policymakers are not motivated to design any supportive measures.

There is a lack of agencies providing necessary information. There are no equipped R & D institutes or specialized market development agencies housing the necessary information.

Uncertainty in technical and economic parameters of SWHs results in insufficient motivation for promotion of this technology.

Poor dissemination of information among technology users (on product, benefits, costs, financing sources, potential project developers etc.)

3.3.9 Technical Barrier

Not to be oversized and too costly the SWH systems satisfy only part of the demand (especially in winter). Therefore the existing water heating devices need to be preserved and combined with the new solar systems.
There is a possibility of collective use of solar water heater technology by condominiums that needs to be explored. Some adjustments may be needed for certain types of SWHs in conditions of intermittent water supply that takes place in some cities and regions of Georgia.

There are no entities prepared to start manufacturing the SWHs. There is no knowledge of technology for producing of SWHs, especially high tech. Evacuated Tube collectors.

Inadequate standards, codes and certification

- Lack of institutions or initiatives to set standards
- Lack of facilities for testing and certification
- Standards not obligatory

Lack of R&D activities in this field leads to lack of adequate standards, certification and quality control, as well as low awareness of suppliers and consumers on the benefits provided by solar water heaters.

3.4 Logic Problem Analysis of Barriers

Based on outcome of stakeholders' meeting and brainstorming of mitigation team two key barriers were selected from the above list of barriers: information and awareness barrier, insufficient market adaptation and financial barrier. These barriers were agreed on to be the main barriers of efficient market operation. For each of these key barriers the logic problem analysis was conducted.

3.4.1 Information Barrier Analysis

The logic problem analysis for information barrier is shown in Fig. 2.14 below. It is similar to the information barriers affecting deployment and dissemination of other technologies discussed above.

As a result of low awareness of market participants the demand from buyers and lack of qualification of suppliers the market is undeveloped. On the other hand Low awareness of policymakers prevents adoption of supportive policies, enabling legal and regulatory framework and institution support to the new technology.

Information barrier itself has the reasons that need to be analyzed and addressed:

Insufficient state support. This is one of the main causes of information barrier. Without state strategy in support of climate technologies there is lack of agencies in charge of RE and EE development that would support generation and provision of information to market participants. Therefore, there is lack of technical and economic information on SWH technology in particular. Insufficient state support also leads to lack of efficient R&D institutions that would provide technical support for technology testing and certification that might be the one activity of such institutions. R & D is needed to conduct feasibility studies, and develop instructions and guidance on installation, technical characteristics, etc. At present these activities are not conducted. This leads to absence of dissemination of information to users and uncertain benefits of SWH technology which lowers demand and doesn't allow users to make unbiased decision.

Lack of effective donor programs. Donor programs are supposed to demonstrate new product and help in their implementation. However the donor programs in general suffer from poor coordination with each other and with the state, as well as insufficient attention to monitoring, experience analysis, sharing and outreach. There is a need for donor programs to support feasibility studies and other research and widely disseminate the reliable technical and economic information and operational guidelines pertaining to SWHs. Therefore, the information on benefits of SWH remains uncertain and the interest to SWHs is lower than it might be. Lack of information and awareness in the market lowers demand and consequently imports and production. Absence of enabling legal and regulatory framework can be explained by low awareness among policymakers. Unskilled sales personnel is also a result of information barrier. All these effects can be eliminated or reduced if information barrier is overcome.

Georgia

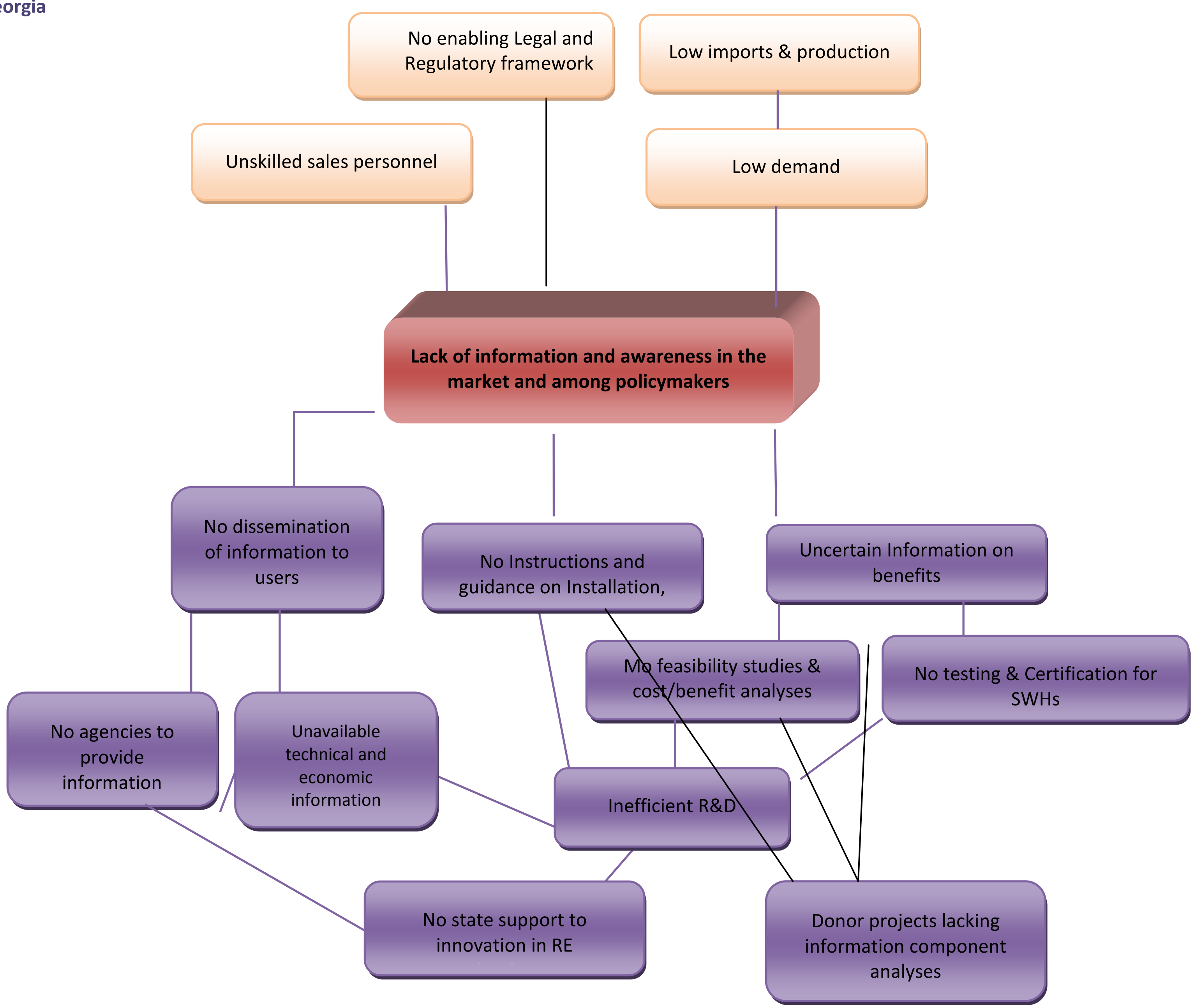

Fig. 2.14 - LPA of information barrier

3.4.2 Financial Barrier Analysis

The main financial obstacle for consumers follows from low income of households combined with the high price of SWHs. General consumer loans and even dedicated financing mechanisms (including[1] EBRD/BP funded Energy Credit facility) are not cheap and developed enough to bridge this gap;

On the other side, the small underdeveloped market results in high market risk of sales and high overhead costs per unit of equipment for importers. This increases the unit cost of solar water heaters. Thus there is a need for supportive financing schemes for new business development enabling the entrepreneurs to boost the business or look for cheaper and more affordable alternatives for SWHs.

Competition with traditional energy sources – especially natural gas that is provided at prices below the regional yields, the economy of solar water heaters is marginal.

Absence of considerable local production/assembly adds to the higher cost of equipment. Lack of special cheap financing schemes and high interest rates in the market discourage the potential entrepreneurial intervention. Georgian banks are in general reluctant to provide project financing, thus making starting investment even more difficult and risky for entrepreneurs.

There are not tax benefits or tax breaks in support of SWH import and installation. VAT exemption on RE equipment has been abolished after 2005. Therefore the prices in Georgia are higher than in neighboring, potentially exporting countries.

These factors lead to high up-front costs for SWH equipment and of manufacturing from one side and low affordability by rural and semi-rural residents from the other. This gap constitutes the essence of financial barrier and prevents deployment and dissemination of SWH technology.

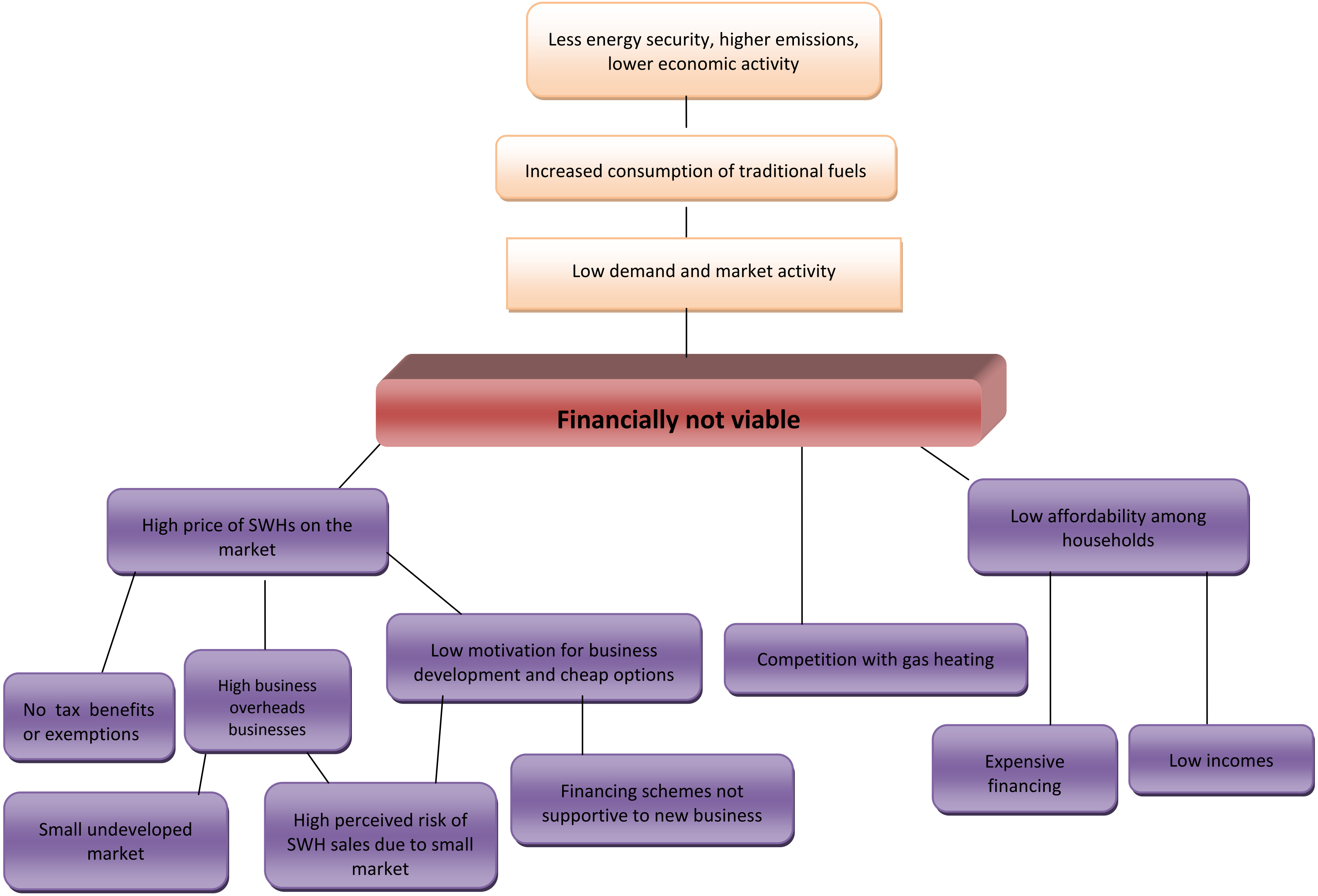

Fig. 2.15 - LPA of financial barrier

3.5 Overcoming barriers

Overcoming the analyzed barriers would require coordinated action of government agencies, non-government organizations involved in EE & RE activities and support of Donor agencies.

3.5.1 Overcoming Information Barrier

The ways of overcoming the information barrier can be visualized as reversal of Fig. 2.14 and is shown in, Fig 2.16 below. It is similar to the ways of overcoming the information barriers affecting deployment and dissemination of other climate technologies discussed above.

Sufficient information and awareness of market participants and policymakers would be the key issues for Solar Water Heater market development. Higher awareness will incentivize the buyers to acquire and use the SWHs. This demand will be sustained by high qualification and preparedness of suppliers that will lead to expansion of effective market. Adequate in-depth informing of policymakers will help eliminate the superficial current views and may facilitate educated policy decisions for enabling legal and institutional environment.

The removal of information barrier should be supported by:

State interest. Change in attitude of policymakers can support development of state strategy and vision in favor of climate technologies that would facilitate adoption of EE & RE legislation and establishment of state agency in charge of RE and EE development. This agency shall be tasked to support development and dissemination of information to market participants, initiate establishment of efficient R&D institutions and activities that would provide technical support for technology testing and certification. This will help to make technical and economic information available. R & D will provide feasibility studies and cost-benefit analyses, and develop instructions and guidance on installation, technical characteristics, as well as assist in testing and certification process. This all will provide information concerning benefits of SWH technology, making it more favorable investment.

Effective donor programs. Donor programs can demonstrate the technology use and help in its implementation on a broader scale, through more intensive information outreach. For increased efficiency the donor programs shall be coordinating with each other and with the state. There shall be enough attention to monitoring, experience analysis, sharing and outreach. The donor programs shall support feasibility studies and other research and widely disseminate the reliable technical and economic information and operational guidelines pertaining to SWHs. Donor projects with strong information component will contribute to dissemination of information concerning benefits of SWH technology.

The above activities can remove the information barrier and open up the way for SWH technology dissemination on a wider basis.

Once information barrier is overcome skill level of sales personnel will increase. Moreover, elimination of this barrier will stimulate demand and as a result import and production will increase contribution to technology development and economy as well.

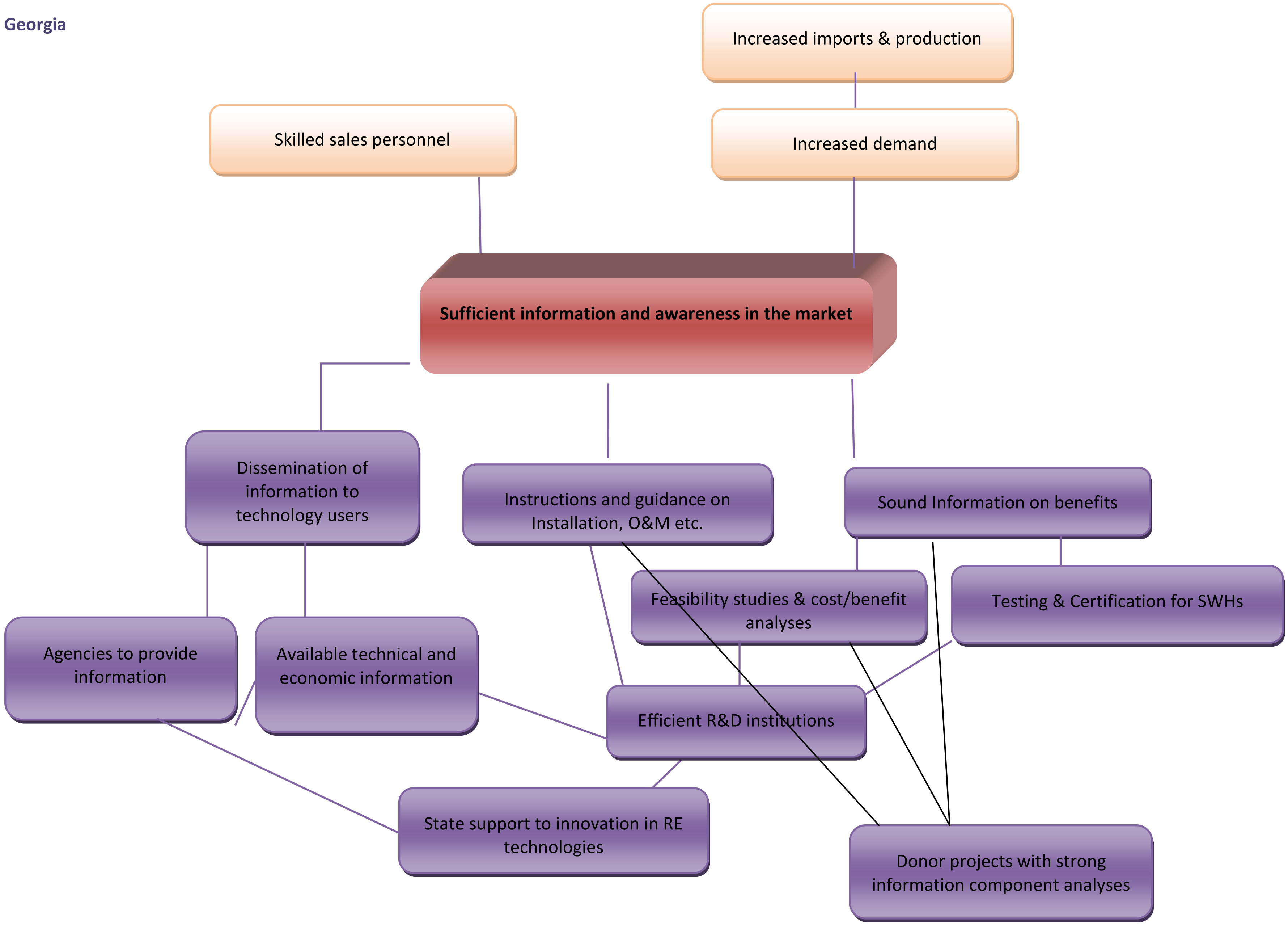

Fig. 2.16 - Overcoming Information Barrier

3.5.2 Overcoming the Financial Barrier

Along with removing of the information barrier, technology needs to be made more affordable for more residential users.

The problem of low income of households cannot be addressed as a part of SWH promotion, however cheap financing schemes might be established by the state with the help of donor programs. Special consumer loans with low interest rates would make the lending attractive for customers.

Development of market will reduce the market risk of sales and reduce the overhead costs per unit of equipment for importers thus bringing down the prices of solar water heaters.

The supportive financing schemes need to be introduced for startup and development. This will motivate the entrepreneurs to boost the business and look for more affordable alternatives for SWHs. Thus the market imperfections and inertia will be overcome by importing or manufacturing relatively cheap and affordable solar water heaters for rural or urban use.

With the lower prices the SWHs will be more competitive with traditional energy sources including natural gas that may also be increased in price to reflect the regional energy prices.

Introduction of tax benefits or tax breaks, similar to majority of developed and many developing countries, might support SWH import and installation. VAT exemption on RE equipment might be restored to bring the prices in Georgia close to the prices in neighboring, potentially exporting countries. The decisions on fiscal support instruments shall be based on preliminary economic analysis that would be compelling for policymakers.

The named factors can lead to lower up-front costs for manufacturing SWHs from one side and increase the affordability for consumers from the other, thus closing the financial and economic gap for SWH technology.

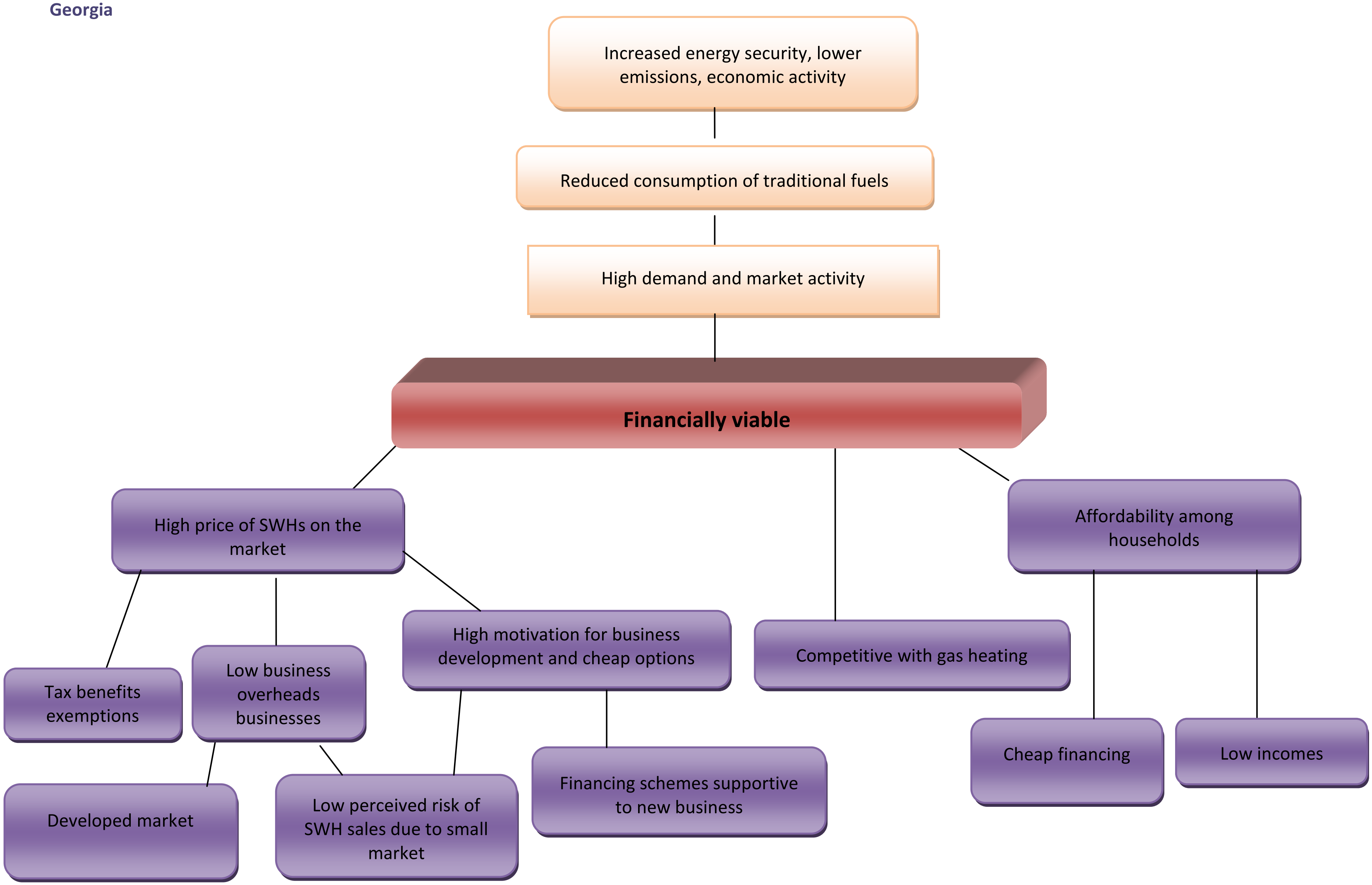

Fig. 2.17 - Overcoming the Financial Barrier

3.6 Technology Action Plans for the selected technologies

Based on the above barrier analyses the attempt was made to develop more concrete measures that would support the deployment and dissemination of selected technologies. Efficient construction technology can be considered a medium term technology since its implementation and wide application will require a broad range of education and capacity building, development of primary and secondary legislation and development of various institutions and business entities.

Tables 2.3below summarize

Tables 2.3 below summarize the technology action plans for this group of technologies

Georgia

Table 2.3 - TAP for SWHs

Measure	Priority	Objective	Implementing agency	How should they do it?	Time scale	Monitoring, reporting and verification	Estimated costs
1	2	3	4	5	6	7	8
Stakeholder Network							
Arrange networking and coordination between Donors, NGOs	2	Improve the quality and effect of Donor projects	Donors & NGOs & State Agency	Arrange consultation process in Donor project development	1 year	meeting minutes and joint documents	No cost
Network vendors and NGOs with R&D for awareness and service quality improvement	2	Improve awareness and service quality of sellers & installers	Donors & State agencies	Initiate free consulting service	1-2 years	guiding material, workshops, consultations	$20K
Arrange consumer networking and information exchange	2	Facilitate information spreading and market activity	NGO project	websites and forums	1 year	number of posts, participants, user activity	$10K
Policies and Measures							
Develop and disseminate technology information, conduct promotion campaign	1	Increase awareness with policymakers and public	R & D centers	Develop information material and plan the campaign	1 year	Audience reached by coverage	$50K
Develop state strategy for EE and RE use	1	Create supportive environment for SWH business development	State with donor TA	Targeted project with participation of stakeholders and wide publicity	1-2 years	State strategy adopted	$100K
Develop and adopt RE Law	2	Create supportive environment for SWH business development	Donors & State agencies	Through participatory law drafting and lobbying program	1-2 years	Law adopted	$100
Energy planning, proper energy pricing and accounting for externalities	1	Develop a meaningful policy in RE	Donor funded TA project	In conjunction with RE strategy	1-3 years	Energy plans with account of RE & EE, proper tariff setting for renewable and fossil fuels	$150K
Establish R & D centers including hardware, personnel and programs	1	Assure expert support to vendors, consumers, develop cost benefit analyses	State, Educational & research institutions	Technology Centers (Techno-Parks)	2 years	Technology reviews, feasibility analyses, equipment testing and classification, guidebooks and training courses	$200K

Georgia

1	2	3	4	5	6	7	8
Develop tax breaks with phase out	2	Stimulate the dissemination	State	Amend tax legislation	1-5 years	amount of tax breaks and effect on technology penetration	TBD
Organizational & Behavioral change							
EE & RE State agency	1	Coordinate implementation of RE strategy and action plans	State with donor TA	Through innovation system support programs	2 years	Agency endorsed by parliament/government	
Establish Effective Technology Centers	1	Support technological development	State with donor TA	Through innovation system support programs	1-3 years	Industry/business support programs, research activities deployment and technology adaptation activities	TBD
Market, system support, financial services							
Cheap loans & Revolving funds	1	Support market penetration of SWHs	Donors	Special credit lines and revolving funds	1-3 years	amount of subsidies	TBD
Grants & Tax breaks	2	Make technology more affordable	Government & Donors	To reduce tax payments either through providing subsidies or through temporary reduction in tax payments	2-3 years	amount of tax breaks	TBD
Cheap financing schemes	1	Enable dissemination of technology through market support	Donor funded RE financing mechanisms	Revolving funds, special credit lines	1-3 years	Number and amount of issued loans and subsidies	$500K
Skills training & Education							
Guide books & other training material	1	Train and inform vendors	Techno Centers, specialist NGOs	Under state and donor programs	1-3 years	available material	$20K
Educate vendors	1	Increased quality of service and provide incentives for "smart" decisions	Techno Centers, specialist NGOs	Under state and donor programs	1-3 years	training courses, consultation programs	$40K

The expense figures are rough cost estimates to be made more precise at the stage of more detailed task planning

PART III

Cross Cutting Issues National TNA and TAPs

There are several cross cutting issues that constitute common barriers for all technologies considered and prioritized under TNA process. These issues result in insufficient development of climate change mitigation technologies in Georgia and in many cases have also common remedies to overcome them.

Consistent state strategy and vision

Lack of a consistent and comprehensive state vision in the field of climate change mitigation technologies, including energy efficiency and Renewable Energy use (except hydropower), is a basic cause for existence of many other barriers. Lack of such a strategy and vision has resulted in absence of relevant state agency, EE & RE legislation and action plans. Up to now there is no government agency working on development of general and comprehensive energy strategy incorporating all energy sources and the potential for energy saving into a common picture. On the other hand there is a good example of promoting the hydropower development through a dedicated program of Georgian government. This example could be extended further and similar programs might be developed for other high priority climate technologies identified under this TNA process.

Lack of proper policy analyses and policymaking capacity to support EE & RE technologies has been the major obstacle in addressing the above issues. This includes proper energy planning and accounting for externalities that would assign adequate value to the sustainable technologies. With the current TNA project an effort is being made to partially fill in the gaps in technology technical and economic information but much more needs to be done.

Need for fiscal Support Mechanisms

The above barriers have resulted in a lack of state policies and action plans for climate technology development. As a consequence there are no effective fiscal mechanisms of tax breaks, state subsidies organs involved to support the deployment and dissemination of climate change mitigation technologies, although there are examples of tax exemptions in other fields. Introduction of such support mechanisms should be justified by understanding of environmental economic, social and political aspects related to continued use of traditional energy sources.

Strengthening of R & D institutions

Existence of efficient R&D centers with targeted programs and effective coordination with ongoing programs is of paramount importance for successful deployment and dissemination of efficient wood fuel combustion, solar heating, efficient construction and other high priority climate technologies. There is an ongoing activity for creation of high technology centers (parks) in Georgian Technical University GTU or establishment of a new institute of technology in Batumi, however It may take some more time before these efforts will result in effective and functional institutions. Meanwhile the existing R & D centers also need to be strengthened and developed as a part of National Innovation System, to address the needs of measurement, testing, design adaptation, other innovation and expert support for these technologies, including information provision, skills and education training etc.

Stakeholder Coordination

A better coordination between the donor agencies, NGOs and specialists is needed around a common plan for EE & RE development in Georgia. This is an opportunity for improving the quality of the projects and achieving better joint results. In absence of the government strategy and action plans in RE and EE there is an increased need for coordinating different donor agencies with NGOs and knowledge field experts in order to develop a coordinated tactics for promotion of EE & RE.The quality of pilot projects can be significantly improved by stronger coordination and emphasizing the information and outreach components in order to collect, analyze and disseminate the practical information to increase general awareness in population and among decision makers who would be willing to take the needed policy measures.

Need for more information at different levels

There is a general lack of practical information about the selected technologies including their principles of operation, costs and benefits, operation and maintenance guidelines and selection criteria. Strengthening of R & D institutions could partly address this problem, though the dedicated data repositories and websites, as well as more knowledgeable experts. International cooperation needs to be strengthened for obtaining adequate information and learning material, Special purpose scholarships for Georgian students as well as fellowships for more mature experts might trigger bringing more CC technology information. Creation of data and information depositories would support adaptation and deployment, as well as the development of indigenous climate change mitigation technologies.

Adequate fuel pricing and accounting for externalities

Although Georgia has no significant production of oil and gas, major energy resource consumed in the country is imported natural gas, which is also a major source of greenhouse gas emissions. Though this is not an indigenous resource but a great part of it comes as a fee for the gas transit between neighboring countries and partly it is purchased from neighbors. Nevertheless, the in-kind transit fee is used to subsidize the gas prices which are inexpensive compared to regional prices at which gas could be sold. Analyses and inquiries under current TNA have shown that such policy stimulates gas usage to the detriment of development of indigenous renewable energy sources including solar, biomass and geothermal, as well as energy saving. Adequate gas pricing and proper accounting for externalities would be the key for developing the supporting policies for the selected technologies.

Innovation system development

Discussions and own analysis during the project implementation have highlighted the need for further development of comprehensive national innovation system (NIS) to assure better interaction of educational and research institutions with businesses and to promote innovation for the benefit of the local industry and to the extent possible based on Georgian resources.

Creation of Technology Parks, Centers of Excellence or Technology Transfer Centers for information storing and sharing, knowledge and know how transfer, and for the support of cooperation between higher education schools, R & D institutions and business is an important part of such a system. Addressing legal and financial aspects of innovation and developing the National Strategy for innovation are essential steps in this direction although beyond the scope of this TNA project.

Current TNA has partially attempted to address the above issues in discussions and presentations to stakeholders involved in climate mitigation technology development in Georgia and PSC. The proper follow-up based on the findings of current study would be desirable for the sake of country's successful technology and innovation development of the country.

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Annexes

Annex I. Technology Reviews

A 1 Technology Options – Building Sector

A 1.1 Efficient lighting

Making improvements to lighting is one of the fastest ways to cut your energy bills. An average household dedicates 11% of its energy budget to lighting. Using new lighting technologies can reduce lighting energy use by 50% - 75%. Advances in lighting control offer further energy savings by reducing the amount of time when lights are aimlessly on. There are two main types of lighting fixtures that can effectively cut down the electricity consumption and reduce energy bills:

Fluorescent Lights

Linear fluorescent tubes and energy efficient compact fluorescent light bulbs (CFLs) in fixtures provide high-quality and high-efficiency lighting. Though it must be noted that initially more expensive efficient bulbs saves money in the long run. Quality CFLs use 1/4 of the electricity and last up to 10 times as long as incandescent bulbs. A single 18 watt CFL of good quality used in place of a 75 watt incandescent can save about 500 kWh over its lifetime. At $0.09per kWh, that equals to $47savings. Newer CFLs have high quality light. They give a warm, inviting light instead of the "cool white" flickering light of older fluorescents. CFLs can be applied almost everywhere the incandescent lights are used.

Compact Fluorescent Bulbs—A Bright Idea!
ENERGY STAR qualified lighting provides bright, warm light and uses about 75% less energy than standard lighting, produces 75% less heat, and lasts up to 10 times longer.

The payback period for CFLs can be as low as 0.5-1 year depending on intensity of use and they can save up to 75% of electricity used for lighting. Although the supply on the market is abundant, currently the CFLs are mostly used in commercial and budget entities and less - in the households.

LED lights

Light Emitting Diode - LED bulbs last up to 10 times as long as compact fluorescents, and far longer than typical incandescent. These bulbs do not cause heat build-up; No mercury is used in the manufacturing of LEDs. More efficient - LED light bulbs use only 2-10 watts of electricity (1/3rd to 1/30th of Incandescent or CFL). Small LED flashlight bulbs will extend battery life 10 - 15 times longer than incandescent bulbs. Also, because these bulbs last for years, energy is saved in maintenance and replacement costs. Although LEDs are expensive, the cost is recouped over time and in battery savings. For the AC bulbs and large cluster arrays, the best value comes from commercial use where maintenance and replacement costs are expensive. Because of the low power requirement use of LEDs in combination with solar panels becomes more practical and less expensive than running an electric line or using a generator for lighting in remote areas.

A 1.2 Weatherization of Buildings

There are a number of low cost measures that can be effectively used for reducing the energy consumption for heating and cut the corresponding amount for GHG emissions.

- Energy efficient windows
- Energy efficient doors
- Interior wall insulation
- Weather stripping
- Insulation of common areas

The double glazing has become widely popular in recent years, because of handiness and lower cost of producing the PVC frames as well as better insulating qualities of these windows. However, there are gases filled high reflectivity windows of higher efficiency that might be introduced to Georgian market. Additional research is needed in order to make sound conclusions on the costs and benefits of such windows for Georgian climate conditions.

These are some of the measures that can be applied to reduce carbon footprint of currently inefficient housing stock at moderate or low cost.

A study in residential block buildings[15] of Tbilisi has shown significant saving potential in simple weatherization of common areas in residential block buildings. Restoring of simple glazing and shutting the entrances can save about 20% of residential heating consumption.

Air infiltration around a window, door, or skylight in the presence of a specific pressure difference across it is one of the major sources of heat losses in old buildings with wooden window/door frames. Weather stripping with simple materials like reinforced foams, door sweeps, insulation tapes and door shoes can have fast and noticeable effect.

All these measures require proper informing and organizing the neighborhoods that can be achieved through condominium associations and programs of city municipalities.

A 1.3 Thermal Insulation of Walls

Insulation is the most effective way to improve the energy efficiency of a house. Insulation of the building envelope helps keeping heat in during the winter, but let the heat out during the summer improving comfort and saving energy. Insulating a house can save 45–55% of heating and cooling energy. Once installed by a good thermal insulation company the amount of energy needed to keep your house at a constant temperature will be greatly reduced with the associated reduction in natural resource usage.

Benefits of insulation:

- comfort is improved year-round;
- it reduces the cost of heating and cooling by over 40%;
- there is less need for heating and cooling which save non-renewable resources and reduces greenhouse gas emissions;
- it virtually eliminates condensation on walls and ceilings;
- some insulation materials can also be used for sound proofing.

Three types of insulation materials were considered.

[15] Energy Audit Report – USAID/Winrock International / WEG
http://weg.ge/images/stories/publications/reports/Final_Energy_Audit_Report.pdf

Mineral Wool

Mineral (rock) wool is made by melting a combination of rock and sand and then spinning the mixture to make fibers which are formed into different shapes and sizes. The process is similar to making cotton candy.

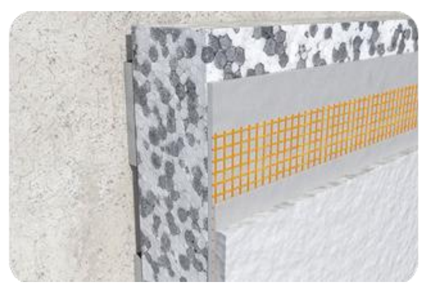
Advantages:

- Rock wool is clean and convenient; it holds together well so it can't spill. It is easy to handle and keeps evaporation to a minimum.
- Since the fibres are non-combustible and have an extreme melting point, rock wool insulation acts as a fire barrier. Its fire resistant characteristics hinder the spread of fire, which could add precious minutes for escape during a fire Rock wool insulation reduces energy costs and requirements in residential houses, office buildings and manufacturing plants. Rock wool insulation can reduce residential energy bills by at least 40 percent. These energy savings are not just beneficial on the finances, but also for the environment, as the dependence on energy decreases.

The quoted thermal conductivity of mineral wool boards is λ=0.04W/mK and the resulting thermal resistance of walls depends on the thickness of material used. Along with insulation material the vendor usually provide the whole technological cycle including materials and devices for preparation of walls, attaching the insulation boards, covering with protective net, plastering and painting the surfaces of the walls

Polistirene/polyurethane boards

Polystiren/polyuretan foam thermal insulation system. Vendors use the same type of technology for thermal insulation of new or existing buildings. 5 to 15 cm thick insulation (neopor) panels are glued on to the wall and in some cases (especially old houses) extra screwed into the wall. A 160 g/m^2 net is then glued on the insulation panels and made smooth. After a drying time from 2 to 4 days (depending weather conditions) a 1,5 mm pasta (with integrated color – more than 1000 colors possible) - is rendered and made it smooth.



There are different vendors of this technology differing in actual insulating material but with the same technology of insulation. The difference in the characteristics of this synthetic material still needs to be understood. Thermal conductivity of most of this materials is around λ=0.035W/mK. Apart from thermal resistance, the main parameters of interest are: durability, strength, fire resistance properties *etc*. These materials are not fire resistant and in case of fire some of them can emit toxic substances.

Basalt non-woven mats (BPG)

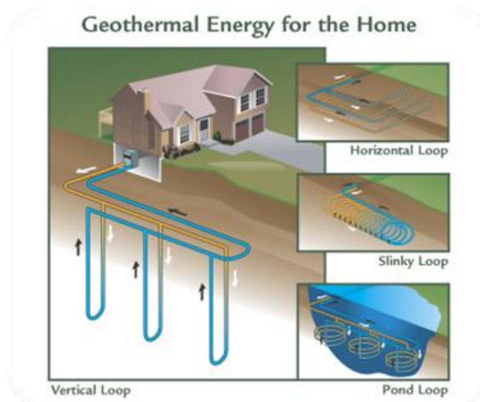
There is production of Basic characteristics:

- High tensile strength
- Low moisture absorption
- High chemical resistance
- Wide temperature operating range: (-260°C)...(+850°C)
- Basalt and glass fiber combined is non-woven mat efficient for acoustic insulation

According to vendor, the thermal conductivity of this material is λ=0.031035W/mK which places it at the high end of insulation materials. However the technology of its application for building insulation still needs to be developed.

Practice of thermal insulation is being developed slowly. There are several buildings insulated with this technology. However the main drawback of thermal insulation technology is its high cost. The cost of insulation of existing buildings varies between \$30-47/m^2 and the payback period for such works is estimated at 12-17 years.

A 1.4 Heat Pumps for Heating and Cooling



Heat pumps like ordinary air conditioning split systems or ground or water coupled geothermal heat pumps are efficient devices allowing heat movement from one media to another. These devices can be used for heating as well as cooling of building inner spaces. E.g. a ground-coupled heat pump can be used for moving internal heat to the ground in summer and pumping the heat to buildings in winter.

The efficiency of these devices is high since for every kWh of electricity used they provide 2.5-3.5 kWh of heat/cool in case of air-coupled air conditioning units and 4-5 kWh of heat/cool for ground or water coupled units.

This is a well known proven technology that has been used mostly for big hotels and big office buildings. However with the development of private housing sector it can be successfully implemented in newly developed small hotels and private housing sector for higher income customers.

There are several factors that may positively influence the deployment and dissemination of these technologies.

1. The development of hydropower potential raises the issue of developing the internal market for electricity.
2. Climate change makes extreme hot/cold weather conditions more likely where the importance of heating/cooling will increase
3. Development of drilling technologies can make the currently almost prohibitive drilling costs more affordable.

Meanwhile the relatively cheap slinky loop or pond/pool systems can be successfully implemented.

A 1.5 Energy Efficient Construction

Construction is one of the most active industries in Georgia. After a short recession caused by 2008 war the construction is rapidly restoring its pace. The estimated building area added annually is up to 2 mln m^2 and is expected to get back to pre 2008 higher figures. Therefore the quality and energy performance of the new buildings will have a significant effect on energy consumption of Georgia over the coming decades.

With minor exceptions the construction is going without consideration of energy performance and future energy consumption of the buildings. There are no applicable standards and codes that would regulate the new construction and there is no capacity and practice in design and planning process to incorporate the principles of integrated design and Green building methods.

There is a number of businesses producing the energy saving and energy efficient materials. However their production capacity is limited and their product is mostly exported to neighboring countries. Therefore the share of local efficient construction materials on the market is negligible.

New technologies and design approaches for building envelopes include design of widened buildings with a lower surface-area-to-volume ratio; energy-efficient windows with sealed glass units; use of light-weight thermal-insulation materials in exterior-wall systems; and others.

The process of *integrated design* applied by architects shall reduce the amount of material needed, use materials with less environmental impact, envisage use of local energy efficient and energy saving materials and renewable energy sources.

Implementation of these new systems and technologies in Georgia is running into problems both at design and construction phases. There is no formal requirement or market demand for the use these new technologies. Therefore the capacity for efficient design and construction technical support, efficient material supply and in general the market for efficient housing are not developed[16]

Perlit and polystyrene insulation materials are produced locally as well as imported from Iran, Czech Republic, Italy, France and Turkey. The most frequently used local natural resources for production of construction materials are perlit, basalt, pumice, slate and tuff, the vast reserves of which are owned by Georgia.

Use of thermal insulation construction blocks in building frames significantly reduces both the weight of the building, naturally reducing the cost of building of a foundation and walls of a building frame, and the natural losses in environment, saving colossal sums spent by the country on heating during winter and cooling during summer period.

Mining of perlit mineral and production of construction materials is slowly expanding and cannot catch up with the construction industry. Most of the product is exported to neighboring countries and has negligible effect in Georgia's construction industry

There is also a number of technologies in early development stages that need to be developed and commercialized.

- A local producer of basalt wool (BPG) which produces high quality mineral wool and non-woven mat. However this material needs to be developed further and adjusted to the needs of building thermal insulation.
- Production of baked slate blocks A technology has been developed by professors of Georgian Technical University to bake the slate rock and thus create a light porous construction blocks with high thermal resistance. The final material has thermal conductivity of is 0.16 - 0.22 W/mk and density of 700-800 kg/m^3 (compared to 0.8 wt/mk 1400 kg/m^3 of brick).

[16]Survey Of Current Construction Practices And Recommendation To Building Industry To Improve Of Energy Efficiency In Georgia – USAID, Winrock International, 2008.

- Production of polystyrene concrete as a light and efficient construction material etc.,[17] require both technological, marketing and financial support.

A 2 Technology Options – Renewable Energy

A 2.1 Solar Energy

The technologies identified for prioritization include use of solar energy for electricity, for hot water supply and for space heating.

Photovoltaic (PV) Solar Panels. Photovoltaic technology is a way to generate electric power by using solar cells to convert energy from the sun into a flow of electrons. PV cells are combined with batteries and power invertors to provide the same voltage and frequency as in utility electricity networks. Alternatively, they are used for feeding DC current to feed stand alone low consumption devices. The PV panels can be used in power stations, in buildings (integrated or mounted), in transport, in standalone devices, in rural electrification and solar roadway lighting. Such wide application is mainly provided due to number of advantages that PV possesses:

1. It is pollution free.

2. The installations can operate for many years with little maintenance or intervention after their initial set-up. Hence, the operation costs are extremely small.
3. Electric generation is economically superior where grid connection or fuel transport is difficult, costly or impossible.
4. Solar cell technologies are developing faster compared to fossil and nuclear energy technologies and there is a considerable potential and expectation of improvements.

However, the technology has also drawbacks:

1. Solar electricity is more expensive than most other forms of small-scale alternative energy production.
2. Solar electricity is not produced at night and is greatly reduced in cloudy conditions, so it is difficult to regulate.
3. Solar cells produce direct current (DC) which must be converted to alternating current (AC) using a grid tie inverter in existing distribution grids which use AC.
4. Solar PVs are expensive – and cost around $10-12/w for larger systems.

Partly due to mentioned above disadvantages and due to availability of cheap hydro energy PV is not widely applied in Georgia. Mainly PV cells are used in remote areas where there is no grid and other alternatives to generate electricity. Market for this technology is undeveloped since there is extremely low demand for it. Having large hydro potential, developed electricity network and electricity export orientation, Georgia does not set development of internal PV market as a priority.

Solar Water Heaters. The SWH system consists of solar thermal collectors, water tanks, interconnecting pipes, and water circulating in the system. According to relevant estimations, such SWH systems in Georgia can substitute traditional fuel expenditure up to 80% on average annually. Taking into account high lifetime of these systems it can be profiTable1. long-run investment.

[17]Energy Efficient Construction Materials Sector In GEORGIA – USAID 2008.

Georgia

Various modifications of solar heater technology are available on the market. Major difference is between flat panel and evacuated tube collectors, integrated and split systems, pressurized or gravity flow, open loop and closed loop systems.

Evacuated tube collectors are the newer technology that is developing further and provides higher efficiency of solar energy gain per unit of area than traditional flat panels. Evacuated tube collectors are more expensive per unit area, but due to their higher efficiency the final cost for kWh of solar energy captured can be lower than in flat collectors.

Based on market survey and discussions with experts, two preferred options were selected for further analysis: a. Closed pressurized integrated systems based on evacuated tube collectors for urban applications; b. Gravity flow open loop integrated systems with evacuated tube collectors and thermo-siphon heat transfer mechanism from tubes to the tanks. These technologies were selected based on their cost and potential applicability. E.g. it was considered that open systems are not suiTable1. in combination with pressurized municipal water supply systems in the cities, while being cheaper they can be used in rural areas with poor water supply. Both these systems are marginally affordable for relevant customers and need supportive measures to be widely disseminated.

Solar Space Heating Systems. Solar collectors can be used for space heating. In this case the thermal solar collectors are combined with space heating boiler with two loops – for heating and for hot water. This thermal system allows not only to heat water with solar energy but also to heat houses. In summer it can solely heat water and in winter it preheats water for hot water applications or for space heating, so the bills are considerably reduced.

The main technical obstacle in case of space heating is high temperature of water in space heating circulation loop that makes transfer of heat from the heating loop less effective. However the systems with evacuated tube collectors can provide high temperature in the primary loops that can provide for sufficient heat transfer.

In general this technology is much more expensive than heating with gas or even electricity. Moreover, in winter when the weather is usually cloudy the system operates at low output. Additionally, the system itself is quite complex and installation is costly. Such systems can be used by high income population and will have much more limited market to compare to conventional water heating systems. Therefore it was considered to be as lower priority for TNA process.

Table A2.1 - Solar water Heater characteristics

General Solar Water Heater (SWH) characteristics		
	SWH for urban areas	SWH for rural areas
Price of installed SWH (GEL)	3000	1500
lifetime (years)	15	15
%HW supplied by SWH	80%	75%
Maintenance cost (GEL)	20	25
If compared to other traditional ways of water heating SWH has the following characteristics. (Table 1.10, 11)		

Georgia

Table A2.2 - SWH characteristics if compared to natural gas		
For Natural Gas Consumers	**Closed system**	**Open system**
Equivalent gas, m3	379.6	379.6
Equivalent gas cost, GEL	193.6	193.6
Saving on gas cost with SWH, GEL	154.9	145.2
Payback, years	24.0	13.0
IRR	-3%	6%
Annual CO2 emission gas, ton	0.82	0.82
Annual CO2 saving , ton	0.66	0.62
Cost of CO2 saving, GEL/ton	591.2	229.6

Table A2.3 - SWH characteristics if compared to electricity		
For Electricity Consumers	**Closed system**	**Open system**
Equivalent electricity, kWh	3568.5	3568.5
Equivalent electricity cost, GEL	624.5	624.5
Saving on electricity cost with SWH, GEL	499.6	468.4
Payback, years	6.4	3.4
IRR	18%	45%
Annual CO2 emission electricity, ton	1.43	1.43
Annual CO2 saving , ton	1.14	1.07
Cost of CO2 saving, GEL/ton	38.1	-169.9

The closed and open SWH systems with traditional fuels are compared in Tables 10 and 11. An open system is twice cheaper than closed one and if substituted to electricity water heating it has negative cost of CO_2 saving. However, it should be pointed out that in rural areas people heat water mostly with biomass. Therefore, the comparison to electricity and gas water heating in rural case is not so relevant.

As it can be seen from the tables, SWH is cheaper than electricity, but more expensive than gas. However, if market for SWH develops, the price of the system will substantially go down and it will become more competitive.

Table A2.4 - Prioritization of Technologies for Solar Energy

#	Technology options:	Relevance to TNA	Priority	Score
1	Solar PV panels for electricity	PV is used for feeding DC current to feed stand alone devices. The PV panels can be used in power stations, in buildings (integrated or mounted), in transport, in standalone devices, in rural electrification and solar roadway lighting. The technology is pollution free and can to some extent substitute electricity generated from other sources. However, in Georgian case electricity is mainly generated by cheap hydro stations, and therefore expensive PV systems are less favorable.	3	59
2	Solar Water heaters for hot water supply	It is estimated that in Georgian conditions such SWH system can substitute traditional fuel expenditure up to 80% on average annually. Taking into account high lifetime of this system in long-term conditions it can be a profiTable1. investment. This technology is pollution free and gives possibility to sufficiently cut utility bills. Wide application of this technology can reduce country dependence on imported	1	75

		natural gas. SWH system applicable for urban areas costs on average 3000 GEL (1800$) while SWH system suiTable1. for rural areas is twice cheaper, 1500GEL (900$). In case of availability of financing option this technology is a profiTable1. Investment and can be widely used in Georgia.		
3	Solar collectors for hot water and space heating	This system is much more complex and expensive than SWH. It suggests using solar hot water for space heating. However, taking into account that in winter the weather is dominantly cloudy this system will not be able to fully substitute gas expenditures. The price of the system is so high that payback is larger than the lifetime of the system itself. Moreover, such systems usually require much space and in urban area it can be problematic.	2	64

Economic Assessment SWH

Solar water heaters in households

Input Constants

3600	sec/h	Gas heat content	9,4 kWh/m3	Emission factor gas	**0,23**	kgCO2/kWh
4,19	kJ/kg.oC	Gas heater efficiency	0,8	Emission factor electricity	**0,4**	kgCO2/kWh
1,163	MCal/kWh	Electric heater efficien	0,8			
0,175	GEL/kWh elect.	Population	4400			
0,51	GEL/m3 N.Gas.	Households	1250			
1,64	**USD/GEL**	Persons per family	3,52			

Hot water requirement	40	lit	60	oC	per person/day
Cold water temperature	12	oC			
Persons per family	3,5	persons			
Annual requirement per family	51100	lit	51,1	ton	
Energy required for HW	201,12	kJ/kg	55,9	kWh/ton	
Annual HW energy requirement			2854,8	kWh/family/year	

Solar Water Heater	**SWH**	
Price of installed SWH	1500	GEL
lifetime	15	years
%HW supplied by SWH	75%	
Interest rate	15%	
Levelized annual cost	256,53	GEL
Maintenance cost	30	GEL
Total Annual Cost	**286,53**	**GEL**

Pressurized open loop integrated systems for urban use	3000	GEL - Installed
Gravity flow open loop integrated systems for rural use	1500	GEL - Installed

Natural Gas Consumers			**Electricity Consumers**		
Equivalent gas	379,6	m3	Equivalent electricity	3568,5	kWh
Equivalent gas cost	193,6	GEL	Equivalent electricity cost	624,5	GEL
Saving of gas cost with SWH	**145,2**	GEL	Saving of electricity cost w.SWH	**468,4**	GEL
Payback	**13,0**	years	Payback	**3,4**	years
IRR	6%		IRR	45%	
Annual CO2 emission gas	0,82	ton	Annual CO2 emission electricity	1,43	ton
Annual CO2 saving	0,62	ton	Annual CO2 saving	1,07	ton
Cost of CO2 saving	229,6	GEL/ton	Cost of CO2 saving	-169,9	ton

	Residential		**Commercial**		**Total**		
Potential market in 10 years	50000	consumers	10000		**60000**		90 000 000
Dissemination adjustment fact	60%						54 878 049
Effective consumer number f. 1(	30000		6000		**36000**		110
Potential 10 year CO2 saving	252916	tons	50583,25	tons	**303500**	tons	

Georgia

Solar Collector Prices

EUR/GEL **2,4**

	CAUSO				Aydio		Thermarsenal	
System Type	**150l**	**200l**	**150l**	**200l**	**150l**	**200l**	**120l**	**160l**
	USD	USD	GEL	GEL	GEL	GEL		
Open system	615	815	1008,6	1336,6	1450	2100		580
Pressurized system	1370	1750	2246,8	2870	2400	3800	1300	

Persons per family	2-4	150lit
Persons per family	3-5	200lit

	150	**200**
Heater cost	2250	3000
Installation cost	500	500
Installed heater c	2750	3500

Installation costs CAUSO - 300-500GEL

Population	4400
Households	1250
Persons per family	3,52

Average price per family **1500**

IRR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
5,9%	-1354,8	145,2	145,2	145,2	145,2	145,2	145,2	145,2	145,2	145,2	145,2	145,2	145,2	145,2	145,2
45,2%	-1031,6	468,4	468,4	468,4	468,4	468,4	468,4	468,4	468,4	468,4	468,4	468,4	468,4	468,4	468,4

A 2.2 Wind Power

Wind power is a technology to be promoted in Georgia mostly due to its technological benefit. There may be selected areas where the wind power would be more feasible than conventional hydro. However, in general it is considered to be more expensive than hydro power. At the same time currently there is no market in the country for wind power development.

Georgia has about 100 year observation data of daily wind speed and from 165 meteorology stations all over the territory of the country. In some locations there have been conducted special wind measurements. Technically and economically justified wind power potential is estimated at 5TWh of annual production and 2GW capacity.

From the wind energy atlas of Georgia it is known that the speed of wind in some of the sites is higher in winter than in summer (Annex-Figure 3). Georgia imports electricity in winter and also uses own thermal power plants, thus the wind farms at such location have higher potential of replacing thermal generation. Also it could reduce gas and electricity import dependence in winter.

According to Scientific Wind Energy Center - KARIENERGO there are 12 significant potential wind farm sites in Georgia. Based on the data for the wind farm sites and their annual seasonality electricity generation characteristics of 6 destination sites with highest capacity potential have been selected:

Georgia

Table A2.5 - Characteristics of 6 destination sites

#	Site	Total capacity	Capacity factor	Turbine size	Capital Cost (€/kW)	O & M Costs (€c/kWh)
1	Samgori*	60	0,23	3,0 MW	1200	0.5
2	Skra*	99	0,24	3,0 MW	1200	0.5
3	Kutaisi	99	0,24	3,0 MW	1200	0.5
4	Chorokhi*	30	0,25	3,0 MW	1300	0.5
5	Sabueti	600	0,38	3,0 MW	1400	0.6
6	Tskhratskaro	99	0,28	3,0 MW	1400	0.6

1. Capacity factors are estimated based on historic wind speed measurements in selected locations own measurements by Karienergo have been also conducted (denoted by *);
2. Potential installed capacity has been estimated using special software (WASP);
3. Installed capacity and operation costs are taken from recent European studies with minor adjustments to Georgian situation;
4. The installed capacity values are corrected to account for the effects of more rugged terrain

Technical and Economic appraisal of wind power potential has been conducted based on the following main assumptions:

Economic assessment

European experience shows that the lifetime of most wind turbines ranges within 25-30 years. The higher is installed capacity of wind turbine the longer is its lifetime. Based on the experience of Western European countries the following main cost assumptions were derived[18]:

- Investment cost per MW installed capacity – 1.2-1.4 Million Euros;
- Life time of the turbine - about 30 years;
- Installed capacity of turbines – 3 MW;
- Initial annual O&M cost – 0.005 Euro/kWh;
- Growth rate of O&M cost – maximum 5% from sixth years of exploitation;

The costs may be slightly lower in Georgia due to lower cost of labor, foundations, electric installations and land. Total GHG replacement potential was calculated based on existing emissions factor 0.4kgCO_2/kWh

[18] Technology data excel model

Georgia

Table A2.6 - Economic parameters of chosen technology option

#	Site	Total capacity	Capacity factor	Turbine size MW	Capital Cost (€/kW)	O & M Costs (€c/kWh)	Annual Output (GWh)	IRR	10 Year Emissions reduction (thd T CO_2)
1	Samgori*	60	0.23	3.00	1100	0.5	120.9	8.3%	411
2	Skra*	99	0.24	3.00	1200	0.5	208.1	7.8%	708
3	Kutaisi	99	0.24	3.00	1200	0.5	208.1	7.8%	708
4	Chorokhi*	30	0.25	3.00	1250	0.5	65.7	7.8%	223
5	Sabueti	600	0.38	3.00	1300	0.6	1997.3	12.3%	6391
6	Tskhratskaro	100	0.28	3.00	1300	0.6	245.3	8.6%	834
	TOTAL	992					2845.4		9,275

*Calculations are made in separate excel spreadsheet.

There are a number of challenges that wind power presents to developers, but at the same time the overcoming these challenges can be a way for improving the energy system. A common problem with the wind energy is its intermittent pattern of generation due to unpredicTable1. wind. In case of Georgia this can be less of a problem due to availability of hydro power that can be easily regulated.

Technical difficulties:

a. Grid connection of wind power on long distances may be costly, therefore only high potential high output plants will be able to justify such investments;
b. Compensation for wind intermittency – special measures may be needed in order to compensate. Hopefully, the hydro-dominated Georgian power system can suggest such mechanisms without significant additional investment;
c. Terrain may be a challenge in some of the most potent wind power locations. Some high potential wind sites are located in mountainous areas and will require significant investments in road and electricity transmission infrastructure.

Commercial issues*:*

a. On internal market the wind power has to compete with hydro-power which is more predicTable1. and in the same range of cost. Domestic market is already saturated with hydro power and Georgia has become a net power exporter. Therefore a decision on wind power development shall be taken based on the growth perspectives of domestic demand and potential hydropower development that can compete with wind generation. Due to abundance of hydro power and export orientation of the system, achievement of state backed guaranteed power sale at feed in tariff may be problematic.
b. Due to intermittent and partly unpredicTable1. pattern of production it will be more difficult to sell the wind power. There will be a need of balancing mechanisms to compensate for the varying output of wind power plant. More intensive involvement of balancing energy market may become necessary.

Environmental problems

a. Georgia is one of the key countries for bird migration, therefore adequate attention should be paid to this fact especially in the west Georgia close to Kolkhis wetlands.

Georgia

Economic Calculations Wind

Switch 0/1		Site	Total capacity	Capacity factor	Turbine size MW	Capital Cost (€/kW)	O & M Costs (€c/kWh)	Annual Output	ToTal Capital Cost (€MM)	ToTal Capital Cost ($MM)	IRR	NPV(@ 12%)	10 Year Generation	10 Year Emissions reduction
1	1	Samgori*	60	0,23	3,00	1100	0,5	120,9	66	92,4	7,6%	($24,04)	1027,5	411
	Capital													
	Sales													
	O&M													
	Cash Flow													
1	2	Skra*	99	0,24	3,00	1200	0,5	208,1	118,8	166,32	7,2%	($18,57)	1769,2	708
	Capital													
	Sales													
	O&M													
	Cash Flow													
1	3	Kutaisi	99	0,24	3,00	1200	0,5	208,1	118,8	166,32	7,2%	($11,12)	1769,2	708
	Capital													
	Sales													
	O&M													
	Cash Flow													
1	4	Chorokhi*	30	0,25	3,00	1250	0,5	65,7	37,5	52,5	7,2%	($3,51)	558,5	223
	Capital													
	Sales													
	O&M													
	Cash Flow													
1	5	Sabueti	600	0,38	3,00	1300	0,6	1997,3	780	1092	11,5%	($30,10)	15978,2	6391
	Capital													
	Sales													
	O&M													
	Cash Flow													
1	6	Tskhratskaro	100	0,28	3,00	1300	0,6	245,3	130	182	7,9%	($1,95)	2084,9	834
	Capital													
	Sales													
	O&M													
	Cash Flow													
		TOTAL	992					2845,4	1251,1	1751,54			23187,5	9275

10 Year O & M	162	$MM
Total 10 year cost	1914	$MM
10 year revenue	1991,8	$MM

Interest 12%

Wind Power

Depending on experiences in the UK, Germany, Denmark, and Spain, O&M costs are estimated to be about 1.2 to 1.5 euro cents (c€) per kWh of wind power produced over the total lifetime of a turbine. Less than 60% of this amount goes strictly to the operation and maintenance of the turbine and installations, equally distributed between labor costs and spare parts. The remaining 40% is shared equally between insurance, land rental and overheads. On the other hand in the German study O&M costs make up a small percentage (2–3 per cent) of total investment costs for the first five years, corresponding to approximately 0.3–0.4c€/kWh. After six years, the total O&M costs increases by less than 5 per cent of total investment costs, which is equivalent to around 0.6–0.7c€/kWh. Wind turbines exhibit economies of scale, with increasing turbine capacity investment cost per kW declines; also there are similar economies of scale for O&M costs.

Main Technology Assumptions

	EUR	USD
Capital cost (per kW)	1300	1820
O&M cost (per kWh)	0,3	0,42
Capacity factor	25%	
Total Installed Capacity	1000	MW
Sale price	7	c/kWh
Lifetime	30	years
EUR/USD	1,4	

Emissions factor

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Scenario :	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4
Scenario :	0,4	0,2	0,2	0,3	0,3	0,4	0,35	0,35	0,35	0,35

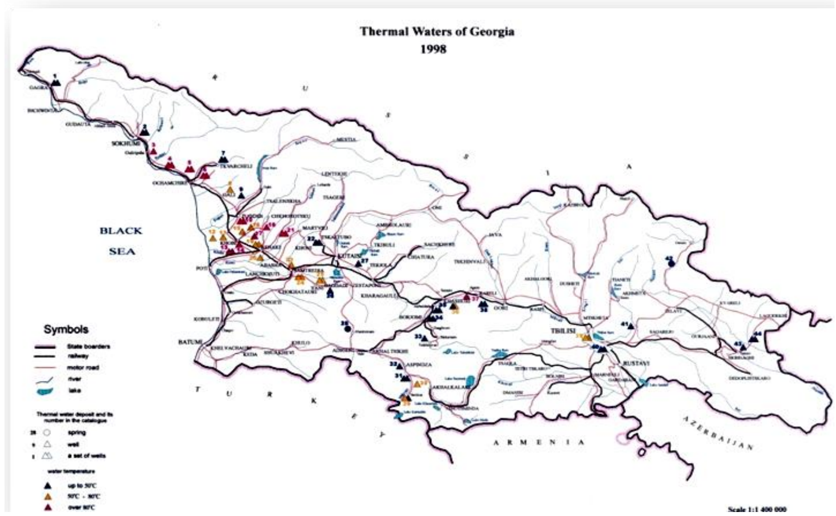
Wind Project Assessments

Georgia

A 2.3 Geo-Thermal hot water

Geothermal Energy Potential

Georgia is rich in Geothermal water resources. There are approximately 206 wells and 4 springs of geothermal hot water (GHW) with temperatures between 30 and 110^0 Celsius located in 44 deposits in Georgia. About 80% of this geothermal potential is located in West Georgia. Total theoretical thermal capacity of all geothermal sources at T0-250C was estimated at 300 MW of thermal capacity. Total achievable potential is estimated at 30% or 100MW of thermal capacity[19]. Temperature of geothermal deposits is not very high and is mostly suiTable1. for heating and hot water supply rather than for power generation.



Among thermal water deposits available on the territory of Georgia two main thermal aquifers – Tbilisi and Zugdidi-Tsaishi, are distinguished for their wide regional expansion, considerable thickness, high collecting and filtration properties, water abundance and high water temperature. These two thermal aquifers can contribute significantly to energy supply and support economy in Georgia.

Total output of geothermal water in Tbilisi is 4 000 m3/day with $55\text{-}72^0$C. Zugdidi-Tsaishi deposit has much higher output of 15000m3/day of $85\text{-}95^0$C water. The estimated thermal potential in selected other locations is: Khobi – 1.2 MW. Senaki – 11 MW, Samtredia – 5MW, Vani- 5 MW *etc*. Geologic studies and collected data provide sufficient evidence that there is a large geothermal potential at deep water horizons that needs to be explored further.

According to preliminary estimations, their thermal power is 420 MW, and output of thermal energy is maximum 2.7 million MWh per annum.

Only a small portion of this geothermal energy is currently utilized. Moreover the current mode of use of thermal water without reinjection leads to depletion of thermal wells and reduction of their useful output. Geothermal waters in Tbilisi supply the Balneological Health Resort and the hygienic bath houses, as well as the population in Saburtalo&Lisi regions which use them as hot water. Geothermal water in the regions is mainly used in an unorganized way for small baths and for greenhouses on the adjacent land plots.

Tbilisi municipality considers geothermal potential as one of the most important resources to be developed in order to make Tbilisi an environmentally friendly city.

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[19] N. Tsertsvadze, G. Buachidze, O.Vardigoreli "Thermal Waters of Georgia", Tbilisi, 1998

GHW for residential hot water supply

Currently 78 residential block buildings in Tbilisi are supplied by thermal water which is used as hot water. The license owner and distribution operator in Tbilisi Saburtalo and Lisi regions "Geothermia LLC" operates six geothermal wells for hot water supply to a part of the Saburtalo district. 78 residential block buildings are supplied with thermal water with 55 ^{0}C and 70 ^{0}C temperature. Current consumer base is 3850 residential and small commercial consumers and this number can be expanded to 19000 with the existing production capacity of wells[20]. Geothermal water is mainly used for hot water supply needs and only to a small extent for heating (mostly through unauthorized use). Unauthorized/unpaid use results in deficit of geothermal hot water in winter months which in turn discourages the customers. Some potential consumers refuse to use the geothermal water due to its smell and uncertain price and availability. Therefore about 20% of available resource is being commercially utilized.

25-year exploitation of the Lisi area showed that utilization of thermal waters under such a regime (well-consumer-sewage) causes a gradual reduction of water discharge in production wells as the amount of produced water exceeds the rate of natural recharge of the underground reservoir. This may result in stopping water flow in the well.

Use of GHW in Agribusiness and Food Industry

In rural areas the residential use of GHW is uneconomical because of long distances. Current use is limited to small baths and greenhouses at neighboring plots of land arranged in a non-organized manner. The most appropriate use of GHW energy in rural areas is the use in agricultural complexes that can fully utilize this energy through technological steps.

A model agribusiness complex has been designed for full use of geothermal water potential in ZugdidiTsaishi. This complex comprises of Chicken farm, green houses, fishery, dryers, mushroom growing facility, soil heating for vegeTable1. production round the year etc. Total needed investment in geothermal deposit is estimated at 8-10 mln and in agribusiness complex 21-25 mln USD is estimated at 8-10 with the total investment of 30-35 mln USD. In spite of large investment the geothermal deposit is competitive with gas fired boilers and can sustain the commercial operation of the complex by utilizing 185GWh of geothermal energy per annum.

This might be a good candidate for a challenging pilot project. However, it requires creation of unique and complex ownership structure that will allow coordinated development of agricultural complex including greenhouses, farms, fisheries, fruit and tea dryers together with geothermal well and water supply infrastructure. This will require united ownership and strong entrepreneurial skills.

Discussions with various stakeholders and review of previous studies have revealed the following technology options for preliminary assessment: Use of GHW for space heating, GHW for residential hot water supply, GHW in agribusiness and food industry.

Geothermal hot water for heating

Since there are significant unutilized reserves of geothermal water an option of its use for heating purposes has been discussed. The main problem in this case is that the heating water leaves the heating system at relatively high temperature and therefore the residual heat needs to be somehow utilized in order to avoid the waste of geothermal energy. Two different options for using this energy for heating were examined [21]

Heat pumps for geothermal space heating

In this technology option the heat pumps installed at the site of residential building are used to drive down the temperature of effluent water to minimize thermal losses. Heat energy is pumped back to heating circulation system to preserve the needed temperature in heating batteries. For operating the heat pump will need electric energy but will move 4-5 kWh of heat to the heating circulation loop for every kWh of electricity consumed.

[20] TSBC

[21] Geothermal Hot Water Use in Multi-Apartment Buildings NATELI- USAID/Winrock International- WEG –2011.

Georgia

Reuse of GHW for hot water supply

In this technology option the GHW passes through the heat exchanger to heat up the water in heating circulation loop. The outflow of about 50^{0}C is subsequently supplied to the same or other buildings for hot water supply.

Both these technologies were closely examined from technical and economic point of view and were found to be uneconomical compared to current practice of natural gas burning, even without full account of investment cost in equipment. Negative result was obtained in a study devoted to central heating of Zugdidi with geothermal hot water[22]. In general the use of GHW for heating does not allow to utilize the geothermal energy potential during the year and thus is more wasteful. It should be chosen only once there are no alternatives for heating with natural gas or no other users can be found that will use geothermal heat in all seasons.

There are several problems that need to be addressed in order to properly develop the geothermal hot water systems. These include:

1. Unsettled distribution system for GHW supply:
    a. Distribution infrastructure providing metering and disconnection capacity
    b. Unorganized billing and collection policies and procedures, including billing system
2. Weak legal basis for licensing and unclear licensing procedures;
3. Lack of entrepreneurial approach of license owners; absence of proper planning, marketing, billing and collection policies.

- Long term sustainability of geothermal well operation requires reinjection system.

1. Smell of geothermal water discourages customers;
2. Expensive modifications needed in existing buildings and apartments to connect geothermal water;
1. Subsidized gas prices making the geothermal water marginally competitive;
2. System requires high investment cost.

Detailed feasibility study is necessary for geothermal resource utilization. The existing studies and reports need to be summarized in a systematic manner and strategy of geothermal resource use needs to be developed based on existing studies and ongoing reports.

[22] Program for rehabilitation of Zugdidi thermal supply system Burns & Roe Enterprises, Inc. Arci Consulting, Geothermia Ltd, Sakburgeothermia 1997, USAID

Georgia

Economic Assessment Geothermal hot water

TECHNOLOGY 1 - Residential Hot Water Supply

Tbilisi Residential Hot Water Supply System

Tbilisi Vake/Saburtalo
UNDP Rambol Geothermia study

Target District - Zones of Boiler houses #1, 32, 47	TOTAL	Currently Supplied	Remaining
Number of buildings	185	78	107
Number of residents	27500	13475	14025
Number of apartments supplied	9131	3850	5281

Rambol 2002		2002	Inflated to 2011 2011	
Total system costs (Rambol)	000 USD	3936	4526,4	
Internal works included	000 USD	640	736	
External works (Rambol)	000 USD	3296	3790,4	
Current water flow		73		
Projected water flow		200		
Thermal capacity	10,6 MW		0,39	kW/household

TSBC 2011	000 EUR	000 USD
Internal works for existing users	400	580

Ramboll and TSBC don not match well TSBC does not provide connections and in-apartment works

Mismatch in internal works per family cost estimate	54%

Cost per household

Internal works (TSBC)	151			
Internal works (connection)	60			
External works (Rambol)	415			
Total capital cost	626	USD/household		
O & M cost per household	4,01	USD/month		

Estimated O & M costs: 60000 GEL; 36585 USD

	Capital Cost		O & M	
Total cost	5,7	USD mln	0,44	USD mln/year

Size of average family	3,5	persons
Hot water usage	30	l/person/day
Hot water usage (month)	900	l/person/day
Hot water usage (family month)	3,15	ton/family/month

Efficiencies Electric		90%	(On demand 95% tank electric 80%)	
	Gas	80%	can be lower	
Gas energy content		9,36	kWh/nm3	
Gas tariff		0,51	GEL/m3	0,054 GEL/kWh
Electricity tariff		0,16	GEL/kWh	

http://www.energystar.gov/index.cfm?c=water_heat.pr_crit_water_heaters
http://www.energysavers.gov/your_home/water_heating/index.cfm/mytopic=13000
http://www.aceee.org/consumer/water-heating

Energy Usage for Hot Water

Input temperature	12			
Output temperature	60			
Temperature difference	48			
				Costs
Energy per liter	48 kCal			
Energy per ton	45000 kCal =		52,335 kWh	
Electricity used per ton	58,15 kWh			9,30 GEL/ton
Gas used per ton	65,42 kWh		6,99 m3	3,96 GEL/ton

Family costs

	Cost	Cost USD	Net savings	Payback
Electricity	29,3	17,9	13,86	3,76
Natural Gas	12,5	7,6	3,60	14,48
Effective Average	22,6	13,8	9,8	5,34

Georgia

CO2 emissions

http://www.engineeringtoolbox.com/co2-emission-fuels-d_1085.html

	Electricity	Gas		
% consumers	60%	40%	Data from Vaja Pshavela Bld1 dist.IV	67%/33%
Emission factor	kg/kWh	kg/kWh	kg/nm3	
	0,399	0,24	2,2	

Average family annual emissions				
Hot water annual usage	37,8	tons		
Emission (gas)	593,5	kg/family/year		
Emission (electricity)	877,0	kg/family/year		
Emission (average)	**763,6**	kg/family/year	218,2	kg/person/year
Total avoided annual emissions	**6 973**	TCO2/a		
10 year emission reduction	69 728	TCO2		

TECHNOLOGY 2 Industrial Use			
Zugdidi Tsaishi	**Agribusiness complex supply system**		
Burns & Roe/ARCI 1998			
Annual thermal output	185	mln kWh	
gas emission per kWh	0,23	kg/kWh	
Equivalent gas emissions/yr	42,55	mln kg	
10 year emission reductions	0,4255	mln tons	
Supply system for agricomplex	**10**	mln USD	8mln as of 1998

Georgia

A 2.4 Efficient Biomass Combustion

Along with the increased deficit of wood as a fuel there is an ongoing process of gasification of Georgia's regions with the possibility of switching to natural gas for heating. The only limiting factor is the cost of gas to be paid by rural population. In baseline scenario it is expected that substantial number of households will switch to partial or full gas heating. Unsustainable wood felling and the expected switching to gas for heating can cause substantial emissions in the coming years, unless the appropriate measures are taken to make the use of wood more affordable and available

Based on previous studies and own research we have analyzed several technologies that might curb these developments and therefore have a positive CO_2 reduction potential. Below the prospects of introducing efficient wood stoves, potential for production and use of wood pellets, briquettes and wood chips for heating purposes are analyzed. Production of pellets and briquettes for export might be considered as a potential mitigation measure as well. However, we have not pursued this option since it does not provide for emission reductions in Georgia.

Several technologies aimed to increase energy efficiency level of space heating in rural areas were investigated in order to distinguish the priority technology. The following technologies were analyzed:

- The wood stoves used in Georgia are of different design and efficiency. The most common stoves are the simplest thin walled tin stoves. According to expert inquiry about 60% of population uses these inefficient and unsafe non-durable simple stoves. They cost about $18-35 and last about 2-3 years if used regularly. The efficiency of such stoves is about 20-30%. Some of these stoves have oven compartments for baking and cooking. These stoves are unsafe due to high temperature and in many cases are installed in a way that heat is lost due to air infiltration and inefficient combustion process[23].

- More advanced "Svanetian" stoves are being manufactured in small private shops. They have thicker iron plate walls, with more efficient design and are more durable. They are used mostly in the highland areas with relatively colder climate and longer heating season. They have 6-8 hours of burning capacity on one load and their design provides 40-50% efficiency of wood combustion in case of seasoned wood. These stoves are available in the regions and Tbilisi at a cost of $150-180.

There is also insignificant amount of Turkish made imported stoves that do not have the above features necessary for efficient burning and thus have estimated efficiency no more than 40-45%.

- Several manufacturers have demonstrated the capacity to manufacture locally highly efficient wood stoves. USAID has conducted the testing and certification of these stoves that have shown about 80% efficiency in combustion. E.g. NGO "Bioenergia" stove certified to 80% efficiency by USAID (Stove 2). These stoves have the features necessary for high efficiency combustion including:
  - High temperature of combustion assured by reflective inner surfaces and insulation from heat loss of combustion chamber;
  - Incoming air control and air preheating;
  - High surface area for heat transfer to the heated environment and oven.

  These manufacturers are selling these stoves at the same or lower price of 250-300 GEL as 40% efficiency Svanetian stoves.

[23]Winrock Int. report for USAID "Wood heating Stoves in Rural Georgia." May, 2008

Table - 1.7

Levelized cost comparison	
Wood logs in Stove 0	0.25
Wood logs in 45% eff. Stove 1	0.15
Wood logs in 80% eff. Stove 2	0.09
Briquettes in Stove 0	0.14
Briquettes in 45% eff. stove 1	0.09
Briquettes in 80% eff. Stove 2	0.06
Pellets	0.26
Gas. wood stove	0.12
Gas. Gas stove	0.24

Pellets and Briquettes

Current practice of woody biomass utilization is wasteful both in sense of inefficient wood burning as well as by leaving the wood cutoffs, agriculture remains and industrial waste from wood industry virtually unutilized. These remains can be used for production of more efficient woody fuel types like pellets, briquettes and chips.

Georgian pellet fuel market is virtually nonexistent and needs to be developed from the beginning. However, this market appears promising both in terms of advantages for the populations and potential for the production of burners and fuel.

This bottleneck can be opened by manufacturing affordable low-cost stoves for the largest part of the population. Potential market in Georgia should be subdivided into two segments:

1. Luxury burners using pellets and briquettes;

2. Economic burners using wood.

The first segment can be developed in collaborations with construction companies, which generally offer various incentives to their real estate customers (a free car with a purchase of an apartment etc.). Free installation of an H. E. burner (boiler, fireplace, stove etc.) may be offered as one of the bonuses for the customers. The supply of pellets/briquettes should be guaranteed. Most of the promotion of these types of heating systems on Georgian market should be conducted by construction and architectural companies.

Briquettes can be burned in the same wood stoves without loss of efficiency.

Pellets require sophisticated efficient stoves with automatic feed and combustion control. These kinds of stoves are quite expensive and cost in the range of USD 1800-3000. Therefore they are out of reach of absolute majority of wood burning community in Georgia.

Wood pellets can be burnt only in pellet boilers or pellet stoves. However, when talking about population in rural areas it is more realistic to think of wood stoves rather than boilers. Boilers used for central heating usually are installed in commercial buildings. Private houses in rural areas are badly insulated and rural residents represent usually a low income layer of society. Therefore, they hardly will be able to afford installation and operation costs of pellet boilers. On the other hand, replacement of existing stoves by more efficient ones will be more appropriate measure.

While pellets can be burnt only in pellet stove, briquettes can be burnt in an ordinary wood stove, which gives them an advantage.

Georgia

In present conditions there is no market for either pellets or briquettes. There is a need for development of relevant strategy.

Economic analysis showed that the most optimal economical and feasible way of reducing wood consumption and expenditures on fuel is achieving of higher efficiency.

Market for either pellets or briquettes does not exist on Georgia and there are some barriers hindering implementation of these technologies.

1. Due to the limited income, many families are not able to afford purchasing burners and pellet fuel at all;
2. Absence of plants suiTable1. for pellets production;
3. Necessity of sufficient start up investments for pellet plant construction;
4. High cost of equipment for plant production;
5. Absence of demand on pellets due to certain reasons:
    - Absence of information among customers on benefits of pellets;
    - Necessity of purchasing of a special pellet stove which is quite expensive;
6. Necessity of wide availability and easy access to raw material, wood waste.

Chips

Wood-chips are made of waste wood from the forests. Trees have to be thinned for room decoration (beams, flooring, or furniture). Wood-chips thus represent a waste product of regular forestry operations. Wood is cut up in mechanical chippers. The size and shape of the chips depends on a machine, but they are normally about one centimeter thick and 2 - 5 cm long. Water content of newly felled chips is usually about 50% of weight, but it drops down considerably after drying. Wood chips are burned in special boilers with automatic feed and high efficiency of combustion.

Careful processing and drying enable optimal storage and trouble-free operation of heating systems with negligible production of ash and low emissions.

Wood chips could be used for Municipal space heating in Tbilisi. Chips are produced from wood waste. Money spent on utilization of wood waste could be spent on production of wood chips. Efficiency of modern wood chip boilers is very high, more than 90%, and due to low cost of chips this source of heating is the cheapest and most economical.

Dry distillation of Agricultural waste

The process of pyrolysis can be effectively used as another technology for utilization of agricultural waste both in East and West Georgia differing according to the cultivated plants. The remains of agriculture can be processed in a dry distillation plant to produce combustible gas, liquid fuel for agricultural machinery and charcoal, for household use.

E.g. the areas in Western Georgia are rich in laurel tree plantations that are mostly grown in private farms. This crop is the primary revenue generating crop that provides significant incomes for households particularly in Khobi district but also in other districts. The amount of laurel leaves produced for sale only in Khobi is 4500 tons per annum in average.

As a result of the production process around 15 -17 thousand tons of laurel off-cuts are aggregated annually. Currently the residues are burnt by local households thus causing emissions of some 22000-25000 tons of CO_2 into atmosphere. It is possible to construct and install a demonstration device for destructive distillation of laurel tree off-cuts. As a result of destructive distillation process from 1 ton of dry laurel tree off-cuts - 500 kg of charcoal, 250 kg of liquid oil and 250 kg (416 m^3) of gas is generated. The charcoal can be used for outdoor cooking; the liquid fuel and gas can be used for heating and cooking, running the greenhouses or to fuel wood dryers and briquette dryers, or to produce steam and electricity. The use of the device can replace the use of wood for heating and cooking; promote energy savings at the household and community level.

The exact numbers of achievable plant efficiency and net output of energy need to be investigated in detail however. The prototype of destructive distillator has been tested at RCDA Demonstration and Technology Center and is approved for use. The devices can also be used for dry distillation of other biomass like: grape prunes, wood particles, grass, alfalfa, etc.

The device can be constructed from locally available materials.

Georg

Price of fuel

					Exchange rate	
				GEL	USD	
GEL				1,64	1	
Electricity	Gas	Wood				
kw/h	cub.m	logs (cub.m)	Pellets (ton)	Chips (ton)	Briquettes (ton)	
0,16	0,51	100	246	114,8	164	GEL
0,10	0,31	61,0	150	70	100	USD
			UNDP	60-70$	own estimation	
				Wikipedia		

Fuel price per 1 KWH

	Unit	kWh per unit	price per unit (GEL)	price per kWh
Electricity	kWh	1	0,16	0,16
Gas	m3	9,40	0,6	0,064
Wood	m3	1650	100	0,061
Pellet	Ton	4800	250	0,052
Briquette	Ton	5000	164	0,033

Prices and performance of stoves (from own research and available reports)

Stove type	$/kW	Output/Cap	Efficiency	Price range
Wood pellet stove	183,3	11-14 kW	75-90%	$1700-3000
Wood chip boiler	200	40-5000 kW	93%	$100 000
Wood stove 0	9	5-8kW	20-30%	$(30-60)
Wood stove 1	8,0	10-15kW	35-45%	$(90-150)
Wood Stove 2	0,0	10kW	80%	$(150-180)
Wood Stove 3	0,0	10-25kW	75-90%	$(500-1500)

http://www.hometips.com/buying-guides/pellet-stoves-cost-comparisons.html

Economic Assessment for Biomass

Fuel characteristics

	Density (kg/m	Energy valu	moisture content
Wood logs	softwood; 450-1250 for	3	20-30%
Pellets	650	4,8	8-10%
Chips	200	3	50% when newly felled; 25% when
Briquette	1000	5	8-9%

Resource

	Potential	Current use	Measure
Wood	1.7 mln ha	2.5 mln	Logs
Wood waste	0.75cub.m/ha		Pellets, chips, briquettes
Agricultural waste			Straw

Source: UNDP

CO2 emissions					
Unsustainable wood cutting					
Annual fuel wood felling		2,5	mln cm	mln kWh	equivalent gas
Unsustainable portion		0,5	mln cm	**0,83**	0,09
Switched to gas		1	mln cm	**2,06**	0,22
CO2 emissions per kWh wood		0,39			
CO2 emissions per kg wood		1,17	kg	15% of current consumption	
CO2 emissions per m3 wood		0,6435	t/m3		
CO2 reduction		0,96525	mln ton		
10 year CO2 reduction		6,75675	mln t		

Dynamics of gas substitution

7 years of full reduction

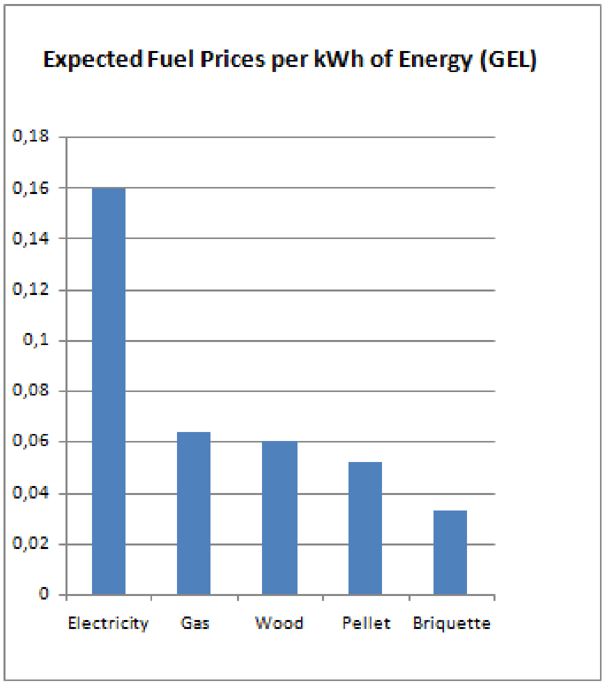
ECONOMIC ASSESSMENT

Wood for Residential Heating	Wood ordinary stove 0		Pellet (tons)	briquettes in Stove 1 (tons)	Briquettes in Stove 2 (tons)	Logs stove 1 m3	Logs in Stove 2 m3	Briquette in stove 0
Fuel Consumption annual	10	cm	1,01	1,83	1,03	5,56	3,1	3,3
Fuel cost	100	GEL	246	164	164	100	100	164
Wood energy value	3	kWh/kg	4,8	5	5	3	3	5
Wood density in logs	0,55	t/m3						
Energy used	16500	kWh	4853	9167	5156	9167	5156	16500
Efficiency of wood stove	25%		85%	45%	80%	45%	80%	25%
Output of stove (heating energy required)	4125		4125	4125	4125	4125	4125	4125
Heating season (months) 5 Months	3600							
Heating continuous load	1,1	kW						
Gas heating value	9,4	kWh/cm						
Equivalent gas	626,9	cm						
Gas Energy used	5892,9	kWh						
Gas stove efficiency	0,7							
Output of stove	4125,0							
Gas tariff	0,6	GEL/cm						
Equivalent gas cost	376,1	GEL						
Exchange rate USD/GEL	1,64							
Desired return	25%							

	Cost	Cost GEL	Efficiency	Annual c	Saving	Stove levelized annual cost
Stove 0	30	49,2	25%	1000		34,2
Stove1	152	249	45%	556	444	69,8
Stove 2	152	249	80%	312,5	687,5	69,8
Pellet stove	1800	2952	85%	294	706	826,8
Gas Stove	250	410	70%	376,1	623,9	114,8

10 year simple cash flow

		1	2	3	4	5	6	7	8	9	10	
Stove 1		-16,5	271,0	271,0	271,0	271,0	271,0	271,0	271,0	271,0	271,0	
IRR=	1643%	NPV=	$737,61									
		LCOE wooc	0,152									end value
		LCOE briqu	0,090									
Stove 2		57,6	419,2	419,2	419,2	419,2	419,2	419,2	419,2	419,2	419,2	$100
IRR=	#NUM!	NPV=	$1 207,50									
		LCOE wooc	0,09									
		LCOE briqu	0,058									
Gas stove		-59,8	380,4	380,4	380,4	380,4	380,4	380,4	380,4	380,4	380,4	
IRR=	636%	NPV=	$1 006,07									
		LCOE	0,119									end value
Pellet stove		-382	430	430	430	430	430	430	430	430	430	
IRR	113%	NPV	$886,87									
		LCOE	0,26									



Levelized cost	GEL/kWh	Gel per season
Wood logs in Stove 0	0,25	1034
Wood logs in 45% eff. Stove 1	0,15	625
Wood logs in 80% eff. Stove 2	0,09	382
Briquettes in Stove 0	0,14	575
Briquettes in 45% ef stove 1	0,09	370
Briquettes in 80% eff. Stove 2	0,06	239
Pellets	0,26	1075
Gas. wood stove	0,12	491
Gas. Gas stove	0,24	990

Wood Chips for Municipal Heating

	$				
Wood Chipper	150 000	each	Capacity	500	kW
Wood Boiler	100 000	each			
O&M	12500				
Wood Chip Cost	5	$/ton			
	0,51	GEL/m3			
Heating Hours	3600	(more than in samegrelo, but less than 5 full months due to shorter heating day			
Load factor	0,7				
Energy	1260000	kWh			
Chips needed (tons)	275				
Chip cost	1373,4				
equivalent gas	134043				
Equivalent gas cost	41684	USD			
Saving on fuel	40311				
CO2 reduction	289,8	tons	CO2 cost	15	$/ton
10 year CO2 reduction	2898	tons			
CO2 revenue	4347				

Cash flow	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Capital cost	-250 000														
O&M	-6250	-12500	-12500	-12500	-12500	-12500	-12500	-12500	-12500	-12500					
Fuel Saving	20155	40311	40311	40311	40311	40311	40311	40311	40311	40311					
	-236 095	27 811	27 811	27 811	27 811	27 811	27 811	27 811	27 811	27 811	27 811	27 811	27 811	27 811	27 811

A 3 Transport

A 3.1 Urban Transport Systems

In order to assess technologies related to urban transport, we used the example of Tbilisi and in particular information from Georgian Sustainable Urban Transport Project and SEAP under the Covenant of Mayors. Several assumptions and statistics data were used in order to generalize the results and estimations of SEAP with other cities and to derive country assessment of GHG reduction potential and other characteristics of relevant measures.

In other cities, except Tbilisi, the measures pertaining only to buses and minibuses were considered. Number of people using buses in all cities except Tbilisi was estimated by applying special auto mobilization indexes (0.7 for Kutaisi and Rustavi and 0.4 for other towns). The index represents ratio of automobiles per 1 person. Basically, number of registered passenger vehicles is divided by population. The numbers of buses per citizen for other cities were estimated based on Tbilisi data by means of use of these indices.

Table - 1.8

Technology	Action needed	Scale of application	availability	CO_2 emission potential (thousand ton/a)	Cost (Georgian lari (GEL))
CNG use in vehicles	Land Allocation for filling stations	Large scale	short term	233.9[24]	196,920.4[25]
	Promotion Campaign	Medium scale	short term		
	Safety assurance	Medium scale	long term		
Popularization of Public Transport	Information campaign (commercials etc)	Medium scale	short term	41.24	To be defined
	PT web page and transport guide development	Large scale	Short term		
Improvement of PT	New comforTable1. minibuses	Large scale	Medium term	60.02	TBD by feasibility study
	Technical inspection of minibuses	Large scale	Medium term		
	Improved safety measures in minibuses	Large scale	Medium term		
	Dedicated bus lines	Medium scale	Medium term		
	Improvement and optimization of routes	Large scale	Short term		
	Electronic display boards on bus stops showing time schedule etc.	Small scale	Medium term		2,022,200
	Better pricing schemes	Large scale	Medium term		TBD by feasibility study
	Electronic display boards in minibuses	Large scale	Medium term		
Encouragement of low emission cars		Large scale	Long term	45.07[26]	TBD

24 Numbers are based on Report of Georgian Sustainable Urban Transport Project – ADB, Tbilisi City Hall 2010
25 Cost represented for 10 years
26 This number doesn't include fuel switching to gas (since it is defined in the Table1. above). This measure can be considered as encouragement of electric cars, cars on biofuel and etc.

Georgia

Public Transport Popularization Campaign

Total number of bus passengers in all cities except Tbilisi was estimated at 35% of the number of Tbilisi bus passengers. For minibuses this indicator was estimated at 70% due to higher share of minibuses in the regions. Therefore, CO_2 reduction effect of identical promotion campaign in other cities will be lower than in Tbilisi (35% and 70% of Tbilisi effect). Expected CO_2 reduction of this measure for Tbilisi according to SEAP is 30.54t/yr. Taking into consideration presence of Subway in Tbilisi, CO_2 reduction of Promotion Campaign for PT in other cities will be even less and taking into account all these factors, it is estimated at approximately 35% of CO_2 reduction in Tbilisi, or 10.7t/a. This will require higher effort and therefore will be more expensive per CO_2 unit. Total expected annual CO_2 reduction in Georgia based on the above considerations is estimated at 41.2 tons per annum.

Improvement of Public Transport Service

This measure includes new comforTable1.and low emission busses and minibuses, arrangement of electronic display boards on bus stops and in buses, management of pricing and routes improvement of safety, technical inspection etc. Total estimated cost for Tbilisi is $838,323. Expected reduction of CO2 of all Y2 measures is 40.72 for Tbilisi.

There are about 935 city buses in Tbilisi, while in other cities together only - 330 (35%). The number of bus stops is also considerably smaller compared to the capital. Therefore, the estimated cost of similar measures in other cities is $375,574 (based on data for Tbilisi). These actions include improvements in minibus and bus services. Total estimated number of people that use minibuses and buses in other cities is 54% of the same indicator in Tbilisi. The estimated load of PT (Number passengers per bus) is higher in regions which means that with equal measures there is less potential of increase it further. Therefore, in order to estimate CO_2 reduction due to these measures the efficiency was downgraded and the estimated CO_2 reduction is approximately 19.3t/a.

Thus for the country in total we arrive at 60t/a.

Private car discouraging actions

These actions were directed to private cars only, and therefore, the related measures can be assumed as identical with the measures proposed for Tbilisi. Potential reduction of $C0_2$ in other cities can be estimated by assessing of number of cars and applying urbanization index. Sum of these indicators for small towns turned to be 44% of the same indicator for Tbilisi. Therefore, the estimation of CO_2 reduction from this measure in other cities is just 44% of CO_2 reduction projected for Tbilisi, or - 26.62t/a.

Country total can be estimated as 87t/a

A 3.2 Electric Transport

Electric cars

Electric vehicles EV are about 2.5 times more energy efficient than their counterparts which are powered solely by internal combustion engines. This high energy efficiency is the main reason why electric vehicles can substantially contribute to lower CO_2 emission and energy consumption of traffic. Actual greenhouse gas emission associated with the use of electric battery vehicles depends largely on the way the required electricity has been produced. In Georgia, due to hydro dominated power sector the emission factor is lower than in the most of the countries and is likely to be reduced with ongoing intensive development of hydro resources. This strengthens the potential of electric transport to contribute to GHG reduction even further.

Main barriers for a wider use of electric vehicles are related to the batteries, service and recharging infrastructure which do not exist in Georgia yet. Batteries for use in electric cars are still expensive and have relatively limited driving ranges. Most existing EV need to be recharged after maximum 150 to 300 km. Complete recharging of batteries may take 4 to 8 hours[27]. The widespread use of electric vehicles requires an extensive recharging infrastructure. Absence of this infrastructure may lead to reluctance to buy electric vehicles because of threat of being stopped for several hours with empty batteries.

Higher cost of an electric vehicle over the conventional alternative is another main obstacle for their proliferation. The high cost is mainly determined by the costs of the lithium ion battery pack. It seems like the recent developments in lithium-ion batteries will reduce additional costs from the current level by about €15,000 in prototypes to an expected level of around €3,000 in 2020.

GOG is considering introduction of electric vehicles to its fleet. 1000 electric cars will be imported starting from 2012 according to agreement between the MSED and Renault Company. This measure will be accompanied with the development of recharging infrastructure and will promote the technology.

Electric Public Transport

Special attention will be paid to the development of electric transport network since the energy intensity of electric transport (such as tram and subway) per passenger/km is much higher compared to other public transport. Also it is envisaged that in the future the emission factor of electricity will decrease significantly due to the plans of national government to significantly increase hydropower share in electricity generation. Restoration of trolleybus infrastructure can be also considered as an option for domestic utilization of Georgia's clean hydroelectric potential.

Biodiesel

Biodiesel is used as a diesel fuel substitute, and is generally blended with fossil diesel to various degrees. Its development contributes to economic and social development through job creation, increasing farms' income, increasing energy security. Additionally, it provides environmental benefits since biodiesel offers net GHG savings compared to fossil fuels.

Ilia State University has recently successfully adopted and implemented innovative methods for producing biodiesel. A new lab for producing biodiesel was launched and is fully operational. The university is planning to help the Georgian industry to start producing biodiesel at large, industrial scale. Therefore the project "Georgian Biodiesel" is expanding and creating agro-economical basis for producing biodiesel in Georgia. Several dozen hectares of lands in Kakheti region, eastern Georgia have been cultivated for growing Rapes (Latin: *Brassica napus*) the oil of which will serve as the raw material for producing biodiesel. In 2010 the winter verity of *Brassica napus* was planted. The results are encouraging; the new culture was adopted pretty well in eastern Georgia and some 2.5- 3 tons of Rapeseeds are expected per hectare. The developers hope to extend the production to several hundreds of hectares and produce enough oil to supply the municipal fleets in Georgia.

[27] US DOE, Alternative Fuels and Advances Vehicles Data Centre (2010): Electric Vehicle Availability. Available at http://www.afdc.energy.gov/afdc/vehicles/electric_availability.html

A 3.3 Compressed Natural Gas (CNG) switching of passenger vehicles

Thismeasure was evaluated separately, based on own inquiries and in the mitigation team.

Using CNG as fuel in vehicles provides about 25% CO_2 well to wheel reduction, almost completely eliminates NOx emissions and pollutants resulting from gasoline additives and thus effectively contributes to local improvement of air quality along with GHG mitigation[28]. This is a cost effective and efficient measure and a proven technology, which is used all over the world. In Georgia there is a visible trend in switching the gasoline consuming vehicles to CNG use, however the scale of CNG use is still small and needs additional promotion and support measures to realize a substantial potential of GHG reduction.

For assessment of the latter it was assumed that about 80% of all gasoline used in the city is consumed by 40% (or less) of gasoline-fuelled fleet - i.e. high mobility and high fuel consumption vehicles. These are mainly taxis, goods distribution vehicles, SUVs, gasoline fuelled trucks and other vehicles travelling long distances. Simple estimate shows that if 50% of these high consumption vehicles (or 20% of total gasoline-fuelled fleet) switch to CNG, this would already provide 10% reduction in carbon emissions from all gasoline vehicles. Even according to moderate assumption the potential cumulative CO2 reduction by 2020 will be about 0.5 million tons.

A more detailed calculation with the use of special excel model is provided in Annex 1.

This is a cost effective measure even today for highly mobile vehicles and is going to be even more cost effective in view of growing and uncertain oil prices as well Georgia's long term gas supply contracts assuring current price for natural gas.

The main barriers for dissemination of this technology are:

- Concerns on safety of technology
- Relative scarcity of gas filling stations
- Lack of adequate information on technology options and promotion

These barriers can be overcome e.g. by:

- Introducing of safe technology and assuring proper safety standards
- Encouraging construction of additional gas filling stations (technology access, soft loans, land allocation etc.)
- Proper information campaign and other supportive measures

One can expect that the bulk of investment in technology will be carried out by private sector, while state will need mostly to provide support and promotion measures. It is relatively easy to implement and can deliver substantial benefits in terms of GHG and local pollution reduction.

This is one of the most promising measures for GHG reduction in transport sector in Georgia also related to other business benefits:

a. There is a lab in Georgian Technical University and a private company established with know-how in gas compressor manufacturing. The compressors are of lower cost, higher durability and lower maintenance cost than most of the imported compressors. Most of gas filling stations are switching to these compressors.

b. Ministry of Sustainable Economic Development is trying to privatize the modern plant for manufacture of high pressure vehicle gas tanks in Vaziani. With the spread of CNG technologies there will be a possibility to supply quality tanks to local market and potentially to the region.

[28] http://climatetechwiki.org/technology/cng)

Georgia

Total estimated costs of switching the top fuel consuming vehicles to CNG are as follows:

Total cost $MM	
State Investment	4.5
Private	19.5
Running cost	0.35

CO_2 reduction 2020		**0.23 mln t/a**
Cumulative by 2020		1,17mln tons
Cost of reduction		Negative

Economic assessment - Transport

Switching to Gas - Basic economic parameters

1400	GEL capital cost			
1,1	GEL/m3			
80	km- Average travel distance in city			160 - for taxi
11	Full tank volume			200km/11m3
12,1	Full tank cost			
200	Full tank total kilometers			
12,1	GEL/200km	6,5	GEL/100km	
50%	Percentage of taxis on gas			
	Gasoline cost	2	GEL/lit	
	Gasoline /100km	12		
	Gasoline per 200km	24	Liters	
	cost of 200km travel	48	GEL/200km	24 GEL/100km
Annual return				
	Working days	250		
	distance traveled	20000		
	CNG price	1300		
	Gasoline price	4800		
	Annual saving	3500		

Tbilisi data		
Number of registered vehicles		233187
Number of private gasoline vehicles Tbilisi		209868,3
Annual km traveled		10 000
Consumption lit/ 100km		12
Annual vehicle consumption lit		1200
Annual Consumption kg/car		960
Total consumption city (tons)		201 474
CO2 emissions t/a		**664 863**
% of vehicles c	80% of gasoline	40%
% of these switched by 2020		60%
% switched of total		24%
% fuel switched		48%
% CO2 reduction		25%
% reduction of total		12%
CO2 reduction t/a 2020		79 784
Cumulative by 2020		398 918

Country		
Number of vehicles	**683751**	
Number of private gasoline vehicles	615375,9	
Average annual km traveled	10 000	
Consumption lit/ 100km	12	
Annual vehicle consumption lit	1 200	
Annual Consumption kg/car	960	
Total consumption city (tons)	590 761	
CO2 emissions t/a	1 949 511	2nd NC
% of vehicles consuming 80% of fuel	40%	**1400000**
% of these switched by 2020	60%	
% switched of total	**24%**	
% fuel switched	48%	
% CO2 reduction	25%	
% reduction of total	12%	
CO2 reduction t/a 2020	233 941	168000
Cumulative by 2020	**1 169 707**	840 000
Average estimate		**1004853**
Vehicle number increase by 2020	20%	
Final	**1205823,906**	

Georgia

Covenant of Mayors - SEAP estimates

SECTORS *& fields of action*	KEY actions/measures per field of action	Implementation [start & end time]	Estimated costs per action	Expected energy saving per measure [MWh/a]	Expected renewable energy production per measure [MWh/a]	Expected CO2 reduction per measure [t/a]
TRANSPORT:						
Municipal fleet						
Action M1:	Renovation of Municipal Fleet	2012-2013		3,96		0,99
Public transport						
Action Y1:	**Popularization Campaign for Public Transport (PT)**			137,69		30,54
Sub-Action Y1.1	Information campaign (commercials, etc.)	2013-2020	TBD			
Sub-Action Y1.2	Marketing	2013-2020				
Sub-Action Y1.3	PT web-page and transport guide development	2013				
Action Y2:	**Improvement of PT service**			183,59		40,72
Sub-Action Y2.1	The electronic display boards on 450 bus stops, showing times/sche	2012	1400000 GEL			
Sub-Action Y2.2	New Comfortable mini-busses	2010-2011				
Sub-Action Y2.3	Electronic display boards in mini-busses (	2010-2011				
Sub-Action Y2.4	Improved top-up services	2010-2011				
Sub-Action Y2.5	Technical Inspection of mini-busses	2010-2011				
Sub-Action Y2.6	Improved safety measures in minibuses	2010-2011				
Sub-Action Y2.6	Improved safety measures in minibuses	2010-2011				
Sub-Action Y2.7	Better pricing schemes	2010-2011				
Sub-Action Y2.8	Improvement and optimization of routes	2011-2020				
Sub-Action Y2.9	Dedicated Bus lanes	2015-2017	TBD			
Action Y3:	**Alternative PT service**			306,05		69,18
Sub-Action Y3.1	Optimization of bus fleet	2010	---			
Sub-Action Y3.2	Extension of Subway to University Station	2013-14	54000000GEL			
Sub-Action Y3.3	Development of Tram Network	2014-15	TBD			
Private and commercial transport						
Action R1.	**Private cars discouraging actions**			271,75		60,5
Sub-Action R1.1	Environmental islands	2017-2020	TBD			
Sub-Action R1.2	Pricing	2017-2020				
Sub-Action R1.3	Parking management	2017-2020				
Action R2	Encouragement of low emission cars	2015-2020	TBD	669,52		179,4
Other -						
Action G1:	**The Street Light Management Centre**			491,06		123,85
Sub-Action G1.1	Gamsaxurdia st Green Wave	2010	388280 GEL			
Sub-Action G1.2	Budapeshti-vazisubani str. Green Wave	2010	9661 GEL			
Sub-Action G1.3	Green Wave by Isani station	2010	330650 GEL			
Sub-Action G1.4	Green Wave at Tsereteli ave	2012	1203125 GEL			
Sub-Action G1.5	Green Wave at Kazbegi ave	2012	687500 GEL			
Sub-Action G1.6	Green Wave at Guramishvili and Dadiani ave	2013	2578125 GEL			
Sub-Action G1.7	Full run Street light management centre	2020	27500000GEL			
Action G2:	**Improved Road Infrastructure**			30,98		7,81
Action G2:	**Improved Road Infrastructure**			30,98		7,81
Sub-Action G2.1	Intensification str	2010	2673000 GEL			
Sub-Action G2.2	New street from Heroes Squire	2010	91826000 GEL			
Sub-Action G2.3	Gelovani-Agmashenebeli Tunnel	2011	8486000 GEL			
Sub-Action G2.4	Tunnel at Gorgasali str	2012	8486000 GEL			
Sub-Action G2.5	New Street connecting Sheshelidze and Gobronidze str	2011	1000000GEL			
Sub-Action G2.6	New bridge connecting Poti and Dadiani str	2015	54000000GEL			
			TOTAL:	2094,6		513

Generalization to Country Level

	2010	Number of buses (estimated)	Number of buses per inhabitant (estimated)	Number of minibuses (estimated)	Number of minibuses per inhabitant (estimated)	% of population	Number of automobiles (estimated)	Number of automobiles per inhabitant (etimated)	Number of bus passengers (based on Tbilisi data)	Number of people that use minibuses (based on Tbilisi data)
Georgia	4436400						683751	0,154122938		
Tbilisi	1152500	934	0,00081	2621	0,0023	26%	230500	0,2	215000	430000
Batumi	123500	0	0,00000	0	0,0000	3%	17043	0,138	0	0
Kutaisi	192500	109	0,00057	306	0,0016	4%	26565	0,138	25137,74403	50275
Zugdidi	175000	57	0,00032	0	0,0000	4%	24150	0,138	0	26117
Rustavi	119500	97	0,00081	272	0,0023	3%	16491	0,138	22292,84165	44586
Marneul	126300	41	0,00032	0	0,0000	3%	17429	0,138	0	18849
All cities except Tbilisi vs Tb		33%		22%			44%		22%	33%

Actual data	
Estimate	

City Urbanisation index	
Rustavi	1
Kutaisi	0,7

REFERENCE DATA

0,032 GJ/lit- Gasoline
0,035 GJ/m3 NG

http://www.engineeringtoolbox.com/co2-emission-fuels-d_1085.html

Fuel	Specific Carbon Content	Specific Energy Content	Specific CO_2 Emission	Specific CO_2 Emission
	(kg_C/kg_{fuel})	(kWh/kg_{fuel})	(kg_{CO2}/kg_{fuel})	(kg_{CO2}/kWh)
Coal (bituminous /anthracite)	0,75	7,5	2,3	0,37
Gasoline	0,9	12,5	3,3	0,27
Light Oil	0,7	11,7	2,6	0,26
Diesel	0,86	11,8	3,2	0,24
Petroleum Gas	0,82	12,3	3	0,24
Methane	0,75	12	2,8	0,23
Crude Oil				0,26
Kerosene				0,26
Wood 1)				0,39
Peat 1)				0,38
Lignite				0,36
Bio energy	0	-		0 2)

1 boe (barell of oil equivalent) = 42 US gallons = 35 Imperial Gallons = 159 liter = 6.1 GJ = 5.8 million Btu = 1700 kWh

1 metric tonne gasoline = 8.53 barrels = 1356 liter = 43.5 GJ (low heating value)

1 US gallon diesel = 130500 Btu

1 liter diesel = 36.4 MJ (low heating value)

1 metric tonne coal = 27-30 GJ (bituminous/anthracite) = 15-19 GJ (lignite/sub-bituminous)

1 cubic feet natural gas = 930 Btu (low heating value)

1 cubic meter natural gas = 35 MJ (low heating value)

http://www.engineeringtoolbox.com/fossil-fuels-energy-content-d_1298.html

Safety	http://www.cleanvehicle.org/committee/technical/PDFs/Web-TC-TechBul2-Safety.pdf

Annex II. Technology Fact Sheets

Sector	**ENERGY EFFICIENCY**
Subsector	Buildings
Technology Name	**BUILDING THERMAL INSULATION**
Scale	Large scale
Availability	Short term
Technology to be included in prioritization (mandatory inf.)	No
Background/notes (short description of the technology option)	Soviet heritage of a high percentage of residential and office buildings with extremely poor thermal resistance has been further aggravated by post independence practice of cheap construction with complete neglect of energy performance of the buildings. Now more than half of Georgia's residential block buildings has bad or very bad energy performance (with thermal resistance as low as 0.5 m^2K/W). This causes excessive energy losses, increased dependence on imported energy and outflow of money that otherwise might be involved in country economic activity. Due to poor thermal resistance of walls the interior of same buildings is affected by excessive heat in summer and requires substantial cooling to create comforTable1. conditions. This building stock will continue to cause huge losses unless adequate organizational and technical solution will be found for building thermal insulation.
Implementation assumptions (how the technology will be implemented and diffused across the sub-sector	There are several technologies for building insulation provided by international vendors. The most common technology is to cover the old buildings with insulation boards attaching them to external walls cover with support nets, plaster and paint. This improves the exterior appearance of buildings as well. State program for old building stock, helps in community mobilization, municipal co-financing and long term cheap loans need to be involved to make this technology affordable. Local production of insulation materials needs to be developed.
Impact Statements	
Social development priorities	Implementation of building thermal insulation is directly related to higher employment, reduced energy bills and improved living conditions, especially for vulnerable population.
Economic development priorities	Since there is a large stock of thermally inefficient buildings, their insulation can be related to significant economic activity, reduction of energy dependence, sustainable economic development and poverty reduction.
Environmental development priorities	This technology can significantly reduce natural gas burning for heating and improve the quality of air in apartments and neighborhoods. The hazards related to natural gas use will be reduced and exterior of buildings will be improved.
Other consideration and priorities such as market potential	
Costs (US$)	
Capital costs over 10 years	55-75GEL/ m2
Operational costs over 10 years	N/A
Other costs over 10 years	N/a

Georgia

Sector	**ENERGY SUPPLY**
Subsector	Renewable Energy
Technology name	**Efficient Wood Stoves**
Scale	Large scale (applicable only in rural areas)
Availability	Short term
Technology to be included in prioritization (mandatory inf.)	Yes
Background/notes (short description of the technology option)	Currently about 60 % of families in rural areas use inefficient stoves. Intensive consumption of wood resources leads to deforestation and deficit of wood in some regions. Replacement of inefficient wood stoves with efficient ones provides saving on wood fuel that can reduce deforestation. Efficient (80% efficiency) stoves require up to 4 times less wood logs per heating season. Leveled cost of energy in such stoves is the lowest. This creates an incentive for people not to switch to gas for heating and helps to avoid increase in CO_2 emissions. Additionally, this stove is more comforTable1. and safe that can reduce number of accidents. It burns wood more effectively, so the amount of dangerous particles that might be released is reduced.
Implementation assumptions (how the technology will be implemented and diffused across the sub-sector	Information campaign is needed prior to implementation of efficient wood stoves to inform people of all benefits that the stove can bring. Additionally, incentive campaigns are needed, such as loan schemes to help people to finance purchase of efficient stoves and to assist producers of stoves, assist market development through providing training, tax incentive schemes, grants, etc.
Reduction in GHG emissions over 10 years	Estimated reduction of GHG emissions over the 10 year period is 2.9mln tones of CO_2.
Impact Statements	
Country social development priorities	The project directly benefits individual households through installation of efficient stoves which will result in energy savings and lower expenditures, and contribute to national objectives to reduce poverty and deforestation.
Country economic development priorities	Sustainable economic development, rural development. Implementation of efficient stoves can assist rural development through job creation, cost-saving for low-income rural residents, and prevent migration of people from villages.
Country environmental development priorities	The major benefit of energy-efficient wood stoves is reduction in consumption of wood. In addition, use of such stoves lead to cost-savings for the consumer over the life-cycle of the appliance, and improve local air quality.
Other consideration and priorities such as market potential	This technology is proven and available in Georgia. The market is undeveloped and production is low-scale. The market can be considerably improved if enabling environment is in place (awareness, financial incentive, policy and regulation, etc.).
Costs (US$)	
Capital costs over 10 years	The cost of an efficient wood stove varies according to design features and materials used. It ranges within 150-180$. Since more than 100 000 families use inefficient stoves, cost of implementation of efficient ones can be 15 000 000-18 000 000$ over 10 yeas. Lifetime of quality stoves exceeds 10 years.
Operational costs over 10 years	This measure saves the fuel costs to consumers compared to current usage of inefficient stoves. Thus the effect on operation costs is positive.
Other costs over 10 years	N/a

Georgia

Sector	
Subsector	Renewable energy
Technology name	**Solar Collector for Hot Water**
Scale	Large scale
Availability	Short term
Technology to be included in prioritization (mandatory inf.)	Yes
Background/notes (short description of the technology option)	Currently only a negligible share of solar energy potential is utilized in Georgia. The prices for solar systems are high and there is no sufficient effort applied for developing of this market. The solar systems are mostly installed by commercial sector, high income residents and donor funded pilot projects. It is necessary to promote the dissemination and deployment of this technology in residential sector by developing the market by generation and dissemination of technology and market information, finding the financing schemes, technical solutions for common use of solar systems. The most appropriate use of solar water heaters is for shared use of solar systems. The primary use of solar water heaters (SWH) is - domestic hot water use. The systems suiTable1. mostly for urban use are pressurized integrated individual systems with evacuated tube collectors, while open systems with evacuated tube collectors can be sufficient for rural application. Both these systems are marginally affordable for relevant customers and need supportive measures to be widely disseminated.
Implementation assumptions (how the technology will be implemented and diffused across the sub-sector	Solar technology needs to be promoted through a system of measures for market development. These measures shall include: market and technical information generation and outreach to inform customers about opportunities, costs and benefits. Creation of mechanisms for cheap financing for supply and purchase of solar systems. Development of independent technical and economic advice capacity, development of tax incentive schemes, etc. Dissemination of technology shall be supported through cooperation with building developers and condominium associations. New technical solutions for reducing the cost need to be developed and tested in pilot projects with strong monitoring and outreach components.
Reduction in GHG emissions over 10 years	0.32 mln tons
Impact Statements	
Social development priorities	Solar water heater technology can directly benefit individual households through energy savings and lower expenditures; development of this business has a potential of providing new jobs and can contribute to national objectives of poverty alleviation.
Economic development priorities	Wider dissemination of this technology can support sustainable economic development of the country through increased economic activity, cost-saving for residents, job creation and increased budget revenues from economic activity. It also reduces dependency on imported natural gas and, therefore, increases energy security.
Environmental development priorities	The major benefit of solar collectors is the reduction in natural gas consumption and improvement of local air quality.
Other considerations and priorities such as market potential	This technology is proven and available in Georgia. Market can be considerably strengthened with supportive enabling environment (awareness, financial incentive, policy and regulation, etc.). The realistic market potential is estimated at more than 60 thousand residential and commercial installations over next 10 years.
Costs (US$)	
Capital costs over 10 years	110 mln USD
Operational costs over 10 years	Negligible
Other costs over 10 years	N/a

Georgia

Sector	ENERGY
Subsector	Renewable energy
Technology name	Geothermal hot water
Scale	Medium scale (applicable only in areas where geothermal hot water is available)
Availability	Short term
Technology to be included in prioritization (mandatory inf.)	No
Background/notes (short description of the technology option)	Georgia has a rich geothermal potential. Total achievable potential is estimated at 100MW of thermal capacity. The current mode of use without reinjection of thermal water leads to depletion of thermal wells and reduction of their useful output. Geothermal water in Tbilisi supplies the Balneological Health Resort and the hygienic bath houses as well as the population in Saburtalo&Lisi regions mainly for hot water use. In Tbilisi geothermal hot water is currently supplied only Saburtalo district where 75 buildings with 3850 customers use it. However, due to low level of commercialization the market is undeveloped.
Implementation assumptions (how the technology will be implemented and diffused across the sub-sector	***1. Residential Hot Water***- In order to utilize the geothermal hot water more effectively the following measures are to be undertaken: a. commercialization of geothermal water distribution system through installation of metering & disconnection outside apartments and introduction of sound commercial procedures and policies, b. proper marketing, promotion and pricing strategies, license conditions requiring development of new resources; c. installation of Geothermal Circulation Systems (GCS) in the Lisi area to assure sustainable operation of geothermal wells. Usage of heat exchangers in low elevation high pressure wells to get rid of hydrogen sulfide; ***2. Development of Agribusiness complex in Tsaishi*** – well rehabilitation and construction of business complex based on geothermal water use including, driers, fisheries, greenhouses, poultry farms etc.
Reduction in GHG emissions over 10 years	70 thousand tons of CO_2 – Project 1. 426thd tons of CO_2 – Project 2.
Impact Statement	
Country social development priorities	Development of this sector requires training of personnel and increased skill level. It also contributes to job creation reducing unemployment. Possibility of usage of geothermal water in agriculture contributes to regional development through assistance of rural development. Number of accidents related to gas water heaters will be reduced.
Country economic development priorities	Use of geothermal hot waters will reduce dependence on imported natural gas. Expansion of customer base will increase economic activity. By utilizing domestic resource instead of imported gas more funds will be available for domestic economic development. The project directly benefits individual households through the installation of geothermal hot water supply which will result in reduced consumption of natural gas and lower expenditures. Use of geothermal heat can directly support development of agribusiness and food industry.
Country environmental development priorities	This technology helps to reduce natural gas consumption and therefore, reduces CO_2 emissions. It also contributes to better local air quality by eliminating the need for gas burning in poorly vented apartments.
Other consideration and priorities such as market potential	Vital condition for market development is commercialization. It will increase efficiency and service quality which in its turn will have positive effect on demand and amount of people using geothermal hot water. It was estimated that the potential market size is about 9000(27000 residents) households, which is 2.5 times bigger than existing market. Potential agribusiness complex can utilize up to 185GWh of geothermal energy.

Georgia

Costs (US$)	
Capital costs over 10 years	Project 1 -$6 mln, Project 2 – 10mln
Operational costs over 10 years	Project 1-$4.5 mln, Project 2 – N/A
Other costs over 10 years	N/a
Sector	**ENERGY**
Subsector	Renewable energy
Technology name	**Wind Power**
Scale	Large scale
Availability	Short term
Technology to be included in prioritization (mandatory inf.)	Yes
Background/notes (short description of the technology option)	Georgia has large untapped potential for wind power production. Achievable wind power production potential is estimated at 2GW capacity and 5TWh of annual output. Among several options of wind power technology the large scale 3MW grid connected wind turbines of world class supplier were selected as preferred option to conduct the economic and technical analysis based on WASP III and economic models. The results indicate that 12 most beneficial wind farm sites can provide around 1GW capacity and 2.8 TWh of energy output. Economic analysis conducted with 7c feed-in tariff assumption shows the return of investment between 8-12% which is below commercially available interest rates in Georgia.
Implementation assumptions (how the technology will be implemented and diffused across the sub-sector)	The cost of wind power is high compared to other generation options (e.g. more generation on existing thermal plants) and the prices on Georgian market. Therefore special support measures are needed in order to deploy and disseminate this technology. It should be supported by government through legislation, grants, subsidies, feed in tariffs or tax schemes and/or reliable access to foreign markets with higher cost of power.
Reduction in GHG emissions over 10 years	In case of gradual implementation over the ten year period, the selected projects can provide about 4.5 mln tons of CO_2 reduction.
Impact Statement	
Social development priorities	Introduction of wind power will create additional jobs and increase employment. It will pose higher requirements on maintenance and operation personnel. Therefore this will have a positive social benefit of introducing modern technical knowledge to country. Wind power development will stimulate the technical development of grid and its operations.
Economic development priorities	Sit Site and foundation for preparation of wind power as well as electric installation and connection works will provide employment opportunities, contribute to economic activity and reduction in unemployment. Wind power in some locations can be competitive with small hydro power and, therefore, can contribute to economic competitiveness of the country. Additional wind power has a potential to contribute to country's energy security and export potential.
Environmental development priorities	Along with general benefit of GHG mitigation, in certain locations wind turbines may have less environmental impacts than alternative Hydro power plants.
Other considerations and priorities such as market potential	Due to abundance of hydro power and export orientation of the system, state backed guaranteed power sale at accepTable1. feed in tariff may be problematic. Due to intermittent and partly unpredicTable1. pattern of production it will be more difficult to sell the wind power. There will be a need of balancing mechanisms to compensate for the varying output of wind power plant. Therefore a more intensive involvement of balancing energy market may become necessary. Due to availability of hydro that can be easily regulated, wind is not a country priority technology and therefore, there is no support from government and market is undeveloped. Neither the pilot projects in this area turned to be successful.

Georgia

Costs (US$)	
Capital costs over 10 years	Total capital cost is 1757.14 MM$, capital cost per kW is 1728$
Operational costs over 10 years	Negligible
Other costs over 10 years	N/a

Sector	**ENERGY**
Subsector	Transport
Technology name	**Compressed Natural Gas in Transport**
Scale	Large scale
Availability	Short term
Technology to be included in prioritization (mandatory inf.)	Yes
Background/notes (short description of the technology option)	Currently majority of vehicles are powered by gasoline which led to air pollution. Estimated sub sector GHG emissions (mega tons of CO2 equivalent) is 1400 Gg[29]- CO_2 .Moreover, increased gasoline prices caused higher expenditures on fuel which creates incentive to switch to alternative type of fuel. The Well-to-Wheel CO2 emission of a natural gas powered vehicle are about 25% lower than from a gasoline powered passenger car. The existing gasoline vehicles can be converted to dual fuel burning vehicle and the cost of travel at current prices is about 25% of the cost of travel with gasoline.
Implementation assumptions (how the technology will be implemented and diffused across the sub-sector	Technology is already highly cost effective for high mobility vehicles. There is a clear trend in switching to gas – especially in view of recent fuel cost increases. The main obstacles are concern about safety of the technology and relative scarcity of filling stations. Accelerated dissemination of the technology can be achieved through: 1.Measures for safety assurance 2.information campaign for potential users 3. Land allocation for gas filling stations in the central districts of cities. Additional benefits can be achieved through the development of compressor manufacturing in GTU and gas tank manufacturing.
Impact Statement	
Country social development priorities	The project provides additional employment opportunities, improves transport availability for low income part of society.
Country development priorities	Sustainable economic development, poverty reduction. Implementation of compressed natural gas in transport assists economic development through promotion of mobility, local manufacturing of tanks and compressors and jobs creation.
Country environmental development priorities	The major benefit of compressed natural gas in transport is reduction in local air pollution. Estimated reduction in GHG emissions is 1.2 mln tons or 1000Gg.
Other consideration and priorities such as market potential	It is assumed that at least 24% of vehicles will switch to compressed gas until 2020. The market can be considerably increased if enabling environment is in place (awareness, information, policy and regulation, etc.). Some gasoline discouragement actions may be in place as well.
Costs (US$)	
Capital costs over 10 years	Cost of converting the vehicles is born by consumers, station costs by businesses. Only state contribution needed is safety assurance, promotion and land allocation for gas filling stations. Estimated capital cost is 4.5 mln USD for the state and 19.5 mln for private sector.
Operational costs over 10 years	There are no additional operation costs for vehicles. Operational and maintenance costs are reduced compared to gasoline vehicles. The estimated running cost of inspection and quality assurance is 3.5 mln over 10 years.
Other costs over 10 years	N/a

[29] Own estimate based on NCCC2

Annex III. Pilot Project Ideas

It was considered by the mitigation team that solar water heating technology does not require a specific pilot project and it can be embedded within the general. The major barrier for this technology is lack of local manufacturing, high cost and lack of information that can be addressed e.g. within the suggested efficient construction

There have been a big number of pilot installations of the solar water heaters, however the information and outreach components of these projects were not strong enough to properly address addressed the deficiency of technical and economic information. The information on solar water heater benefits and costs spreads over the word of mouth rather then. Therefore it was decided to include the pilot installation of solar water heaters as a component of more comprehensive efficient construction pilot project.

Efficient Wood Stove Pilot Project

Introduction

TNA/TAP process has identified efficient biomass combustion and namely efficient wood stoves (EWS) as a top priority technology for climate change mitigation being in line with development priorities of Georgia. The main barriers to deployment and dissemination of this technology are: 1.Lack of public and specialist information about efficient biomass combustion and energy use, as well as lack of information for policy makers to develop adequate strategy in this direction. 2. Another key barrier is the need for adaptation of technology to specific regional conditions and specific needs of consumers taking into account local climatic conditions, cultural preferences, affordability and availability of wood fuel.

An important missing component of enabling environment for EWS technology is the long term strategy for fuel wood – which is second most important indigenous energy source in Georgia. This is largely because of the lack of sufficient information for policy making.

Project description

It is suggested to conduct technology adaptation and manufacture different types of efficient wood stoves in Georgia and to demonstrate their efficiency as well as effective methods of weatherization and heat management in the schools of one of the regions of Georgia.

In many regions schools are being heated by fuel wood which is in short supply or is harvested in unsustainable manner. Therefore demonstration of efficient wood stove technology will ease the students can become an effective information agents to disseminate the awareness of efficient fuel combustion and heat management to their families.

Project Goal

The goal of current proposal is to effectively overcome the barriers to deployment of efficient biomass combustion technology and stimulate the market for EWSs in rural areas of Georgia.

Project Objectives:

- Stimulate technology transfer and manufacturing of EWSs in Georgia
- Increase awareness and stimulate the use of EWS in the regions of Georgia
- Develop R & D lab and advisory services for efficient biomass combustion in Technical University of Georgia
- Develop the base information for efficient biomass combustion and forestry strategy for policy

The project can be implemented in the Mskheta, Dusheti and Tianeti districts of Mtkheta-Tianeti region of Eastern Georgia. This region has a cold climate and scarcity of wood fuel. The deputy governor of the region has been actively involved in stakeholder group and is willing to support the project. There is a readiness to implement the project in 67 schools where up to 7.7 thousand students and more than 1 thousand of teachers will get familiar with the EWS technology. Preliminary discussions have been conducted with NGOs who have worked on promotion of EWS technology as well as with the thermal technology department of Georgian Technical University (GTU) who is capable of providing the technology and R & D support to the project. The stoves can be manufactured in Tbilaviamsheni or Kutaisi Mechanical Plant or Bioenergy Ltd. in Tbilisi and experience of previous donor projects used.

Project Activities

Year 1 – Pilot phase

I Preparation

1. Prepare the project recipients (Mtskheta-Tianeti region) (Implementing NGO)
    a. Survey of wood consumption in selected regions and consumer preferences, climate conditions, wood availability and prices in pilot region(s) (Implementing NGO)
    b. Survey of recipients - schools and local municipalities - visits and preliminary agreements(Implementing NGO)
    c. Develop specialist support for EWS technology (International Expert)
2. Establish a R & D lab with equipment and program for EWS technology support and consultancy (Georgia Technical University, NGO)
    a. Develop and customize designs of efficient wood stoves, including upgrade of existing models, Select and customize potential designs including cooking, heating, combined and greenhouse stoves (NGO and R & D lab)
    b. Develop classification and certification scheme
    c. Develop a guide on efficient wood combustion and heat management
3. Assess manufacturing options, material and labor possibilities (including non-traditional e.g. clay stoves), develop final specifications (NGO, R &D)
4. Develop stove performance monitoring plan, policies, procedures questionnaires (Local NGO)

II Implementation

1. Tender for manufacturing of stoves to specification (Implementing NGO)
2. Manufacture the stoves of 3-4 designs
3. Install EWS for heating in 67 schools of Mtskheta-Mtianeti region, conduct simple weatherization of classrooms
4. Arrange for greenhouse refurbishment and installation of EWS for greenhouse heating 5 sites – Mtskheta-Tianeti region
5. Implement monitoring and data collection plan
6. Trainings, guiding material etc. (R&D)
7. Monitoring feedback (Implementing NGO)
8. Results analysis and conclusions (Implementing NGO together with implementing stoves business)

Year 2 - Deployment

III Deployment

1. Conduct an outreach campaign
    a. Conferences –workshops, TV shows, You tube videos, articles, advertizing (Implementing NGO)
2. Commercialization and technology transfer to vendors
    a. Technology and knowledge transfer to willing entrepreneurs including:

Drawings, specifications, Performance information (certified by experience) (Implementing NGO) and manufacturing technology

   b. Support in setting up the business activity

3. Stimulating customers
   a. Develop financing schemes (lease, revolving fund) (Implementing NGO)
   b. Conduct advisory service for consumers over continued publications and internet (Implementing NGO)

Estimated Budget for 2 years

	Activity	**000' USD**
1	Technical Assistance	50
2	Project Operation costs	250
3	setting up and operation of R& D lab	150
4	Manufacturing	150
5	Installation and School simple weatherization	100
6	Revolving fund for financial aid	200
	Total	**900**

Project relation to Georgia's sustainable development priorities

One of the main sustainable development priorities of Georgian government is regional development, reduction of poverty and improvement of living conditions as well as improvement of environmental conditions and increase of economic activity. Implementation of EWS project contributes to these all. By improving the economic and living conditions of rural residents, saving wood from excessive felling for fuel, promoting manufacturing and sale of EWSs by small businesses and reducing the dependence on imported fuel.

Possible challenges and complications

Although EWS technology has strong benefits, its implementation in Georgia can face some challenges.

At present there is active gasification of rural regions and according to ambitious plans of local gas distribution companies in several years almost every rural family will be gasified. Therefore, there is a risk that certain portion of local population will switch to gas use before EWSs come on scene.

The most important challenge for the technology will be the risk of inefficient administration of the forest code that may leave easy access to wood felling for fuel and continue forest devastation.

Another challenge is people's reaction to a new product. Rural residents may take a conservative approach to the new EWS technology and be slow in its adoption. Therefore, the process of introduction of new technology should be carried out very carefully, with due consideration of local conditions

Sustainability

School is a place of knowledge exchange. During the lifetime of installed stoves school teachers, students and their parents will witness the benefits of efficient stoves. This can serve as a good advertisement. Moreover, during the monitoring process they can suggest the ways of improving stoves to better adjust to local household needs and preferences. Stimulated demand will stimulate supply.

The designs and manufacturing know-how will be transferred to local manufacturers who will be able to carry on the business development. Wide dissemination of information about EWSs will assure initial stimulation of market.

Georgia

If no follow up activities are implemented after pilot project is completed, its effect will diminish over time, however, will last at least 4-5 years.

Sustainable Social Housing Pilot Project

Background

Efficient and sustainable construction has been identified as a top priority mitigation technology by TNA/TAP process, being in line with development priorities and technological advancement needs of Georgia. The main identified barriers to deployment and dissemination are: Lack of awareness and adequate information for all market chain participants as well as decision makers, and absence of enabling policy/regulatory framework including relevant standards and norms for design and construction.

The proposed pilot project envisages the measures to effectively address the information barrier and to prepare the grounds for decision making on policies and standards for efficiency in construction. It addresses the housing needs for vulnerable population to provide them decent living conditions in future. The project has a great potential for being replicated in Tbilisi as well as in other cities of Georgia.

Project Goal: Reduce energy consumption in buildings and associated GHG emissions in Georgia by stimulating deployment of efficient building design and construction technology through construction of efficient social housing.

The Project will:

- Stimulate the use of Energy Efficient sustainable construction and integrated design practices
- Promote EE construction materials and equipment industry
- Training and educate the architects and constructors in Sustainable Integrated Building Design and Construction
- Demonstrate the energy saving and economic benefits of Sustainable construction on the example of new multi-apartment pilot building (design and construction)
- Result in Design and construction of a 20 family residential house for socially vulnerable families to provide decent living conditions to vulnerable homeless households in Tbilisi
- Support Tbilisi City Hall in meeting the obligations under the Covenant of Mayors
- Increased awareness of consumers and policymakers
- Stimulate the introduction and enforcement of new EE building codes and standards

Project Activities and deliverables shall include:

- Practical workshop on sustainable integrated building design for architects, developers and constructors. The main principles and methods used in Integrated Building Design and sustainable construction will be presented and discussed with the group of Architects and developers interested in sustainable design the workshop to be organized as a one week retread with the aid of International expert
- Preparation of designs proposals for social housing settlement by participants. Up to five preliminary designs to be prepared and reviewed by the group.
- The winning design proposal shall be taken to develop a **construction design of a typical multi-apartment social housing residential building for 20 families** based on EU efficiency standard for similar climatic conditions. The process shall be aided by international expert. Locally available energy efficient material shall be used.
- A conference - trade show for architects, developers, constructors and material suppliers to describe developed efficient design, negotiate construction and material prices and solicit the participation of material and equipment providers
- Tender - to select the construction company and construction. Construction oversight and installation of monitoring equipment in apartments will be conducted during the construction process

Georgia

- Apartment allocation policies and procedures to be developed in collaboration with Tbillisi City Hall. Possible measures include: arrange the financing scheme including soft loans and revolving funds combined with sale of housing at discount to willing vulnerable population.
- Monitoring of energy performance and energy costs of apartments. Energy and temperature metering equipment will be installed, data collection and analysis will be conducted in the first year of building operation.
- Information campaign and outreach activities shall be conducted over the whole duration of the project from its inception. The information about the design features, expected energy performance, construction costs and applied methods, construction progress and final actual energy performance shall be made available to the wide public.
- **Policy recommendations** and final report – Detailed account of costs and benefits of the efficient construction will be kept during the construction and in the first year of operation of the house. based on the results of the project the justified recommendations shall be developed for consumers and policymakers

Project Beneficiaries:

- Architects and designers who will acquire practical knowledge of integrated design principles and practices
- Vulnerable families who will acquire dwellings, decent living conditions and reduced energy bills
- Efficient material and construction technology providers – by promoting their product and services
- City Hall through the support in meeting the Covenant of Mayors obligations and addressing social problems in the city of Tbilisi
- Decision makers and supporters of efficient construction technology by providing the material for lobbying and decision making.
- Developers and housing customers through increased awareness and possibility for improving their future energy performance

Project Duration – 2.5 years

Project Budget

Activity	**000' USD**
Technical Assistance	100
Practical Workshop	30
Design/calculations	30
Building construction	550
Monitoring and outreach	50
Operations costs	150
Contingency	50
Total	960

Tbilisi City Hall of Tbilisi has been consulted and is ready to support the implementation of this pilot proposal. The construction can be replicated for typical social housing in other parts of Georgia.

Project relation to Georgia's sustainable development priorities

The project has high relevance to country's development priorities and interests of technological advancement. Efficient construction can improve the quality of residential buildings; make them more safe, comfortable and economical. Energy saving in energy efficient buildings will improve energy security on consumer and country level. Reduce dependence on imported fuel and improved foreign trade balance will positively impact country's position. Important consequence of this development will be technological advancement in efficient material industry, construction industry, Architectural design and engineering know how. This can open a new market of more advanced efficient houses and increase economic activity in this market niche.

Possible challenges and complication

The pilot project is designed to answer the needs of socially vulnerable population that is dependent on government support and care. It is designed in a way to align the interests of all parties involved. Therefore the risks are mostly related to external factors or inability of the participants to implement their part in the project.

- As in all projects there is a risk of cost overruns and poor performance of contractors – this should be addressed at inception and project design stage by detailed planning.
  - There is a risk of apartment allocation procedures that should be addressed by maximum transparency of policies.
- The risk of residents unwillingness to participate in post-construction monitoring activities should be addressed by installation of metering equipment outside the apartments
- In case of co-financing from the city there is a risk of changing budget priorities. This should be preempted by strong political support.
- There is a challenge of implementing the design and construction by specialists not experienced in sustainable design and construction, as well as performance of efficient materials. On the other hand addressing this challenge is already a significant step forward in deployment of efficient construction technology.

Sustainability

The main emphasis of the project is to create wide involvement of interested stakeholders, creation their working relations generation and distribution of relevant practical information. This creates the essential elements of sustainability of the project. Strong monitoring and information component will assure collection and dissemination of the real life data on efficient construction technologies. The number of architects and students will get practical exposure to sustainable design that they will use in their further work. The project can be replicated in other cities who have also joined the covenant of mayors and are now looking for the ways of reducing their GHG emissions

Annex IV. List of Stakeholders

The meetings and discussions have been conducted with following specialists:

1. Grigol Lazriev – Ministry of Environment (& Natural Resources) – Head of Department
2. Nana Pirtskhelani – Ministry of Energy (& Natural Resources) – Efficiency in electricity generation
3. MaritaArabidze – Ministry of Energy (& Natural Resources) Head of Department
4. KarineMelikidze – Building energy efficiency expert
5. Astrid Denker – SEAP development expert
6. ZviadArchuadze – Head of economic office of Tbilisi City Hall – Covenant of Mayors
7. NunuMgebrishvili – Governor – Mtskheta-Mtianeti region – forest & efficient wood stoves
8. DimitriKostiadi – Geothermal Energy Expert- ARCI – Managing partner
9. PaataJanelidze – UNDP project manager - geothermal study
10. Nino Lazashvili – Winrock Int. project manager – EE and RE past projects
11. NatelaDvalishvili – Hydro Meteorology Inst. Chief researcher (waste management)
12. ShotaMestvirishvili - Academician (gas transportation systems)
13. Oleg Shatberashvili – Chairman – Association European Studies for Innovative Development of Georgia – innovation policy
14. AbesalomBeroshvili –Prof.-Technical University/ – Compressors for CNG in filling stations
15. George Papuashvili – Student Tbilisi State University, CNG tank project developer
16. KoteKobakhidze – Sun House – Solar PVs and water heaters
17. Otar Vezirishvili- Professor GTU, Renewable energy expert
18. Ketevan Vezirishvili – Professor GTU, Director of KIMS
19. Nino Cholokashvili –Tbilisi Business Service Center - partner
20. OtarVardigoreli – Geothermia Ltd.
21. George Melikadze - Chairman of Geothermal Association
22. ArchilZedginidze – Karienergo Director, Wind power expert
23. MananaGelovani - Karienergo, windpower expert
24. RostomGamisonia – RCDA director, efficient biomass combustion expert
25. George Abulashvili – Director, Energy Efficiency Center
26. Nodar Kevkhishvili – Professor, Technical University, Geothermal and solar energy
27. IrakliShekriladze- Professor, Technical University
28. AvtandilBitsadze – Bioenergia director – Biomass and Biogas expert
29. GiaSopadze – NGO Eco Vision Efficient biomass combustion expert
30. AvtandilGeladze – Green Alternative lead expert - Biomass Combustion
31. Omar Kiguradze – Professor GTU, expert in heat transfer and efficient wood stoves
32. Kakha Dzodzuashvili – Director Aydio – Solar systems
33. TeimurazKandelaki – Professor, Agricultural University, forestry expert
34. RevazArveladze – President of Georgian Energy Academy
35. G.Kipiani – Architect, Deputy Chair of Architects' union
36. A.Ramishvili – Architect, expert in green construction
37. T.Bolotashvili – Project manager USAID/Deloitte/EPI program
38. T.Gogia –Dr. Tech. Sc. Expert in efficient construction materials, Alioni 99.
39. Z.Kheladze – General Director, Woodservice LTD, Efficiency Construction technologies