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Solar Energy Development Association Ethiopia

Solar energy vision for Ethiopia

Opportunities for creating a photovoltaic industry in Ethiopia

by

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Summary

Solar electricity has clear advantages in accessibility, cost and reliability compared to traditional means of rural electrification. In the mid to long term solar electricity will also be competitive on the grid. The relative benefits of PV compared to the traditional alternatives are increasing because of rapidly declining costs, improving quality and reliability, and proven models of technology diffusion.

Ethiopia has a large population with a rapidly growing economy and very low level of electrification. Photovoltaic systems are cost-effective and reliable means to increase access not only to electricity but also to information and communication through mobile devices. PV is already an important source of power for the mobile network in Ethiopia – it will also be important for of energizing social institutions such as schools, clinics and water supply.

The large domestic market, increasing disposable incomes, and growing technical workforce should enable Ethiopia to develop a sustainable PV manufacturing and distribution industry. Its sizable domestic market should also enable it to position itself as the regional solar energy hub. It is estimated that a local manufacturing and service industry for PV systems can create 50,000 full time skilled jobs by 2020. This, however, requires conceptual transformation for the sector – the existing sector set up is inadequate to achieve this vision. Policy and regulatory issues must be resolved and sector development support must be adequately provided. Since new industries are constantly faced with new challenges the key is to have a strong institution to address them effectively as they appear.

Such an institution could be the rural electrification support unit within the Ministry of Water and Energy. This unit must be truly capable and empowered; flexible in its operations; and be able to work with industry actors. It should first work to improve the policy and regulatory environment, and then attract resources to provide adequate sector development support.

1. Introduction

Ethiopia has 84 million people in 18 million households (2012). The population is growing at 2.6% annually and projected to reach 103 million in 22 million households by 2020 (CSA, 2011). More than eighty percent of the population resides in rural areas. Two-thirds of the population is under 25 years of age, and a third of the population is between the ages of 15 and 35.

The country encompasses an area of 1.1 million square kilometers with sharply contrasting geography and climate. About two-thirds of the population lives in the highlands (higher than 1,500masl) which constitute about a third of the total landmass. The highlands are characterized by cool and wet or cool and semi/arid climate. A third of the population lives in the lowlands which are characterized by hot and humid or hot and arid climates.

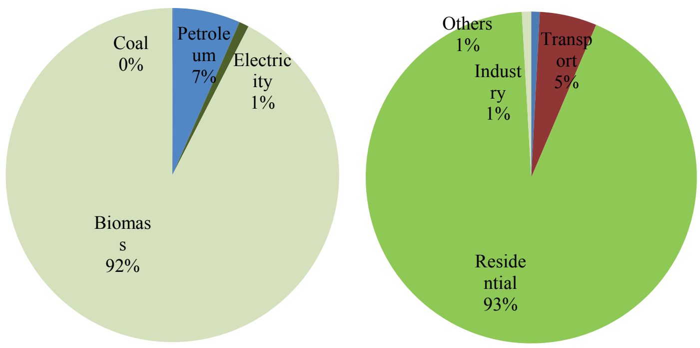
Agriculture is still the main economic activity in Ethiopia: it is responsible for 41% of the gross domestic production (GDP) and employs more than thirteen million households. Population densities are relatively high in the highlands where the main source of livelihood is mixed crop and livestock production. The lowlands are sparsely populated and rural inhabitants in these areas practice mainly pastoral (livestock) and agro-pastoral production.

The industry and services sectors contribute 13% and 46% to GDP respectively. Industrial output is derived mainly from construction and manufacturing. The services sector is dominated by small scale commercial distributive services. The economy has grown at an annual rate of 11% over the past five years and per-capita GDP now stands at US$400. The short term government plan projects 11% annual growth for the economy as a whole and 20% annual growth for the industry sector specifically.

1.1 The energy sector in Ethiopia

The latest national energy balance indicates that Ethiopia consumed 1.3EJ of energy in 2010. This was derived from biomass fuels (92%), hydrocarbons (7%), and electricity (1%). The main consumers of energy were the residential and service sector (93%) and transport (5%) with the remainder going for industrial and other applications. Rapid economic growth has increased the pace of energy demand growth in Ethiopia: 6% for biomass fuels, 11% for electricity, and 11% for petroleum products.

Figure 1.1 Energy supply, 2010.



Total energy supply = 1.3EJ.

Per-capita consumption: 960kg/year of biomass, 25kg/year of petroleum, and 40kWh/year of electricity.

Source: MWE, 2011.

1.2 Strategies relevant to the energy sector

The Ethiopian government has issued sectoral and cross-sectoral policies, strategies and plans to guide its actions. Some of these have been in place since the early 1990s while others have been very recent. The most important and recent of these include the Climate Resilient Green Economy Strategy (CRGE, 2011) the Growth and Transformation Plan (GTP, 2010), and Strategic Plan of the Ministry of Water and Energy (MWE, 2011).

The Climate Resilient Green Economy (CRGE) strategy integrates accelerated economic growth with climate resilience and GHG abatement. The four focal strategies are (a) improvement of agricultural production practices to enhance food security while reducing emissions, (b) protection of forests for economic and eco-system services and as carbon sinks, (c) expanding electricity generation from renewable sources of energy, and (d) leapfrogging to modern and energy-efficient technologies (CRGE, 2011b).

	Traditional growth path	Low carbon, green growth path
Energy	▪ Dependence on imported fossil fuels ▪ High GHG emissions ▪ Power shortages and restricted coverage	▪ Sufficient renewable energy resources to support economic development ▪ Exporter of clean energy regionally ▪ Expansion of rural energy coverage
Economy wide	▪ Dependent on commodities and international price fluctuations including oil price	▪ Macroeconomic conditions bring job and wealth creation, reduce poverty ▪ Increased exports, reduced imports

More than 70% of Ethiopians depend on fuel based lighting including fossil and solid biomass fuels (CSA, 2012b) and a relatively small segment of the population also uses fuel based electricity generators. This contributes to greenhouse gas emissions, air pollution, and local environmental degradation. The green growth strategy seeks to displace fossil and solid biomass fuel use for lighting and other applications by renewable sources of energy including hydro, wind and solar.

The Growth and Transformation Plan (GTP) is the short term national development plan for 2011-2015. The plan envisages rapid growth (11%/year) and increased role for industry in the economy (industrial growth of 20%/year). Development of infrastructure and in particular expansion of energy infrastructure features prominently in the plan where it accounts for 40% of the total investment allocated for the period (MOFED, 2010).

The energy plan in the GTP is heavily biased towards expanding the grid electricity infrastructure including building hydro and wind generation facilities and investment in transmission and distribution.

	Unit	Base - 2010	Target - 2015
Power			
Installed power	MW	2,000	8,000
Distribution lines	km	126,038	258,038
Transmission lines (66kV and above)	km	11,537	17,053
Customers	No. (million)	2.0	4.0
Telecom			
Mobile phone users	No. (million)	6.5	40.0
Mobile network access	%	< 50%	90%

The energy sector strategic plan (2011-2015) specifies the energy sector vision and goals for the period. The plan puts in detail the goals stated in the GTP; quantitative targets are provided for both grid and off grid electricity as well as for other energy applications. Solar electricity appears to be the principal choice for off-grid electrification according to the Strategic Plan where the target is to distribute more than 3 million solar home systems by 2015 (MWE, 2010b).

	Unit	Base - 2010	Target - 2015
Off-grid power			
Solar home and institutional systems	No. (million)	< 0.02	0.15
Solar lanterns	No. (million)	< 0.02	3.0
Other energy programs			
Solar thermal systems (cookers, heaters)	No.	NA	13,500
Liquid biofuel production	Liters (million)	7.0	1,630
Clean cook stoves	No. (million)	7.0	16.0

The strategies envisioned for accelerating the uptake of off-grid and alternative energy systems are (a) promoting greater participation of government and non-government actors and improving coordination for greater effectiveness, (b) developing the market for off-grid and alternative systems through public education, and (c) improving access to finance to suppliers and users, again to increase access to these systems.

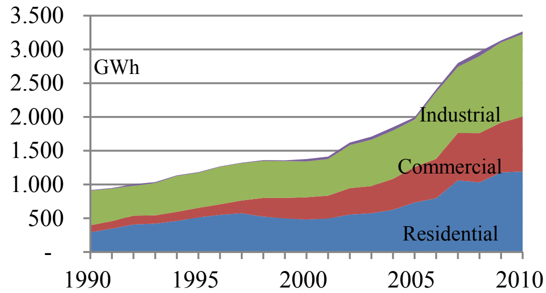
2. Electricity sector context

Electricity production and supply in Ethiopia is dominated by the state owned Ethiopian Electric Power Corporation (EEPCO). At the end of 2011 EEPCO had 1998MW installed capacity, and sold 3,845GWh of electricity to 1.9 million customers. The combined capability of power producers other than EEPCO, either in centralized off-grid systems such as diesel generators, or in user owned petroleum or renewable based generators, is believed to total less than 50MW, i.e., less than 3% of EEPCO's capability.

EEPCO's power generation capability is nearly entirely from large hydropower plants – in 2011, for example, 11 hydropower plants accounted for 99% of the electricity supplied by the company. Diversity of the power generation mix is very low currently but expected to improve in the near future mainly due to commissioning of new wind power plants (320MW of wind power coming online by 2013 and additional 500MW by 2015/16).

Electricity sales on the EEPCO system has shown marked growth in the past two decades: growth was less than 5% before 2001 but slightly above 10% after 2001. Residential demand on the system has grown at11% annually between 2001 and 2010. Note that the period of rapid growth after 2001 was also accompanied by frequent and substantial power black outs due to capability limitation – demand growth with non-constrained capability would have exceeded 20% during this period.

Figure 2.1 Electricity sales (EEPCO)

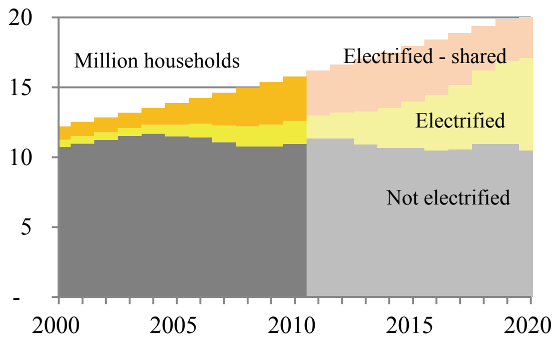


Source: EEPCO, Brief Statistics (several years)

The current five year plan for the power sector envisions increasing installed capacity four fold, doubling the transmission and distribution infrastructure, and doubling the total number of customers. Review of achievements in the past decade show mixed results: capacity additions have been realized rapidly, however new customer connections have slowed down after rapid connection rates between 2004 and 2010 (Figure 2.2).

EEPCO has 1.9 million customers, 1.65 million of which are residential customers (2011). Nearly twice as many residential customers or 3 million households share meters with EEPCO customers bringing the total number of households with connections to some 4 to 5 million or 25 to 30% of the population (Figure 2.2).

Figure 2.2 Electrification rate



Actual rate 2001-2011
Ambitious electrification projection 2012-2020
The ambitious rate assumes doubling of the customer number in 2010 by 2015 then again by 2020

The number of households is increasing by 2.6% annually or by 0.42 million households each year. This is in contrast to EEPCO's highest annual residential connection rate achieved in the past decade, 0.23 million, which is only about half of the growth in number of households. This means the population not getting connected by EEPCO is increasing in absolute terms and only slightly declining in terms of percent connected.

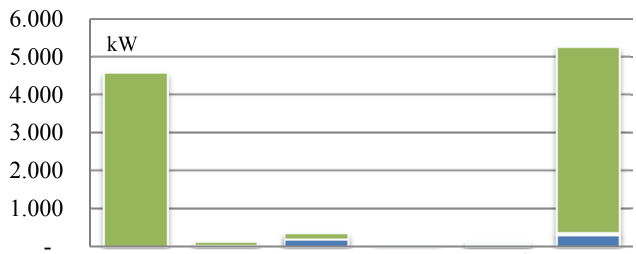
More than eighty percent of the population still lives in rural areas and this continues to be a challenge to increasing access to electricity from the grid. The current short term plan (the GTP) envisages doubling the number of residential customers by 2015; however, this goal appears to be slipping – customer connection rates have slowed down in the past two years (for example, there were fewer than 100,000 new residential connections in 2011). However, even with full realization of the GTP goal and similarly very rapid connections in the succeeding five years, fifty percent of the population or ten million households, may still not be connected to EEPCO supplies (Figure 2.2).

2.1 Solar electricity applications

The first PV systems were installed in Ethiopia in the mid 1980s - these systems were installed for rural home lighting and for school lighting. The largest of these was a 10.5kWp system installed in 1985 in Central Ethiopia which served 300 rural households through a micro grid in the village. This system was later upgraded to 30kWp in 1989 to provide power for the village water pump and grain mill.

It is estimated that a total of some 5.3MWp of PV is now in use in Ethiopia. The main area of application for PV is now off-grid telecom systems (particularly for mobile and landline network stations) which account for 87% of total installations. PV systems are also used in social institutions including health stations, schools and for water pumping. Some thirty thousand residential customers are also electrified with PV in rural areas.

Figure 2.3 PV capacity, kW, 2011



	Telecom	School	Health	Water	Home & business	Total
Public	4.600	101	170		40	4.911
Private					48	48
NGOs		28	191	30	56	305

Source: ERG.

Telecom application of PV, particularly for mobile network supply, is increasing rapidly and accounts for 87% of the total PV capacity installed in Ethiopia. Application in this sector is expected to increase rapidly due to the near universal access to the mobile network planned by the government by 2015. It is to be noted that the great leap in rural connectivity is due to PV powered mobile stations and PV powered wireless phone stations.

2.2 PV sector actors and activities

PV installations in the early days were mainly project based government and NGO action and systems were provided as grant to users. Project based installations are still important, particularly for institutional systems (schools, health centers, and water pumps). However, both government and NGOs now realize that only market based interventions will enable wider dissemination and also sustainability; they now combine project (grant) based actions with market mechanisms and focus on market and capacity development.

PV market and actors in Ethiopia can be broadly divided into three: (a) Telecom, (b) government and NGOs, and (c) private driven. The Telecom market is by far the largest; systems and services are provided mostly by foreign telecom contractors. PV systems for other government and NGO projects are provided by external and local PV companies; local private company roles have been limited to installation in the larger projects. The local private sector is involved in PV system supply to government and NGO projects and more recently also promoting off-grid systems.

About fifteen private companies distribute (import, install and service) PV systems in Ethiopia. Five of these companies account for more than eighty percent of the systems supplied or installed (excluding Telecom systems). The role of private companies had been limited to product supply and service to government and NGO projects prior to 2000. Although government and NGO contracts are still important to their business, private companies are now more active in promoting PV in rural areas particularly for home use.

The Ethiopian PV market is still government and NGO driven and less than 5% of the system provided goes through purely market means. Private companies have therefore been suppliers of systems and services to such projects rather than addressing the market directly. The PV market is very small in Ethiopia (particularly so when the telecom market is excluded) and this does not promote specialization and market links which in turn increases transaction costs.

Table 2.1 Major actors and activities in the PV sector, 2011

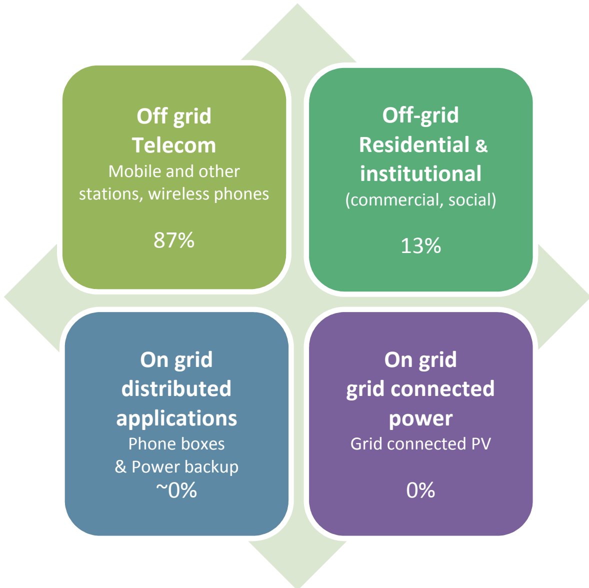
Project	Size (kWp)	Description	Application
Ethio Telecom	4,600	Up to 15kW per mobile station	Increased rural connectivity, access to information,
Rural Electrification Fund (REF) – Solar Home Systems	40	1,111 Solar Home Systems installed	Provide lighting service for 1,111 off-grid rural households, better lighting improved education, access to communication through radio/TV, reduced indoor air pollution due to kerosene lamps
REF – Institutional PV-1	124	345 Institutional solar PV systems installed	345 off-grid rural health posts electrified with solar PV system, improved health services
REF – Institutional PV-1	92	300 Institutional solar PV systems installed	200 rural health posts and 100 rural schools in off-grid areas electrified with solar PV system, improved health and education services
REF – Institutional PV-2	55	270 Institutions solar PV systems installed	270 rural schools in off-grid areas got access to electricity using solar PV systems
REF Solar Home Systems - 2	1,250	25,000 Solar Home Systems; size ranges 20Wp to 130Wp	
GIZ Energy Coordinating Office (ECO)-1	155	100 Institutional systems installed; 1.4kWp to 1.7kWp	100 rural health clinics in off-grid area are electrified with solar PV system. Provide better health service for 24 hours a day.
GIZ-ECO-2	8	5 community battery charging systems; 1.53kWp each	Increased access to electricity through solar PV systems. Replaced kerosene lamps, improved education, reduced indoor air pollution
Solar Energy Foundation (SEF)		Solar home, community and institutional systems	11,012 Solar lanterns; SHS 8,872 for households, small enterprises, schools, clinics, churches, mosques, community houses etc. 5.5kWp water pump for Rema community 6kWp water disinfection system in Rema 7 x 80Wp solar street light systems in Rema 2kWp for Solar Training School in Rema 9kWp Solar system for Solar Valley Addis (Int. Solar Energy Institute)
Plan International Ethiopia - EU grant for energy access	85	Institutional PV and Community system	15 rural schools, 12 health posts and 13 solar pumps in off-grid rural areas were installed. Improved education, evening classes, improved access to potable water, improved health services to rural communities.
Menschen für Menschen (MfM)		Solar home and institutional systems	1,314 x 10Wp Solar systems and 144 x 20Wp systems for rural schools 29 health posts with 260Wp solar system for medicine cooling and light

Source: ERG.

3. Demand for solar electricity

The outlook for the solar electricity sector in Ethiopia is for rapid increase in installation for off-grid applications and later for grid connected applications. Off-grid applications will be dominant in the short term but grid connected PV may become important in the medium and long term. Short term plans that have direct relevance for the PV sector include plans to disseminate more than 3 million PV home systems and plans to increase mobile ownership to 40 million.

Off-grid telecom applications now account for 87% of the total installed PV capacity in Ethiopia. Strong growth is foreseen in the coming ten years for this segment due to the drive for universal access to mobile connectivity (the plan is for 90% mobile network coverage and for 40million mobile users by 2015). This will result in doubling of installed PV capacity by 2015 then again doubling by 2020. This will be public sector driven demand and is highly likely to be realized.



Off-grid residential applications will be an important segment of the demand for PV in the medium to long term. The demand for this segment of the market will be mainly private sector driven and will depend on policies and regulations in place. Existing government plans for 3 million solar lanterns and home systems is expected to spur rapid growth increasing installed capacity by ten fold in the next five years. Off-grid institutional applications will also be important in the short term.

Grid connected PV is likely to be a major market in Ethiopia in the long term. Prices for PV systems are falling rapidly going to grid parity. PV is expected to become grid competitive in the developed world when installed cost of systems reaches the US$3/Wp mark which may be realized before 2015. PV will also be grid competitive in Ethiopia when installed cost reaches US$3/Wp, in which case solar electricity may be delivered at US$0.13/kWh.

3.1 Demand for PV for off-grid applications

Off grid PV applications include home and institutional lighting, mobile charging, running audio-visual equipment, refrigeration and diagnostic equipment in heath facilities, water pumping, and powering telecom stations. Off grid PV systems range in size from the smallest 1Wp solar lantern to a village micro grid serving several hundred households and institutions.

PV systems are ideal to address small levels of demand in rural areas for the following reasons:

- In the short to medium term it will be impossible to reach the scattered population through the grid and PV will be ideal for such markets.
- For a typical rural scattered settlement the unit cost of investment is lower for PV compared to grid extension or petroleum based alternatives. This investment gap is increasing due to declining demand levels because of the predominance of high efficiency (CFL and LED lighting) and low power (mobile charging) devices.[1]
- Investment on user connection is optimally sized (in contrast to a grid system where very similar levels investment is made irrespective of demand levels)

[1] For example, a household that traditionally used four 60W incandescent lamps totaling 240W now needs only four CFL or LED lamps totaling 48W. A village of fifty such households which would have required 12kW now requires only 2.5kW. This means it becomes even less economic to extend grids to such villages than in the past.

- Investment in system is wholly covered by private funds (in contrast to grid extension where the largest investment cost is covered by public funds)
- PV systems are very reliable – crystalline PV modules installed 20 years ago still provide practically the same level of output
- Demand for off-grid power (in small quantities) is increasing rapidly due to rapid access to the mobile phone network; access to the grid cannot grow as rapidly. The number of mobile users will overtake the number of households connected to the electrical grid in 2015! The GTP, for instance, projects increasing grid connected customers to 2 million households (10 million people) while the plan for mobile ownership is 41 million (in more than ten million households).
- Distribution and service of PV systems will create local jobs and incomes (in contrast to grid distribution where jobs and incomes are centralized)

Off-grid systems may be categorized into three segments: home systems, institutional systems (for individual institutions, for water pumping or for telecom stations), and village micro grids. Unit costs decline as system size increases, i.e. cost per unit of energy produced (Birr/kWh) is higher for small home systems compared to large institutional systems and village micro grids (usually due to higher per unit costs for Balance of System (BOS) components in smaller systems).

a. Residential systems

Home systems can vary in size from a 1W lantern to 100W or larger systems providing power for lighting, audio-visual and ICT equipment, refrigeration, and other applications. PV home systems are the least cost and often the only option of electrification of scattered rural settlements. At least two-thirds of the rural population or more than forty million people in eight million households live in such settlements. Connection of such very low density areas to the power grid will be too costly – it will require installation of hundreds of meters of distribution line for each household to address very low demands.[2]

There are about ten million off grid households at present and there would still be ten million off-grid households in 2020 (see Figure 2.2). The technical potential for PV home systems is therefore ten million households in 2020. Addressing just half of the off-grid population with middle to highest expenditure quintile will create a market for 3 million solar home systems. The total demand from these households will be 60MW.

Table 3.1 Electricity expenses: baseline vs. solar home systems, rural areas, 2011

	Expenditure rural $/hh/y	Energy expense share (2005)	Energy expense ($/y)	Lighting expense **est**. ($/y)	Lighting & charging cost **est**. ($/y)	Solar system buyable with 2-year electricity expense
Lowest 20%	861	5.1%	44	12	12	PV lantern
Second 20%	934	5.0%	47	12	24	PV lantern with mobile charger
Middle 20%	1,030	4.7%	48	18	30	10W SHS
Fourth 20%	1,169	3.9%	46	18	42	20W SHS
Highest 20%	1,874	2.3%	43	>24	>48	Systems larger than 20W

Note that despite significant variation in total expenditure levels by income quintile energy expenditure in absolute amounts (Birr or $ spent) is practically the same for all income groups. Energy expenses include cash outlays and imputed costs (for example, for freely collected fuels). Lighting fuel expenses are estimated to account for a quarter (lower income levels) to half (higher income levels) of total energy expenses. Mobile charging costs are estimated to range from nil (lowest 20%) to $2/month (highest 20%).

Sources: Mean rural per-capita expenditure (MOFED, 2012) distributed by expenditure quintile using distributions in 2005 (CSA, 2007); energy expense share for 2005 (CSA, 2007).

Coverage, ownership and desirability – mobile phone vs. electricity

Mobile phone ownership has reached 24.7% of households in 2011 – 65.2% of households in urban areas and 12.8% of households in rural areas (CSA, 2012a). This is related to mobile network coverage of 12% in 2011 (MOFED, 2010). In contrast rural household electricity connection was only 4.8% in 2011 (CSA, 2012a). This leads to two important conclusions: (a) rural mobile ownership is

[2] Rural settlement densities are about 15 households/km^2 compared to 50 to 100 times more for a town or city.

going as fast as mobile network coverage, and (b) the majority of rural mobile phone owners are not connected to electricity.

Mobile phone owning households in rural areas had already reached 1.75 million in 2011. Rural mobile ownership can be expected to reach 45% (this is the planned mobile network coverage for 2015) or 6 .8 million households by 2015. Since the electrification rate is going much slowly than mobile phone network coverage more than two third of rural mobile phone owners (or more than 4 million households in 2015) would not be connected to electricity. This will create a large demand for off-grid power in rural areas which solar electricity is best suited to address.

The significant rural ownership of mobile phones also negates the notion that capacity to pay in rural areas is inadequate to cover costs of solar systems. The cheapest mobile phone costs Birr 400 (US$23) and owners must pay Birr 35/month (US$2/month) to cover minimum monthly call charges and mobile phone battery recharges. First year ownership and operating expenses thus run to Birr 820 (US$47). Mobile phones are usually purchased on cash basis without any formal financing (although owners may finance their purchases from loans from family and friends).

Solar home systems are highly valued although they may not be as desirable as mobile phones.[3]Home systems can provide the mobile charging requirement of a household in addition to replacing lighting fuel requirements – they, therefore, complement mobile phone ownership while substituting fuel based lighting. These two services are worth at least US$2/month for a mobile owning household. The yearly mobile charging and lighting fuel expense avoided (US$24) is sufficient to purchase the basic solar lantern with mobile charging capability.

b. *Institutional systems*

Universal access to basic services for health, primary education, water supply and communication is a key government goal. The number of service facilities has grown very rapidly over the past ten years and universal access is expected to be achieved by 2015. A large proportion of these facilities are situated in off-grid rural areas and quality of service suffers from lack of adequate power to run important applications (for example, refrigeration in a health post, and educational media in schools).

There is one or more social (health post, primary school, water pump) service centers in a Kebele – i.e. there are more than 40,000 such centers in off-grid rural areas. Each of these facilities requires 300W (lights and refrigeration for health posts, lights and audio-visual media for schools) to 1,000W (for water pumping). The total demand for universal electrification off-grid social institutions will be about 20MW. Universal access to the mobile network will require hundreds of new mobile stations each requiring 15kWp – total demand from 500 new stations will be about 7.5MW.

Rural businesses consist of food and drink houses, consumer product retailers, tailors, and open market stalls for food and other items. These businesses are usually located in the Kebele center. Rural businesses require electricity mainly for lighting, mobile charging and audio-visual equipment. A typical rural food/drink house will require several lights and power for a TV totaling 50W or more. The combined power requirement for providing power to just two such businesses in each of the ten thousand non-electrified rural Kebeles will be 1MW.

3.2 PV within the grid

PV prices are coming down fast, going to grid parity. The projection is that grid parity may be reached in developed countries when prices by 2020 (IEA, 2010; p. 3):

> *PV will achieve grid parity – i.e. competitiveness with electricity grid retail prices – by 2020 in many regions. As grid parity is achieved, the policy framework should evolve towards fostering self-sustained markets, with the progressive phase-out of economic incentives, but maintaining grid access guarantees and sustained R&D support.*

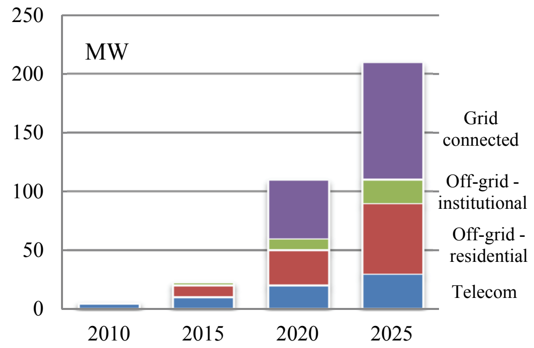
[3] Mobile phones may be more desirable for the household member who makes major purchase decisions in the household or the family in general – because they enable communication for security, social or business purposes and also because they are visible <u>personal</u> status symbols.

Present PV system prices are so low that they are becoming competitive with some thermal systems. Grid parity will come later in developing countries because of generally lower generation and transmission costs for the grid. However, cost of power generation on the grid is rising while PV prices are dropping closing the cost gap. This is opening up the market for grid connected PV and governments are now considering them as feasible alternatives.

> For example, the 265MW Aleltu West hydropower plant planned to be commissioned in 2019 will cost US$0.072/kWh (EAPP, 2011). Transmission and distribution will add US$0.04/kWh increasing delivered cost to US$0.12/kWh. In this case PV can reach grid parity if installed cost (including PV modules, inverter, other auxiliary equipment and service charges) declines to US$3/W[4] – which is very likely to happen in the coming five to ten years.

Local production of PV components may lower production costs; and expanding market for PV systems will lower costs of distribution and installation. These two together will reduce installed cost for PV and cut the length of time required for grid parity.

Figure 3.1 PV demand in Ethiopia



Source: ERG estimates based on potentials.

3.3 Regional demand

The immediate major markets for PV produced in Ethiopia would be South Sudan, Kenya, Uganda, and Tanzania. Regional off-grid markets would be high for mobile networks and home systems; in the long term PV may also be promoted on the grid.

Ethiopia will have the largest regional power market and also the largest PV market by 2020 compared to countries in the region. This favors Ethiopia to be the regional center for PV manufacturing. However, other countries in the region are already in the process of establishing PV manufacturing capability – for example, recently a German PV company (Centrosolar) opened the first PV module assembly plant in Kenya.[5]

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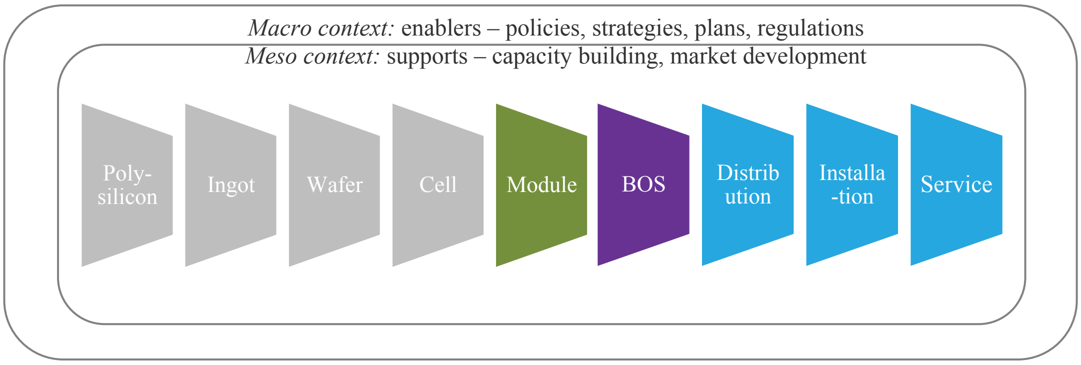
[4] 1Wp PV produces about 20kWh of electricity over 20 years: Present Value (5%, 20 years, 1.8kWh/y). Installed cost of US$3/W implies US$3/20kWh or US$0.13/kWh.

[5] Rivers State News, September 2011 (http://www.riversstatenews.com/first-solar-module-factory-in-east-africa-opens-near-nairobi/)

4. Value of a domestic photovoltaic industry

The PV value chain consists of manufacturers, distributors, installers and service providers of PV systems and associated components. Research and development and marketing are parts of each segment of the chain; R&D is particularly important in upstream activities while marketing is important in downstream activities. Upstream activities are large scale undertakings with international focus while downstream activities are small scale activities with local focus.

Figure 4.1 The PV value chain



Note that BOS (Balance of System) includes batteries, charge regulators, invertors and others.

Production scale, i.e., capacity by a single manufacturer, declines down stream as does the investment required per unit of watt produced ($/Wp) and the technical knowhow. The number of jobs created per unit of watt produced or distributed increases downstream. Generally, the barriers for entry are high for upstream activities (these are very few capital and knowledge intensive industries with very large capacities) whereas there are fewer barriers for entry into downstream industries (less capital and knowhow). These characteristics of the sector are illustrated in Table 4.1.

Table 4.1 PV industry investment, jobs, value added and barriers to entry

	CAPEX M$/MW	Jobs/MW	Value US$/Wp,	Production scale	Technical knowhow
Silicon	0.8-1.5		0.30-0.50		
Ingot, Wafer	0.7-1.0	3-4	0.10-0.30		
Cell	0.4-0.8		0.25-0.80		
Module	0.1-0.5	2-4	0.35-0.70		
Balance of System		1/50SHS	1.60-3.60		
Distribution, Installation, Service		1,000/MW			

Source: Morgan et.al. 2006 (CAPEX); Sovacool, et.al. 2011 (Jobs for BOS and distribution) Gunther, 2010 (value added)

Important conclusions from the above figure include (a) investment requirements are much lower for downstream industries starting from module manufacture; (b) value added is relatively high for downstream activities: for example, module assembly accounts for 28% of the module cost; and (c) the number of jobs created in downstream activities, particularly for distribution and service, can be quite high.

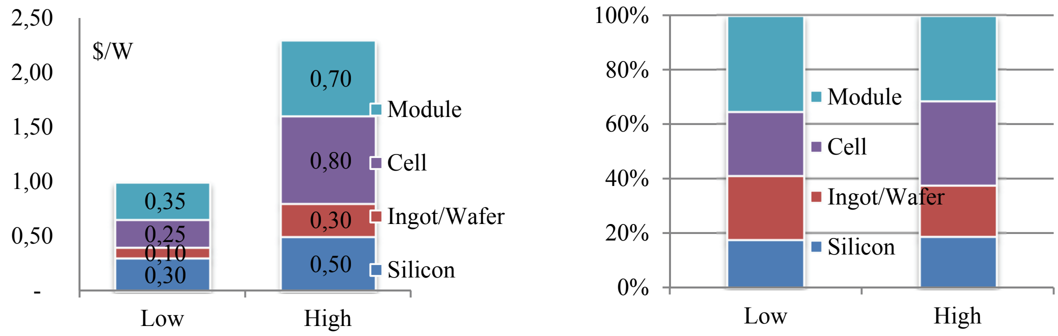
The PV industry has seen unprecedented changes in the past two years where prices have fallen by more than 50% for modules and prices for upstream outputs such as polysilicon has dropped by more than 70%. This shakeup of the industry has accentuated the advantages in downstream activities: downstream industries now account for a larger share of the total value added in the industry.

4.1 Assembly of PV modules and BOS components

The relative barriers to entry and the benefits in value added and employment in the PV value chain indicate that focus should be in the last three stages – PV module and BOS assembly, and distribution and service. PV module and BOS assembly account for about 50% of the total value added in the hardware and the hardware accounts for about 50% of the installed cost – i.e., module and BOS assembly contribute 25% of the total installed cost. Distribution and service account for 40% of the installed cost. This means about two-thirds of the total installed cost for PV systems can be locally supplied.

Local PV assembly will have significant benefits in value addition and employment – however, the extent to which this can be achieved depends on local capacity to deliver components other than the PV cell. Materials required for PV module manufacture, other than the PV cell, include glass, frame, ribbon, and adhesives. The share of the potential value added that can be made here will depend on which of these other components can be produced locally.[6]

Figure 4.2 Value in PV module manufacture



Assembly of BOS components will be the first step in the localization of the PV technology in Ethiopia. Local capability and experience exists for this – two companies have been assembling charge regulators; existing automotive battery manufacturers can also supply appropriate batteries for the PV industry. Starting assembly of charge regulators will be a good entry point into low-cost and medium-skill electronic assembly. Battery manufacturers will have a larger market than the automotive battery market (if the PV market develops to its full potential there will be twice as many solar systems as vehicles in ten years).

4.2 Characteristics of the domestic PV sector

The PV sector in Ethiopia is small and the main applications are for telecom stations and for off-grid lighting. PV modules and balance of system components are all imported. Both foreign and domestic companies are engaged in the distribution and service for PV systems (for example, PV systems for telecom stations are imported and installed by Chinese telecom companies).

Table 4.3 Domestic PV sector – market and present setup

		Market size MW, 2010	VA US$/W	Value MUS$, 2010	Companies No.	Jobs No.
Module	Import	1.0	2.0	2.0	10	30
Balance of System	Import	1.0	1.5	1.5		
Distribution, Installation, Service	Domestic, external	1.0	0.5	0.5	10-20	200

Source: ERG estimates.

[6] For example, glass constitutes 67% of the weight of the PV module, local production of glass would be a great advantage; but making PV grade glass may not be economically feasible here (because of scale).

The present setup of the sector is based on imports and significant role of foreign companies in installation. More value added and jobs will be created with larger market, local assembly of modules and BOS components, and extensive network of local distribution and service. An accelerated development of the sector could increase the value four-fold and employment by more than hundred times present levels within five years.

> The Bangladesh PV program which was initiated in 2003 has created employment in BOS assembly, system installation and service for 12,000 people for a cumulative installed system of about 0.6 million solar home systems or for a total installed capacity of about 10MWp by 2009 (Sovacool, 2011). This is equivalent to one full time job for every 50 households served.
>
> The plan to distribute three million solar home systems (including solar lanterns) and several thousand institutional systems will create employment for more than 50,000 people for installation and service. There would be additional employment effects through part time jobs in complementary industries and services including manufacture and distribution of lamps, batteries and PV module support structures.

Table 4.4 Domestic PV sector – accelerated market development and domestic industry

		Market size MW, 2020	VA US$/W	Value MUS$, 2020	Companies No.	Jobs No.
Module	Manufacture	10	0.5	5	1	50
Balance of System	Manufacture	10	0.5	5	10	1,500
Distribution, Installation, Service	Domestic (cumulative)	50MW 3M SHS	0.5	25		50,000

Source: ERG estimates for market size in the short term and value added from Table 4.1.

The strategy for developing the PV manufacturing sector in Ethiopia should focus on module and BOS assembly and on distribution because the knowhow and investment requirements for these operations are low while the employment and value added gains are high. There are no module assembly plants in Ethiopia but there is some experience for assembly of BOS components including batteries and charge regulators. Knowledge and skills required for BOS assembly and for distribution exist in Ethiopia; where there are shortcomings (quality, specific training) these can easily be addressed by private industry.

Local demand for modules in the short term (five years) will be under 10MW/y – one to three plants with total capacity to produce 10MW of PV will be adequate to address domestic demand in the short term.[7] Investment costs are lower for larger assembly plants – this means the general recommendation is to have few relatively large PV module assemblers than many smaller ones. PV module assembly is feasible through private or government companies (or associations between government and local or external private companies). Considering there is no local experience in module assembly partnership is recommended.

There would be several BOS component manufacturers. In Bangladesh, for example, all the main distributors of PV home systems also assemble charge regulators - there are ten or more BOS assemblers for a market of 5MW/y. Assembly of charge regulators and inverters will require only small electronic workshops which many local companies can easily set up and some have done so already.

Distribution and service will create the largest portion of the employment in the PV sector. The distribution network will span the whole country through a chain of private (or cooperative) enterprises extending from manufacturers and importers at the center to retailers and service providers at the Wereda and Kebele levels.

[7] A UNINDO study in 2010 also proposed 5MW/y module assembly capacity (UNIDO, 2010).

5. Strategies for a PV industry in Ethiopia

Ethiopia has a large off-grid rural power market, equivalent to the combined off-grid market of countries in East Africa. Ethiopia is singular in the opportunities to address its own as well as regional markets through renewable energy due to good renewable resources, rapidly growing incomes, its green economy strategy, and its growing educated and trained workforce. Solar electricity has the potential to address major development goals in rural areas in the health, education, and information sectors. The size of demand and growing manufacturing capability opens potential to create a domestic solar energy industry.

a) A large dispersed rural population: Eighty percent of the population or 65 million Ethiopians live in rural areas. Addressing demand for energy services for this population is a challenge; but it is also an opportunity to meet it through distributed renewable energy services including solar electricity.

b) The fastest growing, non oil-exporting, economy in Africa: Ethiopia grew at more than 8% annually for the past six years, twice as fast as the African average. This increases domestic financial and technical capability and opens opportunities to mobilize consumer, private and public resources.

c) One of the few green economy strategies in the world: Ethiopia has one of the few green economy strategies in the world and only the second in Africa. This creates opportunities to attract resources, domestic and external, for green programs in Ethiopia.

d) Rapidly growing educated and trained workforce. The pool of engineers and technicians has rapidly increased in Ethiopia over the past decade. This opens the opportunity to engage this workforce in the fast growing solar energy sector in research and development, manufacture and distribution.

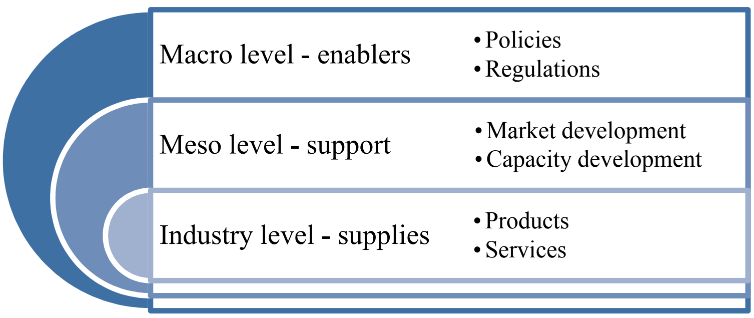
However, Ethiopia needs clearly articulated vision and strategy for renewables, addressing the entire value chain – from R&D to manufacture to services (not just state renewable energy production goals). It needs effective governance to realize the vision. There is also need to integrate this vision and strategy with the industry strategy.

There is obvious desire to make Ethiopia the regional renewable energy leader (stated in the sector Strategic Plan). But this desire is not backed by adequate industry (for renewables) level strategies and actions, sector institutions are also not effective. There is need for long-term outlook, specific strategies for renewables, implementation of plans without loosing focus of goals, learning from experience, incorporating flexibility where needed.

a. The institutional framework for success

The framework for sector development (to create a viable domestic industry) consists of government setting conducive environment for investment and market development, government and other development agencies providing sector development support, and the private sector providing products and services. A generalized context for the institutional frame is shown in the following figure.

Figure 5.1 Institutional frame for sustainable industry and market development



a) *Government provides conducive policies, strategies and regulations*. These include national development strategies such as the Climate Resilient Green Economy (CRGE) strategy; sectoral and cross-sectoral policies, and regulations that promote investment and market development such as tax exemptions for manufacturers and users.

b) *Government and NGOs provide sector development support*. Such support includes market development including information and financing for users, implementation capacity building for government and other development agencies, and technical and financial support to industry.

c) *The private sector invests in manufacturing and distribution to provide products and services*. Large and small companies invest in manufacture, assembly, installation and service to address the market. A sustainable supply chain for products and services is created.

A selection of case examples is provided below to illustrate how the institutional frame just described has been successfully applied to create vibrant renewable energy industries. As the case examples illustrate this general framework is implemented across countries differently with some functions being more important than others in developed and developing countries.[8]

b. Case examples of success

Germany has the largest installed renewable energy capacity and the largest renewable energy market in the world. It also has a large renewable energy industry employing more than 350,000 people. German companies are now industry leaders in many fields. The renewable energy sector in Germany took off after the Feed in Tariff of 1991 and the Renewable Energy Resources Act in 2000. The FiT and the Act were issued to promote energy security, climate sustainability, domestic industry, jobs and innovation.

Institutions and policies – The *Renewable Energy Sources Act,* 2000.

Regulations – subsidy policy based on feed-in tariff that was established in 1991. Renewable resource specific Feed in Tariff (FiT) has been the main instrument of promotion of renewables.[9]Ten years after the Act was issued more than 24GW of PV capacity was fed into the grid (EPIA, 2011) – this is 250 times the amount installed prior to the Act.

Industry – the renewable energy industry grew very rapidly providing R&D and innovation, manufacturing and distribution. Prior to the Act Germany was prominent in some renewable energy manufacturing (mainly wind); after the act Germany became the global leader in manufacturing and installation in wind, solar and biomass energy systems.

The **Chinese** renewable energy industry is the fastest growing in the world. Chinese industry is particularly strong in the solar sector. Chinese low cost manufacturing has been one of the drivers for the rapid decline in PV system prices. China has been leading the solar thermal market for some time; China became the largest PV cell producer in 2008. The Chinese PV industry is export oriented: in 2009, for example, China exported several times more than it installed domestically (REN21, 2009).

Institutions and policies – *National Renewable Energy Law*, 2005; *Medium and Long-Term Development Plan for Renewable Energy,* 2007.[10]

Regulations and programs – The Renewable Energy Law identified four schemes to expand the market and industry for renewables (REN21, 2009):

- Cost-sharing: in which additional cost for renewables is paid by the user through a surcharge
- Feed in Tariff: fixed additional amount is paid for renewable capacity on the grid
- Mandatory grid connection: grid operators are obliged to purchase renewable electricity
- National target: sets target of 10% renewables by 2010 and 15% renewables by 2020.

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[8]Sector development support is not required in developed countries because private industry can deliver services where policies and regulations are conducive. In contrast in developing countries sector development is often the most important area because of inadequate capabilities (market information, technical and financial capability) in government, industry, and the public.

[9] Feed in Tariffs obligate power providers on the grid to accept renewable energy generated at pre determined prices. They provide incentives to developers and manufacturers to invest in renewable energy; they also promote competitiveness because tariffs are periodically reviewed downwards.

[10] Also note that policies in Europe (particularly in Germany and Spain) have had significant impact on increasing manufacturing capacity for PV in China.

For rural areas China made significant government investment (US$ 293 million) to expand the market for renewables through its Township Electrification Program (2002-2004). This program increased the market for PV in rural China.

Another program, called the Golden Sun Demonstration Project, issued in 2009 aims to expand the market and manufacturing capability for PV through subsidies. The project subsidizes 50% of investment for solar power projects connected to grid and 70% of the investment for PV projects in off-grid areas. Other forms of regulation for renewables include standards and mandatory regulations such as for solar water heating in buildings.

Sector development support – China supports its domestic renewable energy industry through tax breaks, R&D and investment subsidies. These financial supports have been responsible for the localization of renewable energy technologies in China. The Chinese government also uses mandatory regulations that require minimum local value for renewable systems installed in China (for example, 70% of the product cost for wind power) which forces external developers to manufacture components in China (set up factories in China or go into Joint Ventures with Chinese companies).

Industry – The Chinese renewable industry has grown very rapidly to address domestic demand as well as the export market. Local financial incentives as well as policies in export markets have been responsible for rapid localization of renewable energy manufacturing in China.

Policy dialogue among stakeholders and effective implementation of policies was one of the challenges for the Chinese renewable energy sector. Establishment of an official renewable energy industry association was recommended to act on these challenges..

India is an important market for renewables and also a growing center of renewable energy system manufacture. An Indian company (Suzlon) is the fifth largest wind turbine supplier in the world. Some Indian companies are also prominent in the PV sector. India launched the National Solar Mission 2010 with the objective of making India a global leader in solar energy by creating policy conditions for the rapid diffusion of the technology in India as well as increase PV manufacture capability.

Institutions and policies – India has the world's only ministry dedicated to promoting renewable energy, the Ministry of New and Renewable Energy (MNRE established in 1992). Several institutes and agencies are administered under the MNRE including the Solar Energy Center, the Center for Wind Energy Technology, and the Indian Renewable Energy Development Agency (IREDA).

Policies are expressed in India through national plans (e.g., development plans and climate change actions). The Eleventh national plan 2007-2012, for instance, provides for 10% contribution by renewables by 2012. The National Action Plan for Climate Change (NAPCC, 2008) issued targets for renewable energy and announced eight missions including one for solar energy.

Regulations – India has issued several Plans, Acts and Missions to facilitate the uptake of renewable energy. These include (NREL, 2010):

- Electricity Act 2003, National Electricity Policy 2005, National Tariff Policy 2005 – allow for minimum energy purchases, preferential tariffs for renewable energy tariffs, renewable purchase obligations (RPO)
- Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) 2005 – provides subsidies amounting to 90% of capital equipment for systems installed in rural areas
- Jawaharlal Nehru National Solar Mission (JNNSM) 2010 – aims to increase domestic installation of PV systems through attractive tariffs.[11]The JNNSM projects addition of 1100MW of PV for grid and off-grid systems by 2013 and 10GW of grid tied and 2GW of off grid PV by 2022. The plan also envisions increasing PV module production to 5GW by 2022.

Sector development support – Support for the renewables sector in India consistent long term support in R&D for example, for biomass energy at the Indian Institute of Technology (where for example the gasification technology has been in development for more than twenty years. R&D work for some of

[11] Feed in tariffs for PV have been in place in India since 2002; however, these have been unsuccessful in increasing installation because tariffs were too low, i.e., US$0.3 /kWh.

the biomass technologies now commercialized by IIE and others in India were initiated in Ethiopia at about the same time as in India these were not consistently applied and as long as was required)

Industry – The Indian PV industry is an export industry. Indian PV manufacturing capacity exceeded 1000MW/y whereas the cumulative installed PV capacity was only 15.2MW in 2010 (NREL, 2010). The Indian government provides 20%-25% subsidies on investment to PV manufacturers through its Special Incentive Package Scheme (SIPS) since 2007.

Bangladesh is a low income country of 145 million people, 80% of whom live in rural areas. Bangladesh is a good example of developing a PV sector in off-grid areas in a low income country. The Bangladesh PV program started in 2003 installed 650,000 solar home systems serving more than 2 million people, and employed more than 12,000 people by 2009. The program aims to increase installation to 2.2 million solar home systems by 2012 (Sovacool and Drupady, 2009).

The Bangladesh PV market was the fourth largest in the world in 2008 (after Germany, Japan and Spain). But it turns out now to be the most sustainable because of the much less subsidy driven nature of the program than in Germany and Spain (where the PV market is stalling and manufacturers and developers are going out of business).

Institutions and policies – Infrastructure development support including for renewable energy is provided in Bangladesh by the Infrastructure Development Company (IDCOL). IDCOL is a government owned investment company established in 1997 and manages renewable energy programs in the solar, biogas and biomass areas.

Sector development support – The success of the Bangladesh PV program is attributed to the strong implementation capacity in IDCOL. IDCOL and its partners have deployed a viable technology diffusion model which provides user and supplier financing, builds the technical capacity of users and suppliers, and ensures quality or product and service.

Integration of supply of product and finance by a single company has put the burden of high quality service to users to the company thus ensuring the sustainable operation of systems as well as loan repayment. Another area where sector development has been useful was in setting up quality management system for PV products and services thus again ensuring sustainability.

Industry – the private companies and NGOs providing PV products and services have gradually increased their technical and financial capability to install and service systems through an extensive presence in most rural villages in Bangladesh.

The market for PV system components was dominated by imports (China and India) in the early years. However, local manufacturing and assembly is now taking an increasing share of the market particularly for BOS components. Five years after initiation of the program three of the companies had started assembly of charge regulators. At the end of 2011 there was one PV module assembly plant in operation (5MW/a) and three others, each with capacity to produce 5MW/a, were under construction.

Lessons from the case examples

The case examples illustrate that supportive policies are instrumental for the uptake of renewable energy systems; however, what is even more important is that effective regulations and sector development support are in place to achieve the policy goals. Policies and regulations must be applicable and must be enforced – regulations that are not applicable (for example, unattractive FiT rates for PV in India) or that are not enforced are worthless.

Regulations and sector development support open up the market and guide industry towards competitiveness. Regulations, in FiT, renewable purchase obligations and others, are the drivers for increasing the uptake of renewables on the grid. Sector development support through technical capacity building and financing for users and suppliers, and monitoring for quality of products and services is the main instrument for uptake of renewables for off-grid applications. Regulations and sector development support are reviewed periodically to adjust to changing circumstances.

Regulations that promote domestic market for renewables must also be accompanied by sector development support in countries where the domestic capacity for supply of products and services is not sufficient. Otherwise domestic market opening for renewables will more likely benefit suppliers in other countries (for example, incentives for renewable energy in Europe have been a major driver for growth in PV manufacturing in China).

Regulations must guide industries towards global competitiveness and not only provide domestic market for them (i.e. be protectionist). Since incentives (through regulations) cannot be sustained indefinitely, when incentives are removed uncompetitive industries will go bankrupt – this has been the case for PV companies in Europe which went bankrupt as soon as FiT's were reduced. Regulations must be transparent, easily applicable (i.e., without lengthy and costly procedures) and effectively enforced; they must also be periodically revised to deal with changing circumstances.

Strong sector development support is critical for rapid diffusion of renewable energy in off-grid areas; and a strong institution is required to deliver it. Such an institution will pool internal and external resources (including finance) and direct these for capacity development, financing and quality management. Rapid development of the rural off-grid market may require limited user subsidies in the initial stages which must be reduced over time. Standard setting and monitoring for products and services is critical for success.

It is not possible to have extensive impact through PV (in off-grid areas) without local presence in the areas served – the Bangladesh off-grid PV program is a good example of this. All the companies have extensive presence in the rural villages to provide technical and financial services. Ethiopian PV companies should also work to develop such a network – not necessarily have their own employees in rural areas but have a network of service providers attached to them.

The industry must be responsible to its customers. Quality standards and their effective enforcement is one means to achieve this; another means could be bundling of technical and financial services by suppliers to customers – thus making supplier gains directly related to the quality of products and services they provide. This strategy of bundling technical and financial services has been successfully applied in Bangladesh and in Ethiopia as well (by the Solar Energy Foundation).

Domestic market development and manufacturing incentives are required to develop the PV industry. Both domestic market development as well as incentives must be provided in countries with no or very low level of manufacturing capability (such as Bangladesh or Ethiopia). In developing countries with some manufacturing capability – external markets rather than domestic markets have been responsible for the rapid development of the renewable energy manufacturing sector (this is the case for China and India).

A significant portion of PV equipment can be locally manufactured with substantial employment and income gains. For example, an aggregate market of a million PV home systems (which is within the government's plan) will support several manufacturers for batteries, regulators and other components. In some cases the PV sector could be a driver rather than a mere addition to an existing industry – for batteries, for instance, a market for one million PV systems will be twice the size for automotive use.

c. Shortcomings in the PV sector in Ethiopia

Ethiopia has good policies and strategies for renewable energy. These include the national energy policy (1994), the Environment Policy (1997), the Climate Resilient Green Economy strategy (2011) and the current energy sector strategic plan. The key gaps appear to be in providing regulations and sector development support coherently and consistently.

The policy and regulatory environment

Policies in Ethiopia are generally supportive of renewables. Sector strategic plans also state vision for the sector that place renewables at the center. However, policies and visions have not been accompanied by instruments for their translation on the ground (effectively). Where such instruments (regulations) have been issued they have either not been easily applicable or effectively enforced.

a) Regulations are not sufficiently attractive to promote investment in manufacturing. This is the view of foreign investors exploring the feasibility of setting up PV module assembly plants in Ethiopia. They all cite legal and financial uncertainty for not investing in the sector.

b) Existing regulations do not favor domestic manufacturing. For example, duties are waived for certain PV product imports but a company that seeks to produce these same products in Ethiopia will need to pay taxes for components that are used to make the finished product.

c) Regulations are not consistently applied. Import duties are lifted for PV modules – however, there is uncertainty about which products and to what type of importer this applies to. Duties are sometimes applied differently depending on tax officers.

d) Useful policies and regulations are pre-empted by cumbersome administrative procedures. This is the case for duties for PV modules, for example: importers have to go through lengthy process of approval through the Standards Authority.

e) Regulations that would promote renewable energy have been promised but never realized. The FiT is an example of this. Rates in the draft FiT are also not attractive (particularly for PV) and would not attract developers as intended.

f) Strategies for off-grid services and for non-public actions are not adequately articulated. Broad plans are provided, for example for solar home systems in the Strategic Plan of the MWE, but these are not backed with specific strategies or investment plans for their implementation.

g) There is inadequate off-grid power service financing (or subsidy) compared to subsidies for consumers on the grid.

h) Access to major PV markets is out of bounds for the private sector. For example, PV for the telecom sector is provided by foreign contractors providing equipment and installation. The private sector is effectively excluded from major public projects.

i) A forum for sector actors, including industry and government, is required to address challenges. An informal forum was initiated in 2008 but was later abandoned.

j) There is a very narrow outlook for private sector engagement in the sector. Private companies are not taken as drivers of development but just as instruments of meeting government plans - for instance, installing systems for public infrastructure not implementing projects themselves.

Sector development support

Ethiopia starts from a very low market base for distributed renewables. Knowledge, information, finance and other inputs to users and the industry are not adequately available. Although the institutional structures for sector development have been there for decades they have not been effective.

a) Resources available for sector development are inadequate. Financial and technical resources have not been sufficiently attracted.

b) Resources already secured from external sources (e.g., WB, GEF) and from the government for sector development or financing users and suppliers have not been fully utilized.

c) Financing for projects, industry actors and users from commercial banks and from MFIs has not been sufficiently attracted.

d) The financial capacity of local suppliers is not built; on the contrary, tendering large procurements through foreign suppliers diverts resources that could have been used by local companies.

e) Technical standards for PV products and services are not available, they are also not monitored. This impacts market development – poor quality works against any promotional effort. A local testing and approval system is not available; external testing and approval take time and money.

f) Technical capacity constraints in the sector are not strategically and widely addressed. Capacity development actions are carried out in an ad hoc manner by several institutions – there are also no standards for them.

g) The model of diffusion or dissemination for PV in off-grid areas is not clearly articulated. A working model for diffusion (such as the one in Bangladesh) is not available. Sector evaluations are not available to improve strategies and implementation effectiveness.

h) Some actions are strategically misguided – for example, tendering out large PV supply and installations to international companies. Resources should be directed to develop a sustainable market and at the same time to develop local financial and technical capacity.

i) Sector information is not available at a single source for potential PV customers or other market actors. Knowledge and awareness of the technology is not sufficiently disseminated.

j) There are practically no research and development activities for PV systems either in universities or government energy agencies.

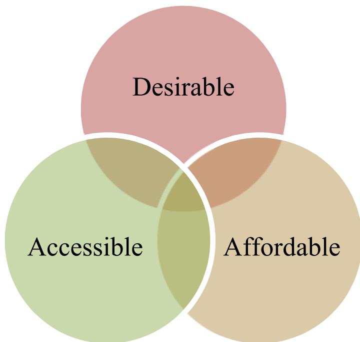
k) Institutional capability to address the strategic, regulatory and sector development functions described above is inadequate. The REF is not adequately staffed, trained and financed to conduct its functions.

Industry

The market for distributed renewables is small but growing in Ethiopia. This constrains product and service providers from expanding their services and increase income. However, companies are also part of the system and they are expected to take part in developing the market which they have mostly failed to do.

a) Very few companies have local presence in rural areas. PV systems are desirable and affordable to a considerable segment of the rural population. The major constraint appears to be that products are not available (accessible) where they are wanted.

Figure 5.2 Model for demand for services



b) PV suppliers have failed to create a supply chain for distribution and service into rural areas. Project based system supply still dominate the off-grid market; few companies work with local level service companies (installers and service providers).

c) Few companies have well thought out strategy to expand their market independently – a large segment of the PV business is still project (tender) based.

d) There are far too few PV companies in Ethiopia in contrast to the huge potential market. Technical and business knowhow for PV is limited to a handful of companies based in the capital.

e) PV companies in Ethiopia are relatively small and unable to take on large projects by themselves. For example, tenders for large number of units are still won by international companies – local companies are sub-contracted for installation.

f) PV companies have shortcomings in addressing the market and business development aspects of their business.

g) There appears to be no means of ensuring industry accountability to customers for products and services rendered. There are no government regulations and there are no industry guidelines for self regulation.

h) PV companies have failed to effectively lobby their case with government. They do not have a common forum to address their challenges.

i) There is little specialization in the industry – all PV companies tend to do everything from import to service.

Table 5.3 SWOT for the PV sector

Sector vision vs. current realities

		Strengths	Weaknesses
		▪ Supportive policies, plans ▪ Growing knowledge, experience ▪ Local level energy units, links ▪ Competitive system (vs. imports) ▪ Proven technologies available ▪ Local production capability	▪ Long term stratetic outlook ▪ Sector information (supply, users) ▪ Financing (carbon, other) ▪ Product and service supply chain ▪ R&D, business models ▪ Quality monitoring
Opportunities	▪ Green strategy, finance ▪ Decentralization, local cap ▪ Growing income ▪ Growing electricity access ▪ Growing market (mobile, otr) ▪ Access to info infrastructure		

d. Actions required to create a PV industry in Ethiopia

A combination of policy instruments, sector development support and industry actions are required to create a viable domestic PV industry in Ethiopia. These actions will help open and develop the market, promote investment and support domestic industry, build implementation capacity, and ease user financing.

Policy instruments: Existing policies and development strategies are supportive of renewables and particularly PV. There is, however, need to develop long term vision for the solar sector, enact regulations and plans and implement these transparently and effectively. Supportive regulations that are in place (such as waiver of import duty for PV systems) must be easily implementable.

Targets are important – this has been the case for all renewable energy systems in both the developed and developing world. Achievable targets with supportive policies and regulations accelerate adoption of RETs; they provide incentives for efficiency in the value chain; and lower costs due to competition, R&D and large scale deployment

The key is to realize that PV is in fact the least cost option for many off-grid and even some on grid applications; it is becoming competitive with grid electricity. Once the justification is accepted policies and regulations should be enforced in a long term basis to achieve the benefits; short term views result in frequent changes in policies, strategies and regulations thus giving conflicting messages to sector actors.

Regulations need to be used to attract investment in manufacturing and open and develop the market for PV. Proper off-grid planning framework should be in place that allows for consideration of PV on the same terms as grid extension (cost, reliability, other). Duty and tax exemption are one instrument to attract investment and lower consumer costs; providing easy access to lending to investors, distributors and users is another tool for the same purpose.[12].

Sector development support: The PV sector is small and needs sustained financial and capacity development support to reach self-sustaining levels. Domestic and external resources should be mobilized to meet these requirements. In order to develop the market quality management should be given due consideration. Technical capacity in the whole chain of activities from R&D to service should be improved.

Actions by industry: The industry should be in a position to promote its cause and self regulate for sustainability. An industry association can lobby the cause of the industry in a national industry forum that may be jointly run by the government and the association. Industry codes of conduct will ensure quality services to consumers and also the long-term sustainability of the industry.

[12] The existing investment regulation exempts investors from import duty and income tax for two to five. Creating and supporting a local PV industry will require long term (5-10 years) incentives for manufacturers (who want to be sure of adequate returns on their investment).

<table>
<tr><th>Objectives</th><th>Strategies</th><th>Deliverables</th></tr>
<tr><td>Policy instruments
▪ Open the PV market
▪ Promote investment</td><td>▪ Solar vision for Ethiopia
▪ Enact regulations for market development (such as the FiT)
▪ Simplify application of import duty regulations
▪ Provide incentives for local manufacture (life import duties for components, facilitate loans from state and commercial banks)
▪ Clarity, coherence and consistency of regulations
▪ Provide clear signal for supply planning for off-grid areas
▪ Investment financing through development and private banks
▪ Financing of distributors
▪ Financing to users
▪ Monitoring of quality of products and services</td><td>▪ PV industry vision and strategy
▪ FiT
▪ Tax exemption for PV manufacturing components
▪ Off-grid plan – that clearly indicates areas for PV (and other distributed) system services
▪ Government and Industry forum to review implementation of PV strategy, regulations (this unit must be truly empowered to make decisions)[13]
▪ Improve access to lending from state and private banks (manufacturers, distributors)
▪ Promotion of consumer financing from MFIs</td></tr>
<tr><td>Sector development
▪ Support domestic industry
▪ Build implementation capacity
▪ Disseminate sector information</td><td>▪ Attract finance (green, other) and investment
  ▪ standard bank financing
  ▪ increase micro financing
▪ set standards and codes
▪ Provide guidelines for services
▪ Simplify quality regulations (through, e.g. local testing centers)
▪ Monitor quality
▪ build the technical capacity of distributors
▪ build the business management of distributors
▪ Coordinate actions – through forums, societies
▪ Support R&D for design, manufacture and service
▪ Share knowledge and experience among stakeholders
▪ inform and educate the public
▪ Adequate monitoring of investors (so that privileges are not abused)</td><td>▪ Strengthen capability in the off-grid RE unit under the MWE
▪ Develop PV product and service standards
▪ Set up a local quality testing centers
▪ Set up national and regional technical training centers
▪ Strengthen capacity of the Solar Society
▪ Support selected universities for R&D on PV systems
▪ Capacity to develop and monitor strategies, regulations, and programs</td></tr>
<tr><td>Industry
▪ Expand market
▪ Ensure quality, sustainability</td><td>▪ Deliver systems and services suited to requirements
▪ Long-term vision for the industry
▪ Promote (lobby) private sector interests
▪ Provide quality products and services
▪ Sustainable industry links – importers to service providers (service network)
▪ User financing</td><td>▪ PV/Solar industry Association
▪ Industry code of conduct
▪ Networking and capacity building at regional/local level partners (symposiums, forums, others)
▪ Dissemination of industry information</td></tr>
</table>

[13] Such a forum was once operational (2008) – it was, however, not effective and was later abandoned.

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Annex

A.1 Energy generation costs for candidate hydropower plants in Ethiopia

Name	Generation and capital cost			Unit Costs		Earliest on Power
	Nom. Cap MW	Avrg Energy GWh	Total cost 2009 MUSD	Energy cost c/kWh	Invest Cost $/kW	
Gibe III	1870	6087	2145.89	3.83	1148	2013
Geba I & II	372	1802	640.18	3.81	1721	2018
Awash 4	38	166	59.25	3.84	1559	2016
Gibe IV	1468	5644	2788.15	5.29	1899	2015
Gibe V	662	1882	1106.95	6.31	1672	2019
Aleltu East	186	885	540.50	6.48	2906	2018
Gojeb	150	526	337.70	6.84	2251	2016
Aleltu West	265	1028	692.28	7.16	2612	2019

Source: Eastern Africa Power Pool (EAPP) and East African Community (EAC), Regional Power System Master Plan and Grid Code Study, Final Master Plan Report, Volum I, May 2011, p.5-26.

A2. Bangladesh PV Program - Challenges and matched IDCOL programme components

Challenges	IDCOL solar program components
Lack of capacity of the government, private sector and financial sector	A private-pubic partnership model was selected as the implementation and monitoring agency of the programme and would use micro financing and outreach capabilities at a grass-roots level to build capacity and harmonize efforts
Lack of tailored financing package	a capital buy down grant was created to reduce the system pricing along with an institutional development grant and long term re-financing channeled to POs
High initial cost of solar equipment	capital Buy-down Grant reduces system price and systems are also sold on credit to households to ensure affordability
Adequate institutional capacity of the executing agencies	Institutional Development Grant and long-term refinancing are channeled to executing agencies for capacity building
Lack of business model	A social enterprise model is used for implementation of the programme with the ultimate goal of commercialization and the presence of multiple Pos ensures healthy competition
Lack of awareness among potential customers	Joint training, marketing and promotional activities are continually undertaken to increase awareness among potential customers
Absence of uniform quality product and lack of tools for ensuring quality	Technical Standard Committee must approve standard equipment and accessories are used in the programme and POs provide after sales service and stringent monitoring
Absence of any administrative agency to monitor quality of products and service	Three tiered monitoring system in place consisting of IDOCL inspectors, re-inspection by regional supervisors, and donor inspection by Pos
Absence of local related and support industries	Programme has spawned a domestic manufacturing based for SHS components such as batteries and charge controllers and also solar PV assembly plants in Bangladesh

Source: Sovacool and Drupady, 2009, p.10.

A3 Household Possessions

Percentage of households possessing various household effects, means of transportation, agricultural land, and farm animals by residence. Ethiopia, 2011

Possession	Residence Urban	Rural	Total
Household effects			
Radio	63.9	33.7	40.5
Television	42.1	1.1	10.4
Mobile phone	**65.2**	**12.8**	**24.7**
Non-mobile phone	19.0	0.2	4.5
Refrigerator	14.3	0.6	3.7
Means of transportation			
Bicycle	5.6	1.4	2.3
Animal drawn cart	0.7	1.1	1.0
Motorcycle/scooter	0.6	0.1	0.2
Car/truck	3.6	0.1	0.9
Ownership of agricultural land	**22.5**	**87.8**	**73.1**
Ownership of farm animals	**30.5**	**89.5**	**76.1**

Source: Central Statistics Authority, 2012a

A4 PV module price development