



# Liberia

## TECHNOLOGY NEEDS ASSESSMENT FOR CLIMATE CHANGE MITIGATION

### REPORT II

### BARRIER ANALYSIS AND ENABLING FRAMEWORK FOR THE ENERGY SECTOR

October 2020



# **BARRIER ANALYSIS AND ENABLING FRAMEWORK FOR CLIMATE CHANGE MITIGATION TECHNOLOGIES IN THE ENERGY SECTOR**

## **REPORT II**

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In September 2015, Liberia, as a signatory of the UN Climate Change Convention, submitted the Nationally Determined Contribution (INDC) in advance of the new climate change agreement reached at the UN Climate Conference in Paris in December. Liberia's INDC was designed as a platform to integrate its Low Carbon Development Strategy into the country's long-term sustainable development vision by 2030 (Agenda for Transformation). Liberia ratified the Paris Agreement in August 2018 and is working hard to revise its NDC for submission. Regardless of the many contributions to climate change, Liberia, like many other developing countries, is especially vulnerable

to its impacts. The country is at this moment susceptible to the adverse effects of climate change such as shifting cultivation in the agriculture sector, unsustainable logging practices, unregulated coastal mining, high level of biomass consumption in the form of charcoal and fire wood for local energy use, and decreasing river flow due to high level of evaporation. The agricultural sector, which ensures the livelihoods of around 70% of the population, remains vulnerable to flooding and erosion with changing rainfall patterns putting lives at risk in a country where nearly 8 out of 10 people do not have secure access to food. Current climate change vulnerability in Liberia include; increase in extreme events (e.g., exacerbated floods, extreme drought), sea level rise, flooding and coastal erosion being experienced on an annual basis that eats up the coast as observed in Monrovia, Buchanan and Greenville.

I would like to add that Liberia has an overall lack of energy. In most rural areas in Liberia, less than 5% of the population has access to electricity while most homes run mini generators. The current energy situation in Liberia is characterized by a dominance of traditional biomass consumption, low access to poor quality and relatively expensive modern energy services. It is estimated that over 95% of the population rely on firewood, charcoal, and palm oil for their energy needs.

The EPA of Liberia is overly happy with the level of the assessment done by the Technology Needs Assessment Team (TNA) through a national stakeholder's participatory process emulating from the identification and prioritization of environmentally sound technologies to the diffusion of these technologies to mitigate and adapt to climate change. We would like to recognize the United Nations Environment Programme (UNEP), DTU Partnership and Global Environment Facility (GEF). Your contributions have resulted in this rich source of information and we hope that this report will spur parties into seeking out partnerships for the purpose of accelerating climate action and increasing ambition in Liberia.



**Dr. Nathaniel T. Blama Sr.**  
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## List of Acronyms and Abbreviations

BA&EF	Barrier Analysis and Enabling Framework
CO <sub>2</sub>	Carbon dioxide
ECOWAS	Economic Community of West African States
EPA	Environmental Protection Agency
ERC	Energy Research Centre
GEF	Global Environment Facility
GHG	Greenhouse gas
GOL	Government of Liberia
GW	Gigawatt
HAP	House-hold Air Pollution
INC	Liberia's Initial National Communication
INDCs	Intended Nationally Determined Contributions
IPPs	Independent Power Producers
kW	Kilowatt
kWh	Kilowatt-hour
LEAP	Liberia Energy Access Practitioners Network
LEC	Liberia Electricity Corporation
LERC	Liberia Electricity Regulatory Commission
LFA	Logical Framework Approach
MCA	Multi-Criteria Analysis
MfDP	Ministry of Finance and Development Planning
MIC	Middle-income country
MME	Ministry of Mines and Energy
MW	Megawatt
NGOs	Non-Governmental Organizations
NIC	National Investment Commission
O&M	Operation and Maintenance
PV	Solar photovoltaic

RESMP	Rural Energy Strategy and Master Plan
RREA	Rural Electrification Energy Agency
SDGs	Sustainable Development Goals
SHP	Small Hydropower
SHS	Solar home system
TJ	Terajoules
TNA	Technology Needs Assessment
TVET	Technical and Vocational Education and Training
UDP	United Nations Environment Programme and Technical University of Denmark Partnership
UNEP	United Nations Environment Programme
UNEP-DTU	United Nations Environment Programme and Technical University of Denmark
UNFCCC	United Nations Framework Convention on Climate Change

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## Executive Summary

The Technology Needs Assessment (TNA) Report II presents the barrier analysis and enabling framework for climate change mitigation technologies in Liberia's energy sector which were identified and prioritized in TNA Report I. Report II identifies the critical barriers that could inhibit the acquisition, deployment, and diffusion of the prioritized technologies. It also outlines appropriate measures to overcome these barriers. Finally, it provides an enabling framework for overcoming the identified barriers and successfully implementing these technologies.

The three identified and prioritized technologies selected for mitigation in Liberia's energy sector are

1. Solar PV Home System (SHS),
2. Solar PV Mini-grid System (SMG) and
3. Small Hydropower System (SHP).

There are three specific objectives for conducting the barrier analysis process. They are:

1. to identify barriers or reasons hindering the acquisition, transfer and diffusion of the technologies, including any failed measures that could have sustained diffusion;
2. to understand the nature of the individual barriers and any relation among barriers in order to determine the critical barriers and those easier to remove; and
3. to identify the potential measures to address the identified critical barriers.

The methodology adopted for this process included desk study of key policy papers, reports and other related literature by the TNA lead mitigation consultant. The desk study was also supplemented by interviews with experts and key stakeholders in the energy sector. The process was further advanced with the Logical Framework Approach (LFA) using the problem and objective tree tool to identify and analyse the barriers for each technology as well as for determining appropriate measures to overcome the identified barriers. Consequently, the barriers identified were then classified under two main categories as economic and financial barriers, and non-economic and financial barriers. The non-economic and financial barriers were further analysed and decomposed into sub-categories in consultation with stakeholders.

This final sections of this report focuses on the linkages of the common barriers faced by the three prioritized technologies in the energy sector and the suggestions of enabling frameworks to overcome these common barriers. All three prioritized technologies (SHS, SMG and SHP) had common barriers. The suggested enabling frameworks for the common barriers faced by the three prioritized technologies in the energy sector were:

Type	All Three Prioritized (SHS, SMG and SHP) Technologies had Common Barriers	Enabling Framework
Economic and Financial	High initial capital or investment cost	<p>-Support commercial banks and financial institution to establish renewable energy portfolios to fund renewable energy development</p> <p>-Design strategies to reduce investment costs for renewable energy technologies' project developers and investors using direct subsidies, tax exemptions, feed-in tariff systems, green certificate schemes and the Clean Development Mechanisms (CDM)</p> <p>-Support public-private partnerships and grant-based funding to lower capital risk</p>
	Limited access to finance and long term capital	<p>-Stimulate public and private investment in the sector by making clear, both qualitatively and quantitatively, the linkages between renewable energy technologies, climate change mitigation and sustainable development.</p> <p>-Provide guarantees for low-cost, low-risk, long tenor financing through credit lines for renewable energy technologies projects linked to climate change mitigation and sustainable development</p> <p>-Capitalized the REFUND and make it operational to provide financial support, capital subsidies, production-based subsidies to investors, suppliers, dealers and consumers</p>
	Absence of adequate subsidies and financial incentives	<p>-Develop appropriate subsidies, incentives and waiver of customs duties on equipment and spare parts for renewable energy technologies.</p> <p>-Provide tax exemptions and tax holidays for private sector investment in renewable energy technologies</p>
	Low ability and willingness to pay for technologies by end users	Develop financial models to take account of affordability and willingness to pay, supported by information, education and communication campaigns.
	High interest rate charge	Provide low interest rate loans
Weak legal, regulatory and	Cheap and Substandard equipment	-Develop codes and standards and the institutional framework to enforce them.

institutional framework	Inadequate legal, regulatory and institutional framework	-Develop certification procedures, and institutions, including test and measurement facilities  -Develop clear regulatory guidelines renewable energy off-grid and mini-grid systems
Information and Awareness	Inadequate and limited information sharing about the technologies among stakeholders at the local and national level	-Intensify adequate information, public education and awareness campaigns through print, electronic and social media; seminars, workshops, conferences, etc.  -Increase local capacity and community engagement to strengthen positive socio-economic impact and increase awareness of the benefits of renewable energy among end users.
Technical	Inadequate trained local technical expertise to install, operate and maintain renewable energy projects	-Establish training and accreditation centers to train and accredit human resource for the renewable energy sector  -Set up scholarship program to incentivize the enrollment of women for gender mainstreaming
Cultural, Social and Gender	Absence of inclusive gender participation in renewable energy projects	-Provide incentives for women active participation in the management, development, operations, installations, engineering, procurement, construction, maintenance and repair works of renewable energy technologies
	Absence of a well-developed and targeted engagement plan to engage with potential beneficiaries, leaders or other influential members in the targeted areas	-Conduct intensive stakeholder consultations before and during preparation of renewable energy projects; and continue after projects are implemented.

## Chapter 1 Energy Sector

The United Nations Framework Convention on Climate Change’s (UNFCCC) recognizes Technology Needs Assessment (TNA) as the first of five key elements towards identifying and accessing climate change mitigation challenges within its technology mechanism on technology development and transfer. In Liberia, the TNA project as commenced in May 2018 in collaboration with United Nations Environment Programme (UNEP) and the Technical University of Denmark Partnership - UNEP-DTU Partnership (UDP), the Energy Research Centre (ERC) at the University of Cape Town with funding from the Global Environment Facility (GEF).

Phase 1 of the Technology Needs Assessment (TNA) project which was “*to identify and prioritize through country-driven participatory processes, technologies that can contribute to mitigation and adaptation goals of Liberia, while meeting the country’s national sustainable development goals and priorities*” (Haselip et al., 2019) was completed in June 2019 with the submission of the first report to UNEP-DTU. Liberia prioritised the energy sector as a key mitigation choice because it is the primary source of greenhouse gas (GHG) emissions as outlined in Liberia's Initial National Communication (INC) submitted to the UNFCCC and based on the country’s national development agenda as expressed in the Pro-Poor Agenda for Development and Prosperity (Government of Liberia, 2018; Environmental Protection Agency, 2013). The TNA project is led by the Environmental Protection Agency (EPA) of Liberia.

As part of the first phase of the TNA project, three out of ten technologies were identified, ranked and prioritized after extensive consultation with experts and other stakeholders. Through a stakeholder’s participatory process using Multi-Criteria Analysis (MCA) tools, the three top ranked prioritized technologies selected for mitigation in Liberia’s energy sector are shown in Table 1.1.

Table 1.1 Prioritized technologies and their categories - Energy Sector

No.	Prioritized Technology for Energy Sector	Category
1.	Solar PV Home System (SHS)	Consumer
2.	Solar PV Mini-grid System (SMG)	Capital
3.	Small Hydropower System (SHP)	Capital

Phase II of the TNA process is “*to identify and analyse barriers hindering the acquisition, deployment and diffusion of the prioritised technologies*”. This second phase is primarily to assess the critical barriers and to identify the appropriate measures to overcome them and

thereby creating an enabling environment for the implementation of the technologies. The specific objectives of the barrier analysis process are:

1. To identify barriers or reasons hindering the acquisition, transfer and diffusion of the technologies, including any failed measures that could have sustained diffusion;
2. To understand the nature of the individual barriers and any relation among barriers in order to determine the critical barriers and those easier to remove; and
3. To identify the potential measures to address the identified critical barriers.

### **1.1 Preliminary targets for technology transfer and diffusion**

Liberia is highly susceptible to environmental degradation and to the consequences of climate change because the country's economy is largely dependent on consumption of fossil fuels and its related energy-intensive products. The country requires more energy to satisfy its increasing demand due to population growth, food production, accelerated industrialization and better living standards for its citizens. However, the use of traditional sources such as fossil fuels and biomass for economic related activities like electricity generation, agriculture and transportation has continued to have significant environmental and climate change implications. The country is exposed to extreme weather events, such as floods, droughts and soaring temperatures. Liberia like most developing nations suffers most because of its inability to cope with the adverse effects of climate change due to poverty, low or no access to technology transfers and capacity for technological development, among others.

Liberia's ambition of achieving middle-income country (MIC) status as well as the country's quest to attain the African Union Agenda 2063 and the Sustainable Development Goals (SDGs) especially SDG7 by 2030 will be unachievable without access to affordable, reliable, sustainable and modern energy sources. The country is trying to rebuild its entire infrastructure for generation and distribution of electricity which was destroyed during a civil war that lasted from 1989 to 2003 (Government of Liberia, 2013).

Liberia has no domestic fossil fuel resources and strongly depends on imported fuel resources to meet its energy demand. The country's present primary energy source is based mainly on biomass (93.4%), petroleum products for transportation and electricity generation (6.3%) and the rest including small scale hydro and solar electric (0.3%). In 2012, petroleum products imported into the country was estimated to be 76.6 million US gallons, or 11,132 terajoules (TJ). By December 2018, Liberia's total installed generation capacity was 126 MW from the rehabilitated Mount Coffee Hydropower Plant (88 MW) and three heavy fuel oil/light fuel oil thermal generation plants (38 MW) (World Bank, 2018). Liberia has one of the lowest access rates in the world, with fewer than 3% of the country's rural population having access to electricity, and just about 31% in the capital city of Monrovia. Electricity consumption in 2016 in the country was estimated to be about 279 million kWh (The World Factbook, 2020).

Liberia's energy sector with approximately 5.4 MtCO<sub>2</sub>e (49%) is the largest contributor to the country's total greenhouse gas (GHG) emissions (INC, 2013).

The transfer and diffusion of climate change mitigation technologies in Liberia will be driven by the targets identified by the government in the Rural Energy Strategy and Master Plan (RESMP), Intended Nationally Determined Contributions (INDCs), the country's climate change strategy, other existing national and sectoral plans, programs and policies.

The relevant targets for technology transfer and diffusion are:

- The government has an ambitious plan to increase rural electricity access to 35% by 2030 and electrify about 265,000 homes, providing energy to approximately 1.34 million people.
- Rural electrification rate at 10% in 2020, 20% in 2025 and 30% in 2030.
- At least 2,000 settlements electrified with grid infrastructure connecting at least 50% of those settlement's population by 2030.
- All county capitals, health facilities and secondary schools electrified by 2025.
- Universal access to affordable Solar Home Systems with 250,000 units sold by 2030 (RREA, 2019).
- Raise the share of renewable energy to 30% of electricity production and 10% of overall energy consumption by 2030 (INC, 2013).
- Reduce greenhouse gas emissions by 10% by 2030 (INC, 2013).

The targets for the specific technology in the energy sector of the country are:

- Provide 250,000 households or 1 million beneficiaries in five rural communities in each of the 15 counties of the country with solar home system by 2030.
- At least 2,000 settlements around the country electrified with solar mini-grid infrastructure connecting at least 50% of those settlement's population by 2030.
- Develop a total of up to 100 MW of installed hydroelectric capacity consisting of 15 or more mini and micro hydro power units around the country by 2030.

In order for the country to achieve these preliminary targets of transfer and diffusion of technologies in energy sector, it is imperative that key stakeholders in the country's energy sector such as Liberia Electricity Regulatory Commission (LERC), Rural Electrification Energy Agency (RREA), Liberia Environmental Protection Agency, Liberia Electricity Corporation (LEC), Liberia Energy Access Practitioners Network (LEAP), Ministry of Finance and Development Planning (MfDP), Ministry of Mines and Energy (MME), Ministry of Gender, National Investment Commission, Non-governmental organizations (NGOs), and civil society get involved and play an enhance role in the successful implementation of technologies. Other actors in the energy sector include consumers, builders, installers, architects, technicians, experts in renewable energy, consultants, donor partners, independent power producers (IPPs),

rural developers, financial institutions, suppliers/dealers of relevant equipment, women advocacy groups, local government administration, youth and community leaders.



Figure 1.1 Stakeholders at the Barrier Analysis and Enabling Framework workshop in Monrovia, Liberia

## 1.2 Barrier analysis and possible enabling measures for Solar Home Systems (SHS)

Barrier analysis and enabling framework process was carried out in compliance with the TNA guidebook “Overcoming Barriers to the Transfer and Diffusion of Climate Technologies” which provided guidance on how to assess the barriers to identified technologies in the countries concerned, and on how to address and overcome these barriers through different types of measures (Nygard & Hansen, 2015).

As a starting point, a desk study of key policy papers, reports and other related documentations was conducted by the TNA lead mitigation consultant to determine the primary reasons why each of the three identified technologies was not currently in widespread use in the country, and why no neither the private or public sectors have invested significantly in these technologies. The desk study was also supplemented by interviews with experts and key stakeholders.

The mitigation consultant, with the support of the TNA national coordinator at the EPA of Liberia, convened a consultative workshop on January 9, 2020 in Monrovia, Liberia with key stakeholders drawn from government ministries, departments and agencies, NGOs, the private sector, technical experts and academics. The workshop was aimed at identifying barriers and developing enabling frameworks or measures to overcome the potential barriers that could impede the possible transfer and diffusion of the three prioritized mitigation technologies in the energy sector of Liberia. In order to ensure that gender issues were taken into account

during the barrier analysis and enabling framework process, gender experts were included as stakeholders. Figure 1.1 shows stakeholders at the Barrier Analysis and Enabling Framework workshop. A detailed list of stakeholders involved, their contacts and the organizations they represented can be found in Annex II of this report.

Several consultative meetings and technical working sessions were held after the main stakeholders' workshop with experts who could not be present at the workshop to seek specific information on barriers and enabling measures for each technology.

During the workshop all barriers and measures identified for the prioritized technologies were grouped into two broad categories, namely economic and financial barriers, and non-financial barriers. The non-financial barriers were further analysed and decomposed into these sub-categories: technical barriers, information and awareness barriers, legal, regulatory and institutional framework barriers, and cultural, social and gender barriers. The Logical Framework Approach (LFA) with the problem and objective tree tool was used to identify and analyse the barriers for each technology as well as for finding measures to overcome the identified barriers (Norad, 1999; Painuly, 2001; AusAid, 2005). The problem tree tool was helpful in identifying and understanding the causal relations of barriers and their linkages. The problem and objective trees have been prepared based on stakeholders' discussions (see Annex I).

For the three technologies prioritized in the energy sector, Solar Home PV System falls under consumer goods while Solar PV Grid-tied System and Small Hydropower falls under capital goods. Market mapping was therefore applied for these technologies which were classified as consumer and capital goods. The market mapping tool was used to identify the market chains and their different components and inter-linkages. The detail of market maps for these categories of mitigation technologies are presented in the Annex I.

### **1.2.1 General description of Solar Home Systems (SHS)**

Solar energy is one of the most abundant energy resources freely available to both urban and rural populations of the world. More solar energy reaches the Earth in one hour than all humans use in one year (Frankl, 2010; Suzuki & Boyd, 2009). Solar photovoltaic (PV) technology uses solar cells to capture and subsequently convert sunlight directly into electricity. A collection of 6 to 10 solar cells are combined and arranged in a grid-like pattern to make a solar PV panel or module which generates electricity from the sun. The three main types of solar power systems are off-grid or stand-alone power systems, on-grid or grid-tie power systems and hybrid or grid-connected power systems with battery storage.

Solar home system (SHS) is a stand-alone PV system that is not connected to the grid to power lighting and appliances for homes and businesses located in sparsely populated remote locations or areas with poor grid reliability. The typical SHS consists of a PV solar panel or module, supporting structures, an inverter, a rechargeable battery, a charge controller and



lamps. SHS uses batteries to store and supply electricity when the solar panels are not producing energy at night or cloudy days. It can provide electricity for powering household appliances such as lights, radio, television, mobile phones, refrigerator, fans and more. Besides households, SHS can provide power for schools, clinics, or small businesses. Moreover, the PV system is a promising source of electricity generation for energy resource saving and CO<sub>2</sub> emission reduction especially for consumers in off-grid and rural areas.

Liberia has enormous potential for solar energy. If this great potential is fully exploited, it could meet a substantial percentage of the country's electricity needs. However, despite these huge solar energy potentials, not much has been done to harness electricity from solar energy in the country.

Some benefits of SHS include the following:

- It can displace the use of kerosene, candles and woodfuel for lighting thereby reducing house-hold air pollution (HAP). It also displaces dry cell batteries which addresses both the economic and environmental aspects of the people.
- SHS can significantly decrease the risk of fire by replacing kerosene lamps and candles.
- It can improve the local economy by generating new job opportunities as well as establishing small-scale industries
- It can enhance the quality of life of the rural poor by offering a clean and sustainable energy supply.
- It can extend study and work hours into the evening. Hence, students have more time to study, and women no longer have to depend solely on sunlight to complete their household chores.
- It helps in reducing national level GHG emissions.

### **1.2.2 Identification of barriers for the technology**

Identifying barriers is the process of identifying the factors that impede technology transfer and diffusion. It includes determining the important barriers and identifying barriers that are easiest to remove. The process also involves identifying any failed or missing measures that could have sustained the diffusion of the technology. Firstly, to kick-start the process of barrier analysis and identify enabling measures, the TNA national mitigation consultant conducted a desk study of policy papers, feasibility studies and other relevant documents to identify the main reasons why the technology is not currently widely implemented and why neither the private nor the public sector made significant investments in projects on solar PV home systems. Secondly, a gender sensitive consultative workshop involving a number of stakeholders from various governmental agencies, ministries, civil society and private sector was held on January 9, 2020 in Monrovia, Liberia. The workshop was aimed at identifying barriers and developing enabling frameworks or measures to overcome the potential barriers that could impede the possible transfer and diffusion of solar home systems as a mitigation technology in the energy sector of the country. The workshop was followed by series of technical working sessions and interviews with other experts for a successful process.

Market mapping was conducted during the consultation with stakeholders' workshop as a tool to aid in the selection of barriers and measures. Stakeholders agreed that market mapping be applied only for those technologies which are classified as consumer and capital goods. Detail of market maps for these categories of mitigation technologies are presented in the Annex I. Furthermore, the Logical Framework Approach (LFA) with the problem and objective tree tool was used to identify and analyse the barriers for each technology as well as for finding measures to overcome the identified barriers. The barriers identified were then classified under two main categories as Economic and financial barriers, and Non-economic and financial barriers. The non-economic and financial barriers category was further analysed and decomposed into sub-categories in consultation with stakeholders.

### 1.2.2.1 Economic and financial barriers

The key economic and financial barriers to the transfer and diffusion of solar home systems in Liberia are shown in Table 1.2.

Table 1.2: Economic and financial barriers and their description for Solar Home System

Barrier Category	Barriers	Barrier Description
Economic & Financial	-High initial investment cost	One of the most significant barriers hampering the widespread diffusion of SHS in Liberia is the high initial up-front capital cost or investment for the system. In Liberia there is no production or manufacturing of any part of the SHS. Solar PV components are all imported into the country. The high cost also applies to all replacement and maintenance parts such as inverters, charge regulators and batteries which are all imported into the country from mainly China, Europe and United States of America. The cost of a standard SHS in Liberia ranges between US\$ 500 to US\$ 1,200 depending on the size, duties and taxation, and the quality of the components. This is a large investment and without financing is not affordable to majority of the poor rural people in a country where 38% of the population has an income of less than US\$ 1.90 a day. The main target groups for SHS in Liberia are the rural and peri-urban households who are not connected to the national grid and without a sustainable or reliable source of electricity. They also have limited saving potential and usually fall into the low energy consumption bracket. Moreover, financial services such as loans from the banks to acquire the SHS are usually not available or accessible for the urban or rural poor.

	- High interest rates	Interest rates in Liberia are highly volatile. Banks and financial institutions often charge interest rates exceeding 25% for people wishing to get loans. The same interest rates apply to those wishing to obtain loans for the purchase of SHS.
	- Absence of subsidies	Many of the rural population in Liberia cannot afford to pay for solar home system without end-use subsidies, assistance from NGOs, bilateral and multilateral donor agencies. The government provides economic incentives to encourage investment in energy from fossil fuel sources through tariff exemptions, subsidies, etc. Most of these incentives subsidies are not available to projects in solar PV technology and these are factors that play a significant role in impeding the diffusion of SHS in the country. Shifting these incentives and subsidies on fossil fuels to renewable energy projects will accelerate growth and diffusion of renewable energy technologies in Liberia, especially, solar energy. For example, the removal of income tax on solar technologies will be a good start.
	- Limited access to finance and long term capital	Banks and other financial institutions are expected to play a crucial role in the diffusion and growth of renewable energy technology in the country. The PV supplier/dealer does not have the working capital required to offer credit to the end-user and depend on the banks to fill this gap. However these commercial banks and other financial institutions are hesitant to offer a long maturity loan facility the low-income population in rural areas on the basis on their perceptions about credit risk to low-income people, lack of collateral and the unclear legal status of market segment of SHS.
	- Low ability and willingness to pay	Affordability is a major barrier for many consumers in poor peri-urban and rural communities. The upfront cost is often prohibitive, even on payment plans. Most rural areas in Liberia consist of very poor population with low ability and willingness to pay for the connection and operation fees. Default and delinquency rates tend to be quite high for rural poor with little disposal income for energy.

### 1.2.2.2 Non-financial barriers

The key non-financial barriers to transfer and diffusion of Solar Home Systems in Liberia are shown in Table 1.3.

Table 1.3: Non-financial and economic barriers and their description for Solar Home System

Barrier Category	Barriers	Barrier Description
<b>Non-Financial Barriers</b>	Technical	-Inadequate local technical expertise  The 15-year civil war and the Ebola crisis that hit the country between 2014 and 2015 have resulted in inadequate trained technical personnel and training facilities for the installation, operation and maintenance of solar PV technologies. Local technical expertise is particularly important for rural and remote areas with poor road networks, where regular repairs and maintenance are often needed.
	Information & Awareness	- Inadequate and limited information sharing  Liberia is gaining experience in solar PV home systems. However, people do not understand its capabilities and where it can be of benefit. This low level of awareness and information of the applications and benefits of SHS technology amongst policymakers, potential investors, governmental agencies and prospective consumers is a major constraint to the successful dissemination, commercialization and adoption the technology.
	Cultural, Social & Gender	-Absence of inclusive gender participation in SHS projects  There are limited initiatives that focus on training and supporting women and vulnerable people in the renewable energy sector. The absence of inclusive gender participation especially in the rural areas is a barrier to the deployment of the technology since women benefit more than men from the access to clean energy. Stakeholders also suggested the presence of certain local customs, practices and social norms as further obstacles to the deployment of SHS in the region.
		- Absence of a well-developed and targeted engagement plan with potential beneficiaries  Another socio-cultural barrier is lack a well-developed and targeted engagement plan with potential beneficiaries, leaders or other influential members in the rural communities where the SHS intervention is to take place.

	Legal, Regulatory and Institutional framework	-Cheap and Substandard equipment	No existing legal or regulatory framework that may serve as rules for required standards regarding the transfer and diffusion of the technology. At the moment, there is no local commercial company manufacturing SHS equipment. These gaps in regulations have led to the importation of low quality or fake solar PV systems and spare parts which can affect the acceptance of the technology in the targeted localities or communities.
		- Inadequate legal, regulatory and institutional framework	The Liberian off-grid electricity market for solar PV systems has largely remained unregulated with unclear policy directions and weak implementation of existing policies and strategies. A portion of the RREA Act for the establishment of a Rural Energy Fund (REFUND) to provide low interest loans, loan guarantees, and grants as targeted subsidies to ensure energy access by the poor has not been capitalized and made operational. These gaps in legal, regulatory and institutional framework have led to limited technical and operational standards, codes and guidelines to measure the performance of operators or service providers; limited private sector investment; and limited technical skills and capacity of local actors.

### 1.2.3 Identified measures

The identification of required measures to overcome key barriers that could prevent the transfer and diffusion SHS technology in the country has been done through a stakeholder consultation and the enabling measures thus identified as shown in Table 1.4.

#### 1.2.3.1 Economic and financial measures

The key economic and financial measures to overcome the barriers to the transfer and diffusion of solar home systems in Liberia are shown in Table 1.4.

Table 1.4: Measures to overcome economic and financial barriers of Solar Home System

Barrier identified	Measures identified to overcome the barriers
Economic & Financial	<p>- To reduce the high investment cost for SHS and increase the diffusion of the technology in the country, the government should provide support for local production of components to lower the initial investment cost for suppliers and customers.</p>
	<p>- In order to lower the high interest rate on loans, it is recommended that the government arrange financial support or assistance to poor rural households at zero or low interest rates with acceptable loan duration for them to acquire SHSs.</p>
	<p>- In order to address the barrier of the absence of subsidies and to accelerate the diffusion of SHS technology in rural and peri-urban areas of the country, it is recommended that the government put in place appropriate subsidies, incentives and waiver of customs duties on all solar PV system components for suppliers and household. This measure should also include tax exemptions for private sector investment on energy in order to incentivize private and commercial funding. The implementation of this strategy has to be monitored very closely to avoid unscrupulous suppliers and investors from taking undue advantage of the custom duties waiver by fraudulently reclassifying other imported goods as solar PV system.</p> <p>- It is further recommended that the RREA carry out a comprehensive impact assessment aimed at understanding the political, economic, social and environmental impact of the waiver of customs duties for quality-tested off-grid solar PV systems.</p>
	<p>- In order to address the barrier of the limited access to finance and long term capital, it is recommended that the government should capitalize the REFUND and make it operational to provide financial support, capital subsidies, production-based subsidies to investors, suppliers, dealers and consumers of off-grid solar PV system targeted at remote areas and islands without access to electricity.</p>
	<p>- In order to address the barrier of the low ability and willingness to pay, there is a need to develop financial models that will take account of affordability and willingness to pay for the cost of acquisition of SHS products. This will also help to estimate the cost of the solar home systems that solar companies need</p>

	to charge in order to reach commercial viability in a non-subsidized market. It could help companies determine where to focus their efforts.
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### 1.2.3.2 Non-financial measures

Table 1.5: Measures to overcome non-financial and economic barriers of Solar Home System

Identified Barriers' category		Measures identified to overcome the barriers
Non-financial and economic measures	Technical	- To overcome the barrier of inadequate local technical expertise, government needs to institute capacity building initiatives to train both males and females in the areas of construction, installation, operation and maintenance of solar PV projects, development of manufacturing capabilities of solar PV components and spare parts, training of critical mass of scientists, engineers, economists etc. for research and development. It is also important for the government to set up training centres in each county of the country where regular training programmes such as training of trainers, vocational training, short courses and workshops on solar PV technologies can be designed and implemented.
	Information & Awareness	- In order to remove the inadequate and limited information sharing barrier and also to promote solar products and services, it is important to provide all stakeholders, in particular rural households, with adequate and sufficient information on the potential of off-grid solar PV solutions. There is the need for the RREA and the MLME to improve and increase information, education and communication regarding the use of SHS products.
	Cultural, Social & Gender	- There is a need for government to establish numerous initiatives focused at training local staff especially women in the renewable energy sector. Women can be trained in sales, installation and maintenance of SHS in peri-urban and rural areas where the lack of qualified professionals is a barrier to the deployment of the technology.  - For a successful diffusion of solar home system technology in poor peri-urban and rural communities, there is a need to involve all stakeholders including potential beneficiaries, leaders or other influential members in the communities regarding the programme design, and implementation using a well-developed and targeted engagement plan to avoid conflict and generate support for the SHS project.

	Legal, Regulatory and Institutional framework	<p>- To overcome the barrier of weak legal, regulatory and institutional framework, the following measures needs to be implemented:</p> <ul style="list-style-type: none"> <li>• Establish an independent and transparent regulatory process;</li> <li>• Establish quality standards for all energy products and services;</li> <li>• Empower the Liberia Electricity Regulatory Commission (LERC) and the Bureau of Standards to monitor and enforce quality standards on all solar PV components and spare parts imported in to the country;</li> <li>• Empower the RREA to enforce safety standards, minimum technical standards for mini-grids, as well as licensing or certification procedures of SHS installers, and other professionals to ensure that firms active in the sector have the required technical skills and are insured;</li> <li>• Improve policy and regulatory framework to provide adequate incentives for investment by the private sector to accelerate the development of the off-grid solar market;</li> <li>• Establish the appropriate policy and legal framework that will allow solar PV technologies to grow and compete with the conventional energy sources;</li> <li>• Introduce relevant provisions in funding agreements, technical assistance programs and consultancy services contracts imposing contractors’ commitments and obligations to transfer skills and knowledge to local personnel.</li> </ul>
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### 1.3 Barrier analysis and possible enabling measures for Solar Mini-grids Technology

#### 1.3.1 General description of Solar PV Mini-grids

Solar PV mini-grids technology offers a promising solution to adequately meet the energy needs of many urban and rural poor communities far away from the national grid in Liberia. They have the potential to stimulate socio-economic development and better the living standards of the population of these deprived urban and rural communities. Solar mini-grids are designed to generate electricity centrally and distribute the same for various applications to households and small businesses spread within a particular area. According to the World Bank, “mini-grids are electric power generation and distribution systems that provide electricity to just a few customers in a remote settlement or bring power to hundreds of thousands of customers in a town or city” (ESMAP, 2019). Solar PV mini-grids consist of They consists of (i) solar PV array for generating electricity, (ii) a battery bank for storage of electricity (in some business models), (iii) power conditioning unit consisting of charge controllers, inverters, AC/DC distribution boards and necessary cabling and (iv) local low-tension power distribution network.

The PV energy system can be classified into three basics groups. These groups are: grid-connected system no storage facility, grid-connected system with storage facility (e.g., battery)



and, off-grid PV system (mainly with battery). In an isolated or remote area with no grid access, the off-grid PV system with storage facility may be the only viable way for the people of those areas to have access to electricity.

Mini-grids will contribute significantly to meeting the GOL ambitious plan set out in the Rural Energy Strategy and Master Plan of Liberia to increase rural electricity access to 35% by 2030 and electrify about 265,000 homes by providing energy to approximately 1.34 million people. Mini-grids have great potential for helping the country achieve Sustainable Development Goal 7 (SDG7) by 2030 in a cost-effective manner.

A small number of isolated solar PV mini-grid systems have been installed in some remote communities in Liberia as part of private initiatives, or internationally funded projects by bilateral and multi-lateral development partners. This technology is still in its early phases in Liberia and the RREA has identified a number of pilot projects to initiate the deployment of solar PV mini-grids systems.

### 1.3.2 Identification of barriers for the technology

The key barriers to the transfer and diffusion of solar PV mini-grids in Liberia have been identified through desk study and bilateral meetings with the experts by the consultant and stakeholders consultations during the workshop held on January 9, 2020 in Monrovia, Liberia by analysing causal relation using Logical Framework Approach (Problem and Objective Trees, in Annex I) and Market Map (Annex I) for the technology. These are discussed in sections 1.3.2.1 and 1.3.2.2. The key barriers to the diffusion of solar PV mini-grids are categorized under economic and financial and non-financial barriers.

#### 1.3.2.1 Economic and financial barriers

The key economic and financial barriers to the transfer and diffusion of Solar PV Mini-grids (SMG) in Liberia are shown in Table 1.6.

Table 1.6: Economic and financial barriers and their description for Solar PV Mini-grid System

Barrier Category	Barriers	Barrier Description
Economic & Financial	-High initial investment cost	The high initial up-front capital cost and the unwillingness of banks to fund such investment is the main economic barrier that hinders the widespread deployment of solar PV mini-grid systems in Liberia. All solar PV mini-grid components and spare parts are all imported into the country. According to the International Renewable Energy Agency, “installed solar PV mini-grid costs for systems below 40 kW, range from 6,000 to 13,000\$/kW” (IRENA, 2016). Simple pay back periods for solar PV mini-grids can be relatively long, between 3

		and 7 years, depending on the generation capacity and number of customers. These long payback periods make it hard for developers to mobilize commercial financing. Currently, most of the country's investments in mini-grids are donor-funded. Consequently, the limited private sector participation in the project development stage of solar PV mini-grid technology has an adverse effect on its long-term sustainability.
	- High interest rates	Interest rates in Liberia are highly volatile. Investment capital from commercial banks and financial institutions in the country is difficult to access and this is exacerbated by high interest rates of over 25%. The same prevailing high interest rate is offered to private sector investors wishing invest in rural electrification solar mini-grid projects.
	- Absence of subsidies	The absence of subsidies and financial incentives to foster the solar PV mini-grid technology to mature commercial status is another barrier to its successful diffusion in the country. The government provides economic incentives to encourage investment in energy from fossil fuel sources through tariff exemptions, subsidies, etc. Most of these incentives subsidies are not available to solar PV mini-grid projects and these are factors that play a significant role in impeding the diffusion of the technology in the country.
	- Limited access to finance and long term capital	Banks and other financial institutions are expected to play a crucial role in the diffusion and growth of renewable energy technology in the country. However, most commercial banks and other financial institutions are reluctant to finance solar mini-grid projects based on perceived high risk and a low rate of return compared to fossil fuel projects. Owing to the inability of investors to secure long tenor capital financing from commercial banks and other financial institutions, several promising solar PV mini-grid projects in parts of the country remote from the national grid have suffered setbacks.
	- Low ability and willingness to pay	The cost of electricity from utility-scale solar PV mini-grids is generally higher than the cost of national grids, particularly for customers in isolated rural communities. In these rural areas the consumers' ability and willingness to pay for the power becomes a major barrier for

		investors and operators of these mini-grids because the average purchasing power of the consumer is very low. Most rural areas in Liberia consist of very poor population with low ability and willingness to pay for the connection and operation fees. Default and delinquency rates tend to be quite high for rural poor with little disposal income for energy.
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### 1.3.2.2 Non-financial barriers

The following section provides the key non-financial and economic barriers to the transfer and diffusion Solar PV Mini-grid Systems in Liberia as shown in Table 1.7.

Table 1.7: Non-financial and economic barriers and their description for Solar PV Mini-grid System

Barrier Category		Barriers	Barrier Description
Non-financial and economic barriers	Technical	-Inadequate local technical expertise	There is inadequate local technical expertise to conduct technology and feasibility assessments, as well as to build, operate and manage solar mini-grids in the country. There is also the absence of local manufacturer of PV components and spare parts.
	Information & Awareness	- Inadequate and limited information sharing	The solar mini-grid technology is still in its infancy in Liberia. Low understanding of this technology by the public and media is not doing much in its promotion. Most people do not understand its capabilities and where it can be of benefit. This low level of awareness and information of solar mini-grid energy savings and associated environmental benefits amongst policymakers, potential investors, governmental agencies and prospective consumers is a major constraint to the successful dissemination, commercialization and adoption of the technology.
	Cultural, Social & Gender	-Absence of inclusive gender participation in SMG projects	There are limited initiatives that focus on training and supporting women and vulnerable people in renewable energy sector in the country. The absence of inclusive gender participation especially in the rural areas is a barrier to the deployment of the technology since women benefit more than men from the access to clean energy. Stakeholders also suggested the presence of certain local customs, practices and social norms as further obstacles to the deployment of SMG in the region.

	Legal, Regulatory and Institutional framework	- Inadequate legal, regulatory and institutional framework	The Liberian off-grid electricity market for solar PV systems has largely remained unregulated with unclear policy directions and weak implementation of existing policies and strategies. A portion of the RREA Act for the establishment of a Rural Energy Fund (REFUND) to provide low interest loans, loan guarantees, and grants as targeted subsidies to ensure energy access by the poor has not been capitalized and made operational. These gaps in regulations have led to limited technical and operational standards, codes and guidelines to measure the performance of operators or service providers; limited private sector investment; importation of low quality or fake solar PV systems and spare parts; and limited technical skills and capacity of local actors. Moreover, there are inadequate regulations to protect investment in isolated mini-grids if the main grid arrives.
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### 1.3.3 Identified measures

The identification of required measures to overcome key barriers that could prevent the transfer and diffusion Solar PV Mini-grid technology in the country has been done through a stakeholder consultation and the enabling measures thus identified in Table 1.8.

#### 1.3.3.1 Economic and financial measures

Table 1.8: Measures to overcome economic and financial barriers of Solar PV Mini-grid System

Barrier identified	Measures identified to overcome the barriers
Economic & Financial	<p>- To reduce the high investment cost for Solar PV Mini-grids, there is a need to provide secure access to financing from commercial banks to lower initial investment cost. The government needs to assist commercial banks secure access to financing that will enable them to offer longer tenors and lower interest rates on loans to overcome high upfront costs to both investors/developers and end users.</p> <p>- To lower the high interest rate on loans to solar PV mini-grid investors, it is recommended that the government offer financial support to lower interest rates. The government needs to shift incentives and subsidies on fossil fuels to renewable energy projects to accelerate growth and diffusion of RE technologies in Liberia, especially, solar PV mini-grids. For example, the</p>

	<p>removal of income tax on solar technologies or feed-in tariffs that guarantee a minimum price for electricity generated will be a good start. They are needed to close the affordability gaps and the higher cost involve in guaranteeing that the poorest and most remote areas are not left behind.</p>
	<p>- To address the barrier of the absence of subsidies and to accelerate the diffusion of SMG technology in rural and peri-urban areas of the country, the government need to provide good tax waivers and incentives to suppliers and households. Clearly defined subsidies and financial incentives schemes from the government, particularly for solar PV mini-grid investors and end users, will be needed to boost the deployment of this technology in poor urban and rural areas without access to modern energy.</p> <p>- It is further recommended that the RREA carry out a comprehensive impact assessment aimed at understanding the political, economic, social and environmental impact of the waiver of customs duties for quality-tested solar PV mini-grid systems.</p>
	<p>- In order to address the barrier of the limited access to finance and long term capital, it is recommended that the government should capitalized the REFUND and make it operational to provide long term financial support, capital subsidies, production-based subsidies to investors, suppliers, dealers and consumers of off-grid solar PV system targeted at remote areas and islands without access to electricity.</p> <p>- The government should be supported by international development partners and donors by offering concessionary loans or grants to extend solar PV mini-grids to isolated and remotes areas in the country.</p>
	<p>- To address the barrier of the low ability and willingness to pay, there is a need to provide capacity building that will help solar PV mini-grid installers and investors better assess the creditworthiness of their customers and incorporate it into financial models. This could also help solar electric companies determine where to focus their efforts The provision of duty exemptions for solar PV mini-grid equipment and accessories by the government can substantially lower the retail price and lead to improved affordability.</p>

### 1.3.3.2 Non financial measures

Table 1.9: Measures to overcome non-financial and economic barriers of Solar PV Mini-grid System

Identified Barriers' category		Measures identified to overcome the barriers
Non-financial and economic measures	Technical	- To overcome the barrier of inadequate local technical expertise, government needs to institute capacity building initiatives to train both males and females in the areas of construction, installation, operation and maintenance of solar PV projects, development of manufacturing capabilities of solar PV components and spare parts, training of critical mass of scientists, engineers, economists etc. for research and development. It is important for the government to set up training centers in each county of the country where regular training programs such as training of trainers, vocational training, short courses and workshops on solar PV technologies can be designed and implemented.
	Information & Awareness	- In order to address the inadequate and limited information sharing barrier, there is a need for government to disseminate adequate and sufficient information on the availability, advantages and opportunities of solar PV energy resources to the general public in order to raise public awareness and generate activities in the RE market. This initiative is crucial to building public trust and embracing solar PV mini-grid technologies in rural communities without access to modern electricity. Providing information to selected stakeholder groups such as private investors will help leverage the financial capital required to fund solar PV mini-grid projects.
	Cultural, Social & Gender	- To address the absence of inclusive gender participation in SMG projects in the country, there is a need for government to provide equal opportunity for women to work in the renewable energy sector. Moreover, special focus on gender inclusion to enhance the well-being of women and children is needed in the renewable energy sector. Women should be empowered to participate more actively in decision-making in the renewable energy sector and to contribute to areas such as operations and management of solar PV mini-grids installations, engineering, procurement and construction, maintenance and repair works.
	Legal, Regulatory and Institutional framework	- To overcome the barrier of weak legal, regulatory and institutional framework, the following measures needs to be implemented: <ul style="list-style-type: none"> <li>• The government need to strengthen the various regulatory agencies so that they can enforce compliance with respect to quality of solar mini-grid equipment and spare parts imported in to the country.</li> </ul>

		<ul style="list-style-type: none"> <li>• The government must also reform the policy, regulatory and institutional frameworks to enable a rapid expansion of the solar mini-grid technology market. This will involve the review of policy, legal, institutional, fiscal and regulatory instruments that would attract domestic and international investment to diffuse the technology in the country.</li> <li>• The RREA needs to be empowered to enforce safety standards, minimum technical standards for mini-grids, as well as licensing or certification procedures of solar PV mini-grid installers, and other professionals to ensure that firms active in the sector have the required technical skills and are insured;</li> <li>• The government need to develop a well-designed and effectively implemented public policies, programmes and projects to overcome this barrier;</li> <li>• The introduction of relevant provisions in funding agreements, technical assistance programs and consultancy services contracts that impose contractors' commitments and obligations to transfer skills and knowledge to local personnel.</li> </ul>
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## 1.4 Barrier analysis and possible enabling measures for Small Hydropower (SHP)

### Technology

#### 1.4.1 General description of Small Hydropower (SHP)

Small hydropower (SHP) is an appropriate technology for tackling the issues of energy security, access to clean energy and the mitigation of climate change simultaneously and in a sustainable way. SHP technology can make a significant contribution to meeting the electricity needs of urban and peri-urban areas as well as remote rural areas. By leveraging the abundant hydropower potential in Liberia, small hydropower mini-grids can provide for an economically viable, environmentally sustainable and climate-friendly power supply alternative to fossil fuel-based energy sources.

SHP uses the flow of water to turn turbines connected to a generator for the production of electricity. The amount of electricity power produced is proportional to the head drop and the water flow discharged on turbine. According to the Economic Community of West African States (ECOWAS) hydropower definition, hydropower can be divided into the following categories depending on its size (ECOWAS, 2012):

- Pico hydropower: From a few hundred watts to 5 kW
- Micro hydropower: From 5 kW to 100 kW
- Mini hydropower: From 100 kW to 1 MW
- Small hydropower: From 1 MW to 30 MW
- Medium hydropower: From 30 MW to 100 MW
- Large hydropower: Above 100 MW

Liberia has more than 2.3 GW of hydro potential identified under the RESMP study. The country hydro potential includes numerous potential small hydropower sites with indicative capacities of less than 10 MW. Twenty-four of these sites have an estimated combined total capacity of 86 MW. Across the country there are also hundreds of other sites with smaller hydropower capacities. Despite these potential, SHP below 10 MW remain unexploited for the production of electricity in the country.

### 1.4.2 Identification of barriers for the technology

The key barriers for small hydropower plant have been identified through desk study and bilateral meetings with the experts by the consultant and stakeholders consultations during workshop held on January 9, 2020 in Monrovia, Liberia by analysing causal relation using Logical Framework Approach (Problem and Objective Trees, at Annex I) for the technology. These were discussed in sections 1.4.2.1 and 1.4.2.2. The key barriers to the diffusion of small hydropower plants are categorized under economic and financial and non-financial barriers.

#### 1.4.2.1 Economic and financial barriers

Table 1.10: Economic and financial barriers and their description for Small Hydropower

Barrier Category	Barriers	Barrier Description
Economic & Financial	-High initial investment cost for SHP	Due to the absence of local manufacturing industries, all equipment for SHP plants is imported. The cost includes cost of generation at SHP plant, cost of transmission, and cost of distribution to the clients' meter. The target sites for SHP are remote areas usually with poor road network. This increases the operation and maintenance cost of the system due to the unavailability of spare parts in the local community.
	-Limited access to finance and long term capital	Commercial banks and other financial institutions do not provide loan facility to finance the construction of SHP plants. Local banks are reluctant to allow long maturity loans to private operators.
	-Low ability and willingness to pay	Most rural areas in Liberia consist of very poor population with low ability and willingness to pay for the connection and operation fees.



### 1.4.2.2 Non-financial barriers

The following section provides the key non-financial and economic barriers to transfer and diffusion Small Hydropower systems in Liberia as shown in Table 1.11.

Table 1.11: Non-financial and economic barriers and their description for Small Hydropower System

Barrier Category		Barriers	Barrier Description
Non-Financial and economic barriers	Technical	-Inadequate local technical expertise	Liberia still suffers from the effects of 14 years of civil war which devastated much of the country's institutions and infrastructure and displaced many people. Liberia is faced with severely depleted human and institutional capacity for designing, developing, operating and managing SHP plants. Particularly challenging is finding the local technical expertise to design, construct and maintain hydropower mini-grids. MLME, LEC and RREA have limited institutional and technical human resource capacities.
	Information & Awareness	- Inadequate and limited information sharing	SHP technology is still at an early stage of development in the country, although the technology is well established in other parts of the world. There are insufficient levels of awareness and information about the state of technological development, cost and effectiveness of technology among policymakers, potential investors, governmental agencies and prospective consumer.
		-Absence quality hydrological data	Resource data on water availability and flow are not detailed enough to help investors and project developers make informed decisions. Most of the available data on hydro resources were collected prior to the civil war. In some locations, changes in land use patterns have led to changes in stream flow patterns.
		- Low awareness of the technology	Low awareness of SHP technology possesses a great challenge for rural electrification. Promotion of technology and ideas with the stakeholder groups including policy makers is vital for successful introduction of a technology.
	Cultural, Social & Gender	-Absence of inclusive gender participation in SHP projects	Failing to conduct gender impact assessment does not ensure that gender equality is integrated into project design.

	Legal, Regulatory and Institutional framework	-Cheap and Substandard equipment	No existing legal or regulatory framework that may serve as rules for required standards regarding the transfer and diffusion of the technology. At the moment, there is no local commercial company manufacturing or supplying SHP equipment. Cheap, but often substandard equipment is mostly imported from China.
		- Inadequate legal, regulatory and institutional framework	The legal, regulatory and institutional framework is not yet adequate despite laws and rules have been drafted, but their ratification and application is still pending. There are gaps between existing legislation and actual implementation. This can lead to a negative perception by investors to consider the country as very high risk for investment and business.

### 1.4.3 Identified measures

#### 1.4.3.1 Economic and financial measures

Table 1.12: Measures to overcome economic and financial barriers of Small Hydropower System

Barrier identified	Measures identified to overcome the barriers
Economic & Financial	- To reduce the high investment cost for SHP and increase the diffusion of the technology in the country, the Government will have to eliminate taxes and duties on imports of SHP equipment. In addition, in order to reduce the high initial costs due to a poor road network to the sites, the government would need to provide a decent road network to ensure ease of access to equipment and spare parts.
	- All of the SHP projects in Liberia have been funded either from development partners or central governments. To become less dependent on donors and public funding from central government, strategies must therefore be put in place on how to attract other sources of financing such as from the private financial institutions and commercial banks. The GoL will have to support the development partners in accessing bilateral and multilateral donor funding and other dedicated funding such as the Green Climate Fund and Adaptation Fund.
	- To overcome the low ability and willingness to pay for electricity, an affordable tariff structure based on customers' ability and wiliness to pay is recommended. This will allow poorer consumers to benefit from targeted subsidized tariffs, including life-line rates for the poorest.

### 1.4.3.2 Non-financial measures

Table 1.13: Measures to overcome non-financial and economic barriers of Small Hydropower System

Identified Barriers' category		Measures identified to overcome the barriers
Non-financial and economic measures	Technical	-To solve the problem of unavailability of local technical expertise, it is vital that government provide funds to strengthen existing training facilities such as universities and Technical and Vocational Education and Training (TVET) institutions so that they can train experts to manage the technology. MME, LEC and RREA need to build the capacity and expertise of their staff. Inclusion of women and girls in the training programmes for gender mainstreaming.
	Information & Awareness	<p>-Adequate levels of awareness and information about the state of the SHP technology, its cost and effectiveness play a major role in overcoming this barrier and diffusing the technology in the country. Adopting a technology is easier for users who know something about the technology. Therefore, it is very important to create awareness among policymakers, energy experts, potential investors and governmental agencies.</p> <p>- To overcome absence of quality hydrological data, the government must support renewable resource assessment and site reconnaissance, especially for small hydropower mini-grid development in the country. Information on the hydrological data will help investors and project developers make informed decisions.</p> <p>-To overcome the low awareness of SHP technology, it is important to create awareness of the technology through communication campaigns such as electronic, print and social media for all stakeholders. Investors, vendors and installers must be made of aware the technology and understand their benefits and drawbacks, to be able to promote and sell them to individuals and communities. These communication campaigns should benefit to both genders. Some of them should therefore be addressed specifically to women.</p>
	Cultural, Social & Gender	- To overcome the barrier of the absence of inclusive gender participation in SHP projects, gender-sensitive components must be design in projects. Women and vulnerable groups should be prioritized for project employment. Also the project should include gender-sensitive targets and indicators for monitoring and evaluation.

	Legal, Regulatory and Institutional framework	<p>-To overcome the problem of cheap and substandard equipment, special training programs should be organized for relevant staff of the Ministry of Commerce, the Bureau of Standards, Customs agency, the MLME Department of Energy and other relevant agencies of government on certification procedures, compliance monitoring, and enforcement of national standards and regulation for SHP equipment and spare parts.</p> <p>-To overcome the problem of inadequate legal, regulatory and institutional framework, the GOL need to provide and implement adequate legal, institutional and regulatory frameworks for small hydropower mini-grids deployment and operation.</p>
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### 1.5 Linkages of the barriers identified

Even though the nature of the technologies varies from one another, it is evident from a review of the various barriers faced by the three prioritized energy sector technologies that there are some common barriers associated with these technologies. All the technologies are market goods; solar home systems are consumer goods while solar mini-grid and small hydropower are capital goods. This section focuses on the linkages of the common barriers faced by the three prioritized technologies in the energy sector. Table 1.14 shows the linkages between the three technologies.

Table 1.14: Linkages of common barriers identified for three prioritized technologies in the energy sector

Common Barriers	SHS	SMG	SHP
<p><b><u>Economic and Financial</u></b></p> <ul style="list-style-type: none"> <li>• High initial capital or investment cost.</li> <li>• Absence of adequate subsidies and financial incentives.</li> <li>• Limited access to finance and long term capital.</li> <li>• Low ability and willingness to pay for technologies by end users.</li> <li>• High interest rate charge by banks and other financial institutions on loans for renewable energy projects.</li> </ul>	✓	✓	✓
<p><b><u>Weak legal, regulatory and institutional framework</u></b></p> <p>The absence of strong legal, regulatory and institutional framework have led to</p> <ul style="list-style-type: none"> <li>• limited technical and operational standards, codes and guidelines to measure the performance of operators or service providers;</li> <li>• limited private sector investment;</li> <li>• importation of low quality or fake solar PV systems and spare parts;</li> <li>and</li> </ul>	✓	✓	✓

<ul style="list-style-type: none"> <li>limited technical skills and capacity of local actors.</li> </ul>			
<b><u>Information and Awareness</u></b> <ul style="list-style-type: none"> <li>Inadequate and limited information sharing about the technologies among stakeholders at the local and national level</li> </ul>	✓	✓	✓
<b><u>Technical</u></b> <ul style="list-style-type: none"> <li>Inadequate trained local technical expertise to install, operate and maintain renewable energy projects.</li> </ul>	✓	✓	✓
<b><u>Cultural, Social and Gender</u></b> <ul style="list-style-type: none"> <li>Absence of inclusive gender participation in renewable energy projects.</li> <li>Absence of a well-developed and targeted engagement plan to engage with potential beneficiaries, leaders or other influential members in the targeted areas.</li> </ul>	✓	✓	✓

### 1.6 Enabling framework for overcoming the barriers in the Energy Sector

The enabling framework developed for the energy sector which seeks to provide key measures to address the critical common barriers for all the technologies is presented in Tables 1.15. The three technologies had common barriers.

Table 1.15: The enabling framework for the common barriers of energy sector technologies

Type	All Three Prioritized (SHS, SMG and SHP) Technologies had Common Barriers	Enabling Framework
Economic and Financial	High initial capital or investment cost	<p>-The government should support commercial banks and financial institution to establish renewable energy portfolios to fund renewable energy development</p> <p>-The government need to design strategies to reduce investment costs for renewable energy technologies' project developers and investors using direct subsidies, tax exemptions, feed-in tariff systems, green certificate schemes and the Clean Development Mechanisms (CDM)</p> <p>-Support public-private partnerships and grant-based funding to lower capital risk</p>
	Limited access to finance and long term capital	<p>-Stimulate public and private investment in the sector by making clear, both qualitatively and quantitatively, the linkages between renewable energy technologies, climate change mitigation and sustainable development.</p> <p>-Provide guarantees for low-cost, low-risk, long tenor financing through credit lines for renewable energy technologies projects linked to climate change mitigation and sustainable development</p> <p>-Capitalized the REFUND and make it operational to provide financial support, capital subsidies, production-</p>

		based subsidies to investors, suppliers, dealers and consumers
	Absence of adequate subsidies and financial incentives	-Develop appropriate subsidies, incentives and waiver of customs duties on equipment and spare parts for renewable energy technologies.  -Provide tax exemptions and tax holidays for private sector investment in renewable energy technologies
	Low ability and willingness to pay for technologies by end users	Develop financial models to take account of affordability and willingness to pay, supported by information, education and communication campaigns.
	High interest rate charge	Provide low interest rate loans
Weak legal, regulatory and institutional framework	Cheap and Substandard equipment	-Develop codes and standards and the institutional framework to enforce them.
	Inadequate legal, regulatory and institutional framework	-Develop certification procedures, and institutions, including test and measurement facilities  -Develop clear regulatory guidelines for renewable energy off-grid and mini-grid systems
Information and Awareness	Inadequate and limited information sharing about the technologies among stakeholders at the local and national level	-Intensify adequate information, public education and awareness campaigns through print, electronic and social media; seminars, workshops, conferences, etc.  -Increase local capacity and community engagement to strengthen positive socio-economic impact and increase awareness of the benefits of renewable energy among end users.
Technical	Inadequate trained local technical expertise to install, operate and maintain renewable energy projects	-Establish training and accreditation centers to train and accredit human resource for the renewable energy sector  -Set up scholarship program to incentivize the enrollment of women for gender mainstreaming
Cultural, Social and Gender	Absence of inclusive gender participation in renewable energy projects	-Provide incentives for women active participation in the management, development, operations, installations, engineering, procurement, construction, maintenance and repair works of renewable energy technologies
	Absence of a well-developed and targeted engagement plan to engage with potential beneficiaries, leaders or other influential members in the targeted areas	-Conduct intensive stakeholder consultations before and during preparation of renewable energy projects; and continue after projects are implemented.

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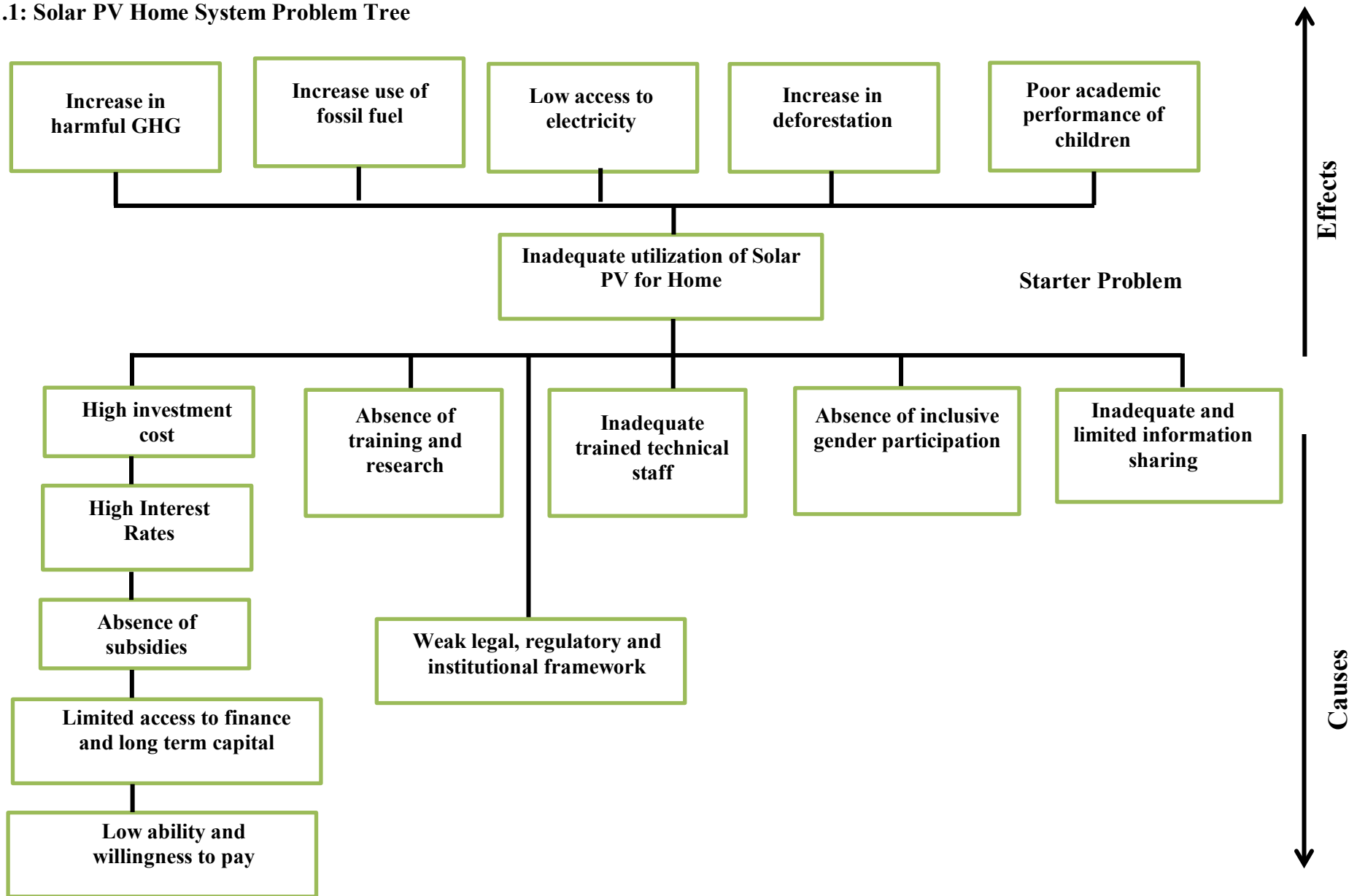
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**Annex I: Logical Problem Analysis (Problem and Solution trees) and Market maps for the three prioritized technologies in the energy sector**

**A1.1: Solar PV Home System Problem Tree**



**Figure 1.2 Problem tree for Solar PV Home System Technology**

A1.2: Solar PV Home System Solution Tree

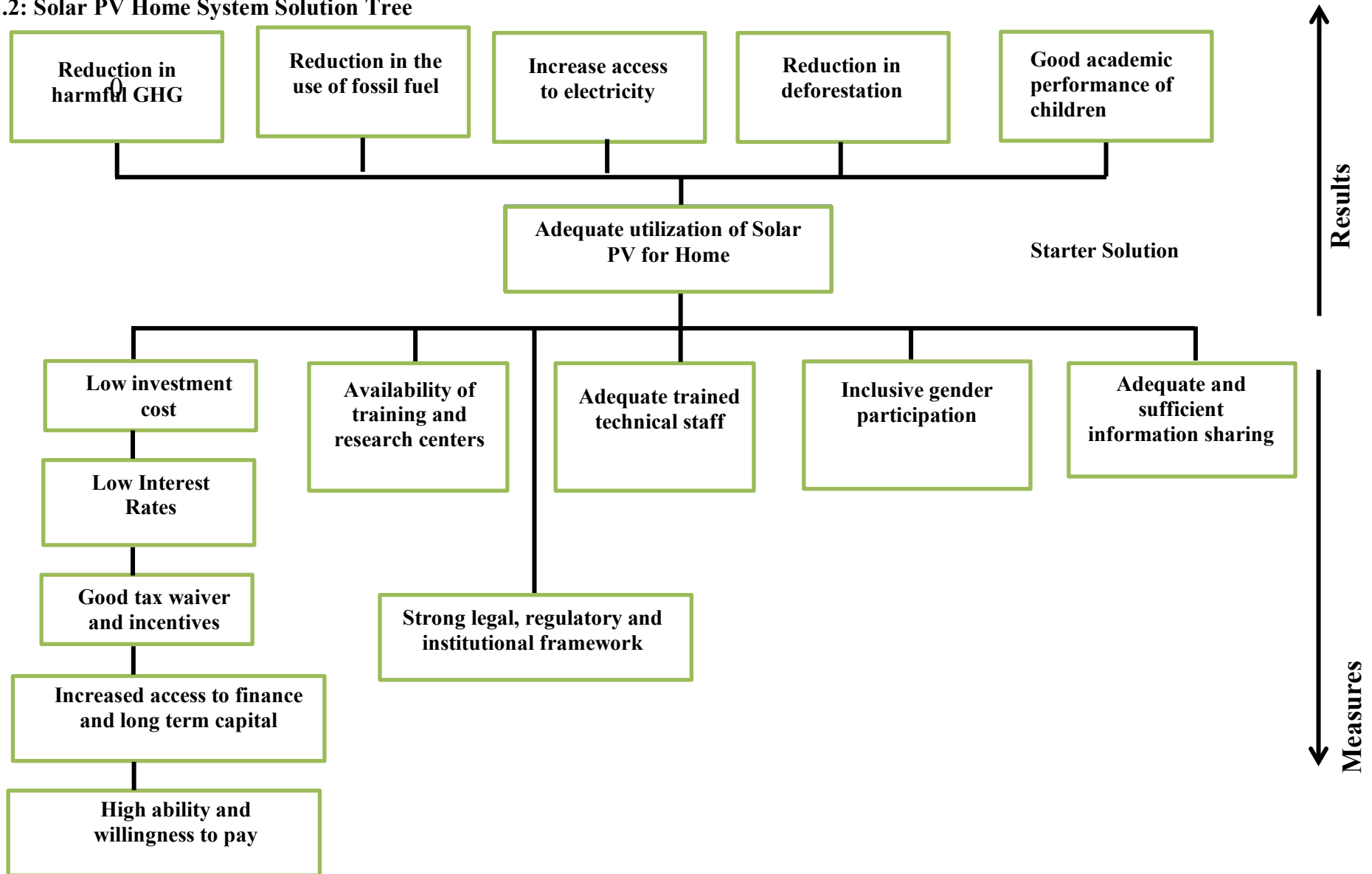
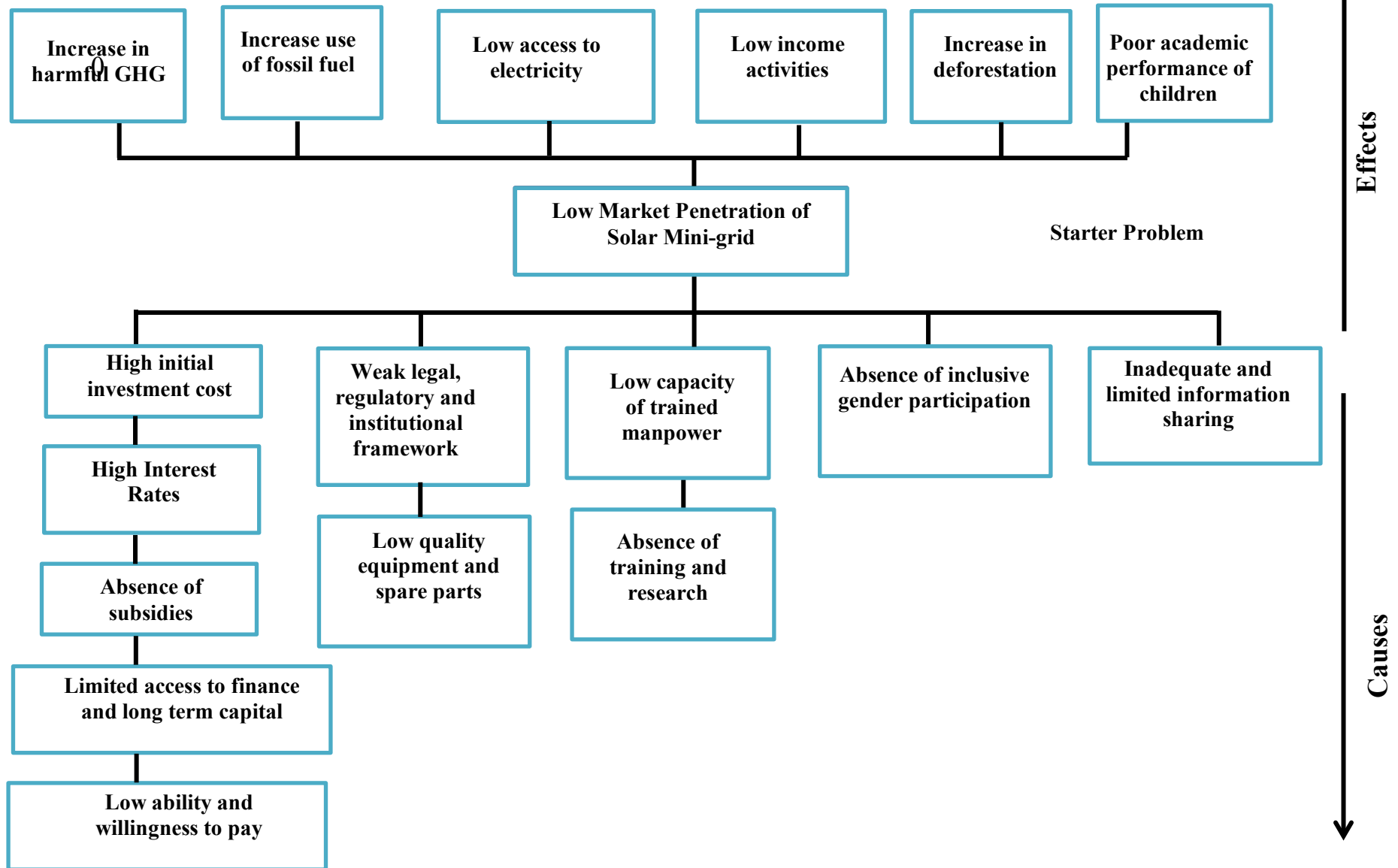


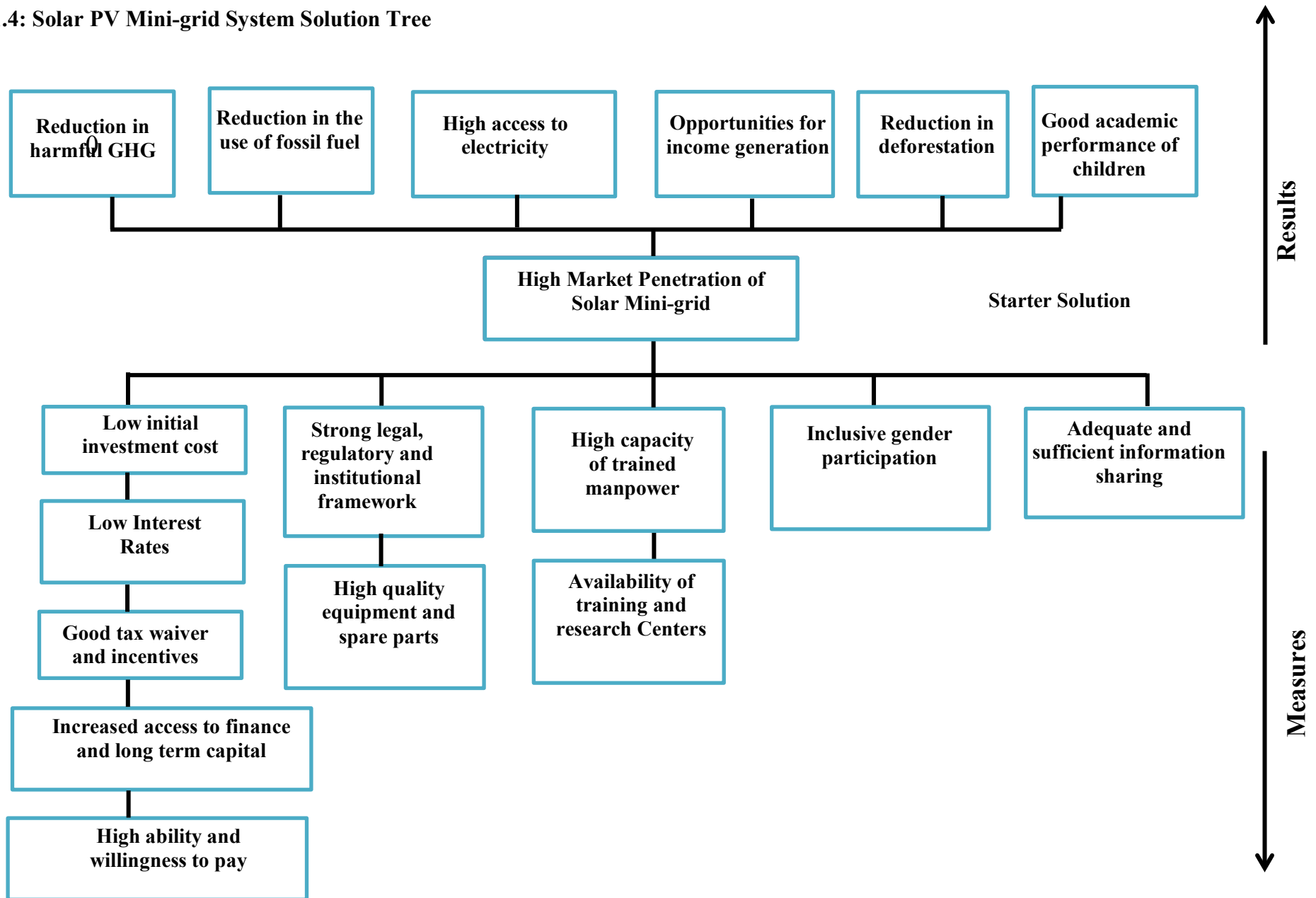
Figure 1.3 Solution tree for Solar PV Home System Technology

**A1.3: Solar PV Mini-grid System Problem Tree**



**Figure 1.4 Problem tree for Solar PV Mini-grid System Technology**

**A1.4: Solar PV Mini-grid System Solution Tree**



**Figure 1.5 Solution tree for Solar PV Mini-grid System Technology**

A1.5: Small Hydropower (SHP) plant Problem Tree

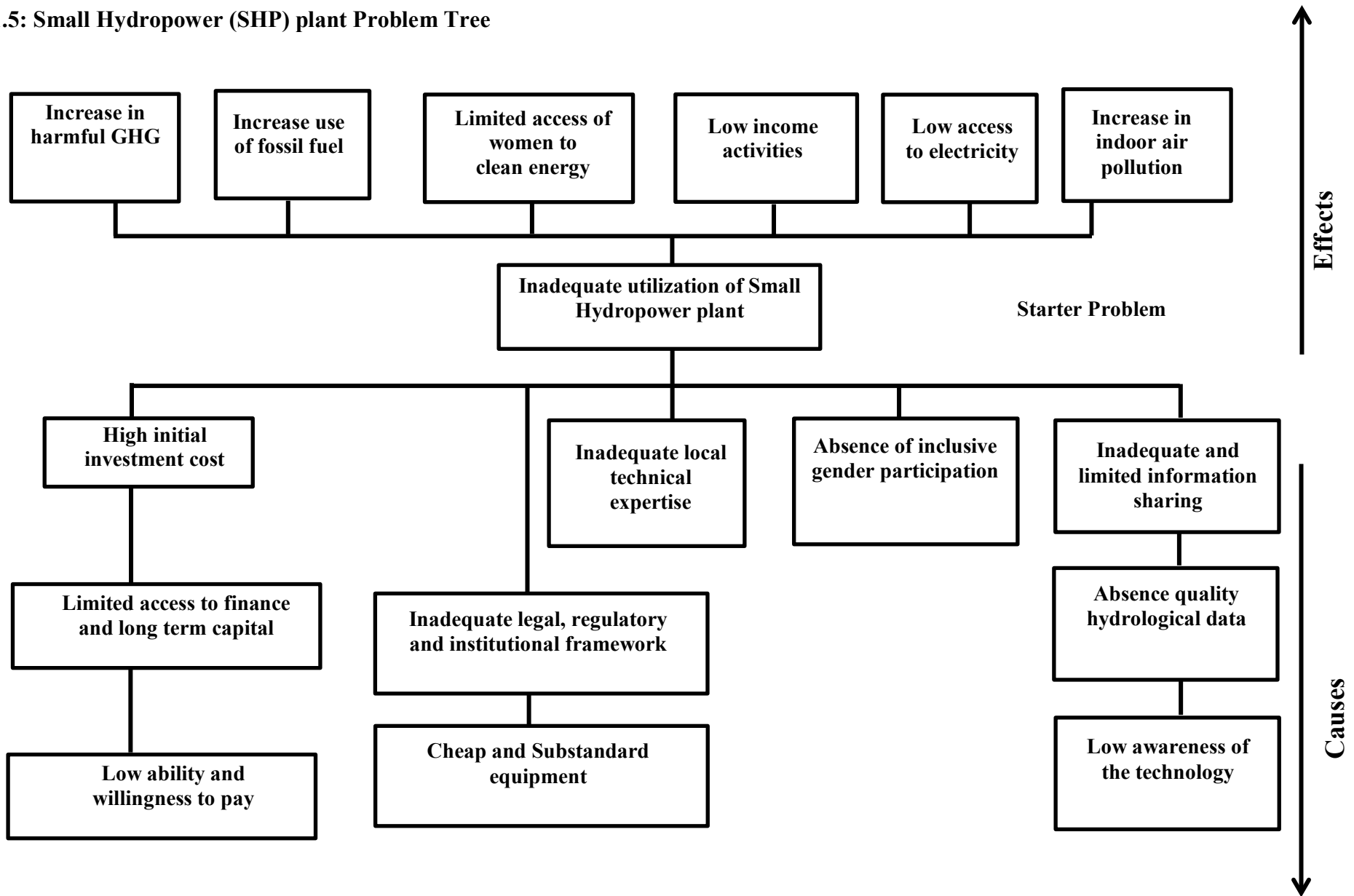
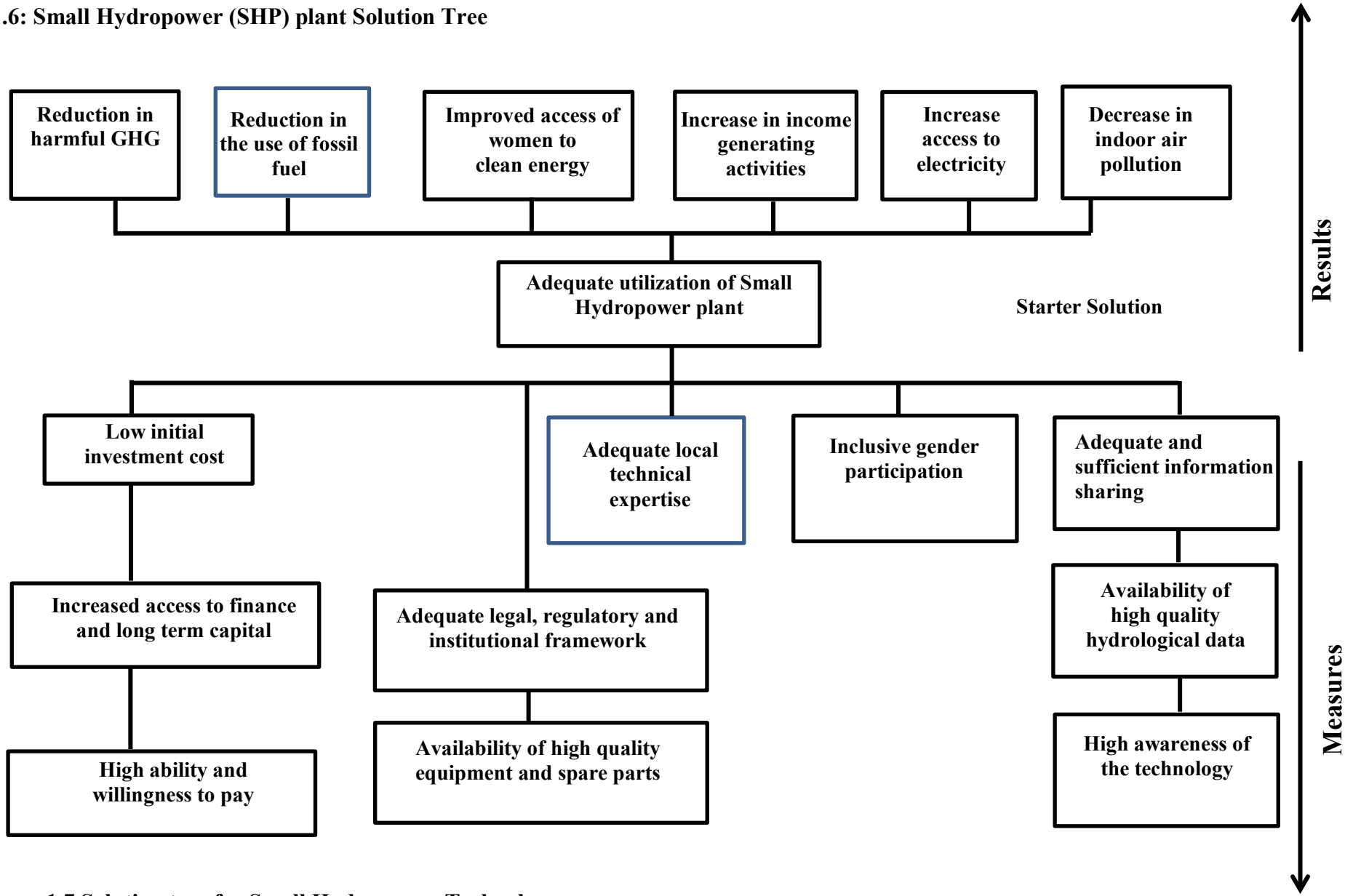


Figure 1.6 Problem tree for Small Hydropower Technology

**A1.6: Small Hydropower (SHP) plant Solution Tree**



**Figure 1.7 Solution tree for Small Hydropower Technology**

A 1.7: Market map for Solar PV Home System

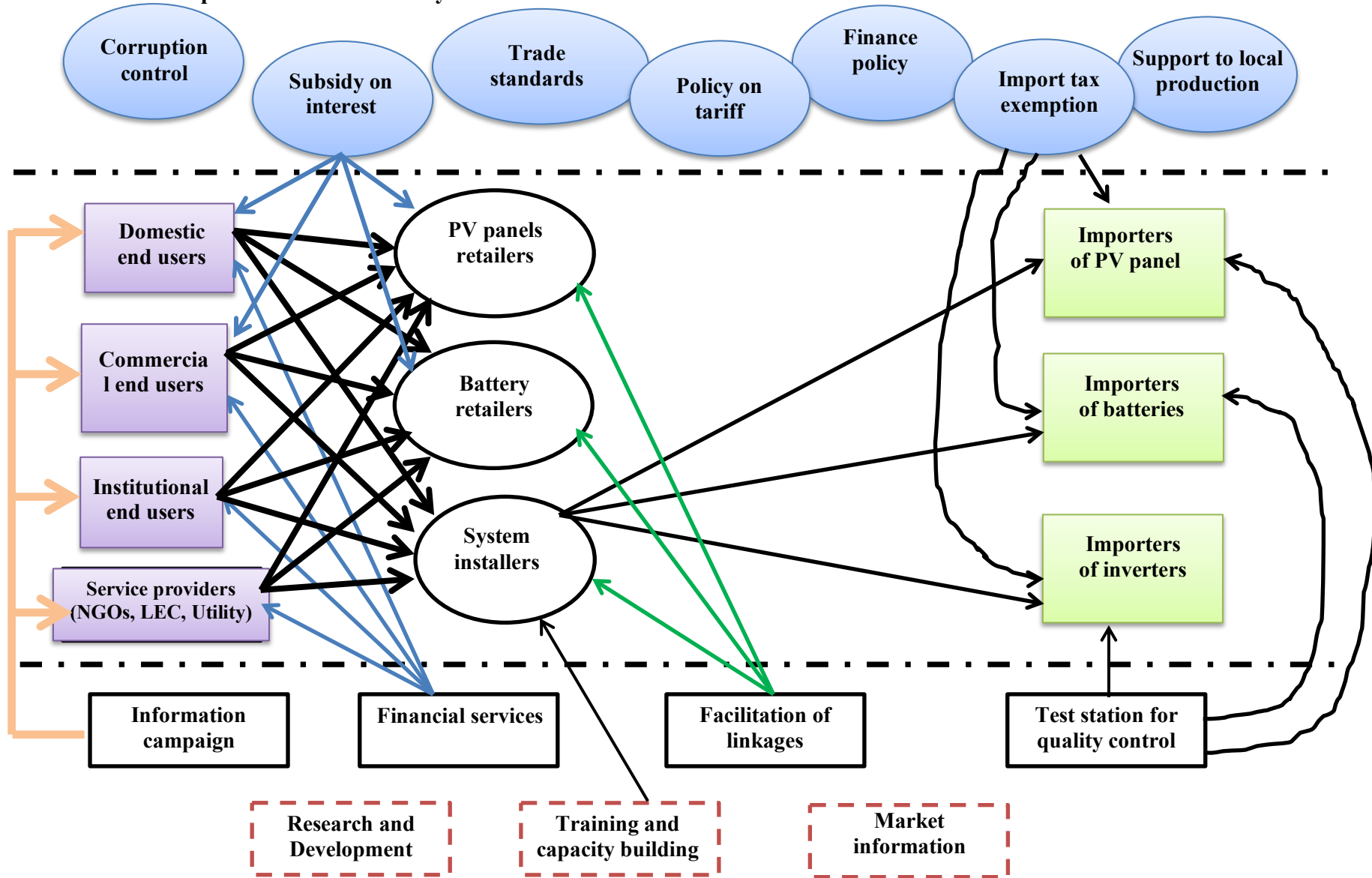


Figure 1.8 Market map for Solar Home System Technology



A 1.8: Market map for Solar PV Mini-grid System

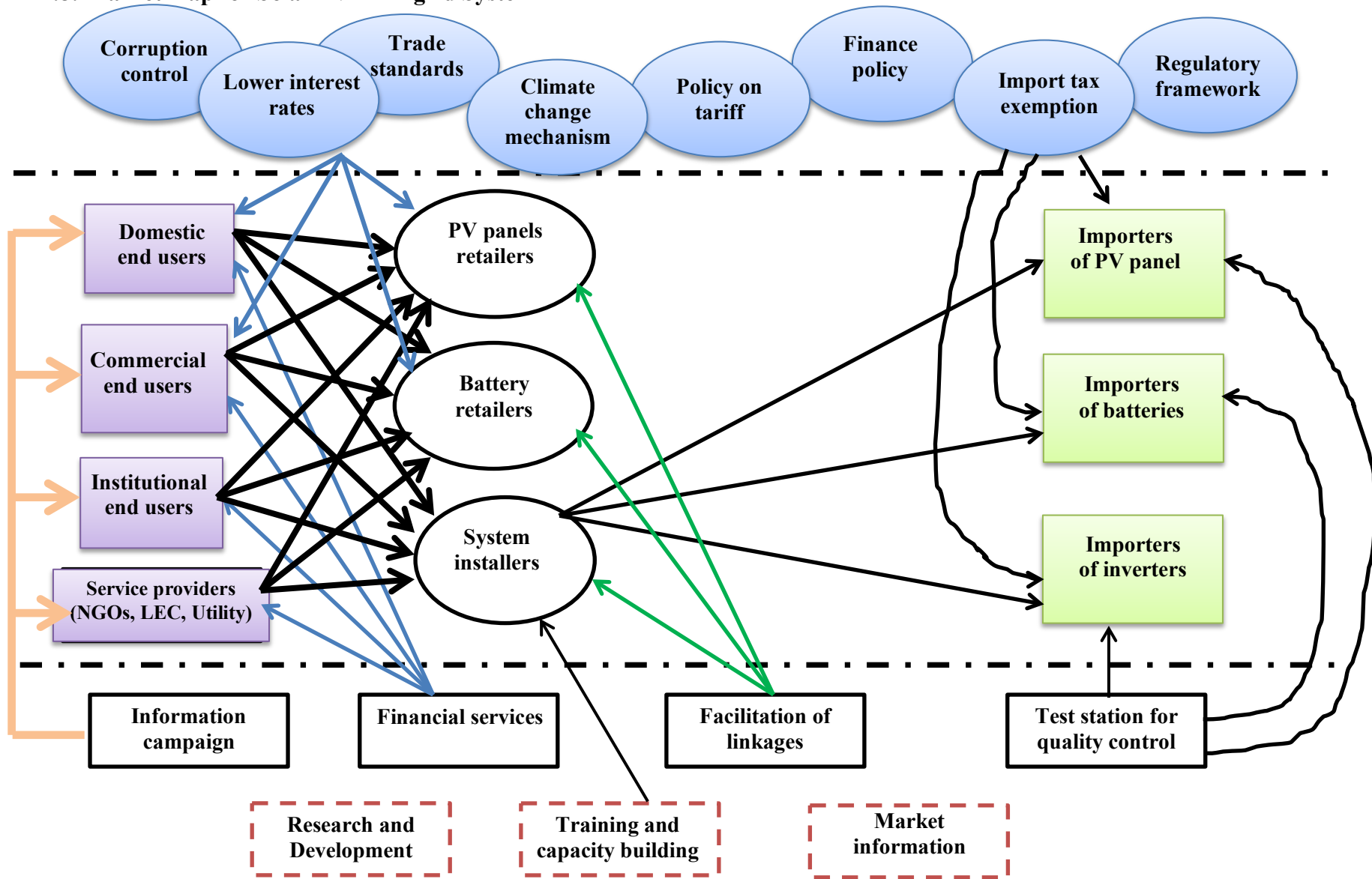


Figure 1.9 Market map for Solar Mini-grid System Technology

## Annex II: List of stakeholders involved and their contacts

Table 1.16: List of Stakeholders Involved and their Contacts (Energy Sector)

No	Name	Gender	Institution	Telephone #	Email Address
1	Ms. Nuwoe Kollie	F	WOCHIAD, Inc.	+231 775085252	wochiad@gmail.com
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4	Aaron Smallwood, Jr.	M	BUR-1/EPA	+231 970272417	aaronsmallwood25@yahoo.com
5	Andrew K. Macgona	M	Green Gold	+231 886539876	wacliberia@yahoo.com
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10	David L. Wiles	M	Rural Renewable Energy Agency of Liberia (RREA)		davidw@rrealiberia.org
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