International Trade and Access to Sustainable Energy: Issues and Lessons from Country Experiences

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December 2013

ICTSD
International Centre for Trade and Sustainable Development

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ICTSD
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Published by

International Centre for Trade and Sustainable Development (ICTSD)
International Environment House 2
7 Chemin de Balexert, 1219 Geneva, Switzerland
Tel: +41 22 917 8492 Fax: +41 22 917 8093
E-mail: ictsd@ictsd.org Internet: www.ictsd.org

Publisher and Director: Ricardo Meléndez-Ortiz
Programme Manager: Ingrid Jegou
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Acknowledgments

This paper is produced by the Global Platform on Climate Change, Trade and Sustainable Energy of the International Centre for Trade and Sustainable Development (ICTSD). The concept of the research has been informed by ICTSD policy dialogues during the past year, in particular a dialogue organised in Washington DC in November 2011 by the Peterson Institute for International Economics (PIIE) with support of the Global Green Growth Institute (GGGI) and ICTSD, a Policy Dialogue on *Renewable Energies and Trade: Addressing Tensions and Challenges* co-organised with the Global Green Growth Institute (GGGI) and the Peterson Institute for International Economics (PIIE) in January 2013, ICTSD Panel Sessions on SETA at various Global Green Growth Forum Stocktaking meetings in Copenhagen since 2011 and an ICTSD Session at the Global Green Growth Summit in May 2012 in Seoul, Korea.

The authors thank Ricardo Meléndez-Ortiz, Ingrid Jegou, Mahesh Sugathan and Joachim Monkelbaan from ICTSD for their guidance and inputs during the production of the paper and Rene Vossenaar (independent consultant) for comments as well as contribution of content. The authors are also grateful for the valuable comments on an earlier draft received from Moustapha Kamal Gueye (International Labour Organisation).

ICTSD is grateful for support to its activities on sustainable energy trade initiatives by the Global Green Growth Institute (GGGI) and by the Ministries of Foreign Affairs of Norway and Denmark. It also wishes to acknowledge its core and thematic donors, including the UK Department for International Development (DFID); the Swedish International Development Cooperation Agency (SIDA); the Netherlands Directorate-General of Development Cooperation (DGIS); the Ministry of Foreign Affairs of Denmark (Danida); the Ministry for Foreign Affairs of Finland; the Ministry of Foreign Affairs of Norway; Australia's AusAID; the Inter-American Development Bank (IADB); Oxfam Novib and the Deutsche Gesellschaftfür Internationale Zusammenarbeit (GIZ).

ICTSD welcomes feedback on this document. These can be forwarded to Mahesh Sugathan, smahesh@ictsd.ch

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Citation: Nampoothiri, M. and Manoharan, H. (2013); *International Trade and Access to Sustainable Energy: Issues and Lessons from Country Experiences*, International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org

ISSN 2225-6679

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Abbreviations And Acronyms

ADD	Anti-dumping duties
ARI	Acute respiratory infection
Btu	British thermal unit
CAR	Central African Republic
CBO	Community based organization
CDB	China Development Bank
CEG	Clean Energy Good
CFL	Compact fluorescent lamp
COMTRADE	United Nations Commodity Trade Statistics Database
COPD	Chronic obstructive pulmonary disease
C-Si	Crystalline silicon
DCR	Domestic content requirement
EU	European Union
FiTs	Feed-in-tariffs
GGGI	Global Green Growth Institute
GHG	Greenhouse gas
GIZ	German Society for International Cooperation
HDI	Human Development Index
HS	Harmonised System
ICTSD	International Centre for Trade and Sustainable Development
IDCOL	Infrastructure Development Company Limited
IEA	International Energy Agency
IEC	International Electro-technical Commission
IFC	International Finance Corporation
LED	Light emitting diode
LPG	Liquefied petroleum gas
MDGs	Millennium Development Goals
MFIs	Micro-financing institutions
MFN	Most-favoured nation
NABARD	National Bank for Agriculture and Rural Development
NGO	Non-governmental organisation
PIIE	The Peterson Institute for International Economics
PV	Photovoltaic
R&D	Research and development
RBI	Reserve Bank of India
RECL	Rural Electrification Corporation Limited
RGGVY	Rajiv Gandhi Grameen Vidyutikaran Yojana
RPS	Renewable purchase standards
SEA	Sustainable energy access
SEGS	Solar energy generating systems
SETA	Sustainable energy trade agreement
SETIs	Sustainable energy trade initiatives
SHS	Solar home lighting systems
SMEs	Small and medium-sized enterprises

SOVA	Southern Orissa Volunteer Association
SPLs	Solar portable lights
STP	São Tomé and Príncipe
TBT	Technical Barriers to Trade
TERI	The Energy Research Institute
TF	Thin film
TL	Tariff line
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
US	United States
VAT	Value-added tax
WTO	World Trade Organization

Foreword

Climate change is an unprecedented challenge facing humanity today. As fossil fuel-based energy use is the biggest contributor to anthropogenic greenhouse gas (GHG) emissions, a rapid scale up and deployment of renewable or sustainable energy sources could significantly reduce the emissions responsible for climate change. From a development perspective, developing countries face the enormous challenge of reducing carbon intake while ensuring people's access to energy and powering rapid economic growth. Most countries are also seeking ways to enhance their energy security by reducing reliance on fossil-fuel imports. Developing sustainable energy through a transition to cleaner, low-carbon transport fuels and technologies along with greater energy-efficiency measures could make a positive contribution toward achieving these goals.

Efforts to scale up sustainable energy require generation costs to be as low as possible. Relatively high capital costs associated with renewable energy investments, the non-consideration of environmental and health externalities in fossil-fuel pricing, and the enormous levels of subsidies still granted to fossil fuels make this a challenging proposition. At the same time, renewable energy costs are enduring a rapid global decline that will likely continue for some time. In certain locations, renewable energy generation has already attained 'grid-parity,' equalling the cost of fossil fuel-based power generation.

Incentives, such as feed-in tariffs and tax breaks, help reduce the cost of renewable power. At the same time, lowering the costs of equipment and services used to produce sustainable power can facilitate the scale-up process, enabling economies of scale and cost optimization for renewable energy projects. Addressing barriers to trade in sustainable energy goods and services can also contribute to scale economies and cost-optimization, as trade in sustainable energy goods can be hampered by tariffs, subsidies, diverse or conflicting technical standards, and lack of harmonisation or mutual recognition efforts.

In striving to lower production costs, governments often seek to promote domestic manufacturing of renewable energy equipment and the provision of services, with many policymakers viewing the sustainable energy sector as a potential engine for job creation. These factors could potentially induce sustainable energy policies designed with protectionist intent and trigger trade disputes in the sector. The recent World Trade Organization (WTO) Appellate Body ruling at the first trade dispute (Canada vs. Japan and the EU) over renewable energy feed-in tariffs and local content led to a clear ruling against local content measures in the province of Ontario. Yet, these measures persist in a number of countries, and more such disputes may be expected. A number of other disputes also concern trade remedy measures centred on unfair incentives for manufacturers of clean energy products.

Moving forward, the urgency of addressing climate change will require, among other policy responses, a clear and coherent governance regime for sustainable energy and related goods and services supported by trade rules and robust markets. The current stalemate in the WTO's Doha negotiations, particularly in efforts to liberalize environmental goods and services, has prevented action to address barriers to trade in sustainable energy goods and services. Even a successful conclusion of the round would leave a number of trade-related rules pertaining to sustainable energy—including government procurement of solar-energy generating systems (SEGS)— unclarified, given the Doha mandate's lack of a holistic perspective on energy.

Given such a scenario, sustainable energy trade initiatives (SETIs) may present worthwhile alternatives. These possibilities include a sustainable energy trade agreement (SETA), a stand-alone initiative designed to address barriers to trade and enable a trade policy-supported energy governance regime to advance climate-change mitigation efforts and increase sustainable energy supply.

This agreement might be pursued initially as a plurilateral option—either within or outside the WTO framework—and eventually be 'multilateralised.' It could serve to catalyse trade in sustainable energy goods and services and address the needs and concerns of participating developing countries, many of which may not be in a position to immediately undertake ambitious liberalisation in sustainable energy goods and services. A SETA could also help clarify existing ambiguities in various trade rules and agreements as they pertain to sustainable energy and provide focalised governance through effective operational provisions.

An important issue to consider in this regard is to the extent to which a SETA will respond to the needs and concerns of the populations that lack access to energy for cooking, lighting, and other essential needs and the manner in which it could catalyse diffusion as well as lower costs of energy access. It is estimated that nearly 800 million people in Asia live without access to electricity while about 630 million people have limited or no access to electricity in Africa. India alone accounts for about 400 million people who lack access to electricity or good-quality primary energy sources. Providing such access will certainly take enormous investments. According to an estimate endorsed by the United States (US) Administration, it would take about USD 300 billion to provide all Africans with power by 2030. As part of the Power Africa initiative launched by US President Barak Obama during his visit to Africa in July 2013, the US is set to provide USD 7 billion through public and private sources over the next five years. This marks a promising beginning in what will be a long road ahead to ensure sustainable energy access for all in Africa. It is worth the effort though, and as President Obama remarked while drawing an analogy between Africa's continued suffering with poverty and unemployment and Nelson Mandela's experience with captivity, "Just as freedom cannot exist when people are imprisoned for their political views, true opportunity cannot exist when people are imprisoned by sickness, or hunger, or darkness."[1] Access to energy will certainly improve the quality of life for millions, empowering them in diverse ways from running agricultural pump-sets to enabling children in rural villages to study at night. If such provision is made available through sustainable carbon-free energy sources, it will also contribute to climate-change mitigation efforts and protecting the planet.

In the effort to provide energy access, trade policy will have an important role to play. This paper scopes out the main trade-related issues and challenges related to access to energy. It sets the context by highlighting the various sustainable development issues related to energy access as well as trends in energy access, including geographical trends; human poverty; gender issues, underscoring the disproportionate impacts of the lack of energy access on women; and other adverse economic impacts on education and the environment. It also examines the various reasons for lack of access to energy and consequent energy poverty. The paper then maps the key technologies as well as inputs used in the manufacture of solar portable lights, solar portable off-grid home systems, and solar mini-grids for rural areas. It spotlights the essential eco-system ingredients necessary for a successful provision of energy access, including *inter alia* financing schemes, infrastructure for sales and after-sales service, standardisation and quality issues, and understanding of demand drivers, such as usage patterns and product and price preferences. The paper then addresses the relevance of trade and investment policies, including a detailed examination of geographical trends in trade flows as well as applied tariffs on important solar-energy systems-related equipment and solar lamps. The analysis brings out issues related to classification under the Harmonised System (HS) and underscores the importance of clearer specification of products for more accurate tracking of trade flows. The paper concludes by reviewing the main lessons that emerge from the paper, identifying the needs and priorities for developing countries as well as how trade policy could respond to the important trade-relevant issues through a SETA.

The focus in the paper is on equipment critical to providing access to off-grid sustainable energy through (i) solar off-grid home systems and rural mini-grids and (ii) solar lighting appliances. While important from the perspective of providing energy access, the paper excludes cleaner cook-stoves mainly because of the greater difficulty in identifying clear HS codes for the purposes of tracking trade flows.

This paper was conceived by the International Centre for Trade and Sustainable Development (ICTSD) and written by Madhavan Nampoothiri, Managing Director and Founder and Hari Manoharan, Consultant with RESolve Energy Consultants in India. Trade analysis and inputs for Chapter 4 were provided by Rene Vossenaar, Independent Consultant and Mahesh Sugathan, Senior Research Fellow with ICTSD.

The paper is produced as part of a joint initiative of ICTSD's Global Platform on Climate Change, Trade and Sustainable Energy, and the Global Green Growth Institute (GGGI).The concept of the research has been informed by ICTSD policy dialogues, in particular, a dialogue organized in Washington, DC in November 2011 by The Peterson Institute for International Economics (PIIE) with support of GGGI and ICTSD; a high-level Roundtable in Geneva organized on 16 December 2011 on the occasion of the Eighth Ministerial Conference of the WTO that was attended by a number of high-level representatives from WTO missions and capitals, a session organized at the Global Green Growth Summit 2012 in Seoul, Korea on 11 May 2012, and ICTSD's Bridges China Dialogue in 2012.

As a valuable piece of research, it has the potential of informing innovative policy responses on SETIs and will be a valuable reference tool for policymakers involved with energy access as well as trade negotiators. We hope that you will find the paper to be a thought-provoking, stimulating, and informative piece of reading material and that it proves useful for your work.

Ricardo Meléndez-Ortiz
Chief Executive, ICTSD

Executive Summary

Access to energy plays a very important role in human development. It is estimated that nearly 800 million people in Asia live without access to electricity, while about 630 million people have limited or no access to electricity in Africa. India alone accounts for about 400 million people who lack access to electricity or good-quality primary energy sources. There exists a huge inequality in electricity consumption, where the per capita consumption in North America is almost 25 times that in South Asia or sub-Saharan Africa.

The number of people without access to energy globally is high, and there is a significant bias towards developing nations, particularly India and sub-Saharan Africa. One indicator of the mismatch between developed and developing countries is the amount of energy consumed per capita. It has been estimated that the per capita primary energy consumption in South Asian and African countries is about 17 million BTU per person and 16 million BTU per person, respectively. This is in stark contrast to the 254 million BTU per person and 134 million BTU per person seen in the US and Europe, respectively.

The Human Development Index (HDI) rankings produced by the United Nations Development Programme (UNDP) show a strong correlation with the per capita energy consumption of nations. No country with annual electricity consumption of less than 4000 kWh/person/year has an HDI value of 0.9 or higher. Similarly, no country with consumption of more than 5000 kWh/person/year has an HDI value lower than 0.8. This suggests that to improve the quality of life and nurture socio-economic growth in developing nations, it is vitally important to ensure that the populations of these nations have adequate access to primary sources of energy, including electricity.

On a micro level, lack of energy access has a bigger impact on the livelihood of women than on men, while the quality of life for people in rural areas suffers more than those in urban areas. In addition, most people with insufficient access to electricity use traditional fossil fuels, especially kerosene, which is highly subsidized globally to satiate energy requirements, which has an adverse effect on health, leading to various respiratory infections as well as a higher risk of cancer, and resulting in significant losses of productivity.

Available technology

Due to highly disbursed centres of demand, solar technology and associated products lend themselves to fulfilling energy demands in regions where it is most needed. The various solar products available at the moment fall into three broad categories, namely:

- Solar portable lights (SPLs)
- Solar home lighting systems (SHSs)
- Solar-power-based mini or micro grids

The choice of any given product depends on the following factors:

- Affordability or cost to consumer
- Density of population

Numerous bottlenecks stifle sector growth and the rate of uptake

- **High capital costs** for solar products remain prohibitive. However, with the sector growing at a tremendous rate and with competition increasing, prices have fallen drastically over the last few years, and it is expected that in the near future, solar products will be affordable without the need for subsidies.

- **Ease of access to finance** is a major issue both on the supply side and the demand side, and it is one of the factors that affect the entire value chain. This coupled with the (comparatively) higher cost of solar products lowers demand.

- **Market spoilage,** due to the sale and distribution of low-quality products with low durability, has a negative impact on customer satisfaction rates and through word of mouth might serve to limit sales.

- **Lack of awareness** of available products and associated subsidies is another major issue. On the one hand, the consumer is not aware of the available products, subsidies, and associated ways to secure financing for the products. On the other hand, financial institutions (such as local banks and micro-financing institutions) who play a key role in improving affordability by offering cheaper financing options for these products are unaware of the benefits of these new technologies and are apprehensive of embracing them.

- **Slow rate of policy implementation** and lack of focus of policies to foster the growth of a domestic ecosystem with subsidies being focused solely on products.

- **High import duties and taxes** levied on renewable energy-based products and components associated with their manufacture/assembly. This issue is especially adverse in the case of certain countries in Africa where taxes and duties can at times be two times higher than those seen in India for corresponding products.

- **Difficulties in after-sales service and distribution arise, owing** to the remote nature of the market where the need for the product is highest.

- **Improper implementation of standards** stifles growth and customisation, especially when subsidies are linked to said standards.

Though significant hurdles exist, they are not insurmountable

- **Innovation in business models**, such as the use of a 'pay-as-you-go' model or a rental model, help combat the high capital cost of solar products, which limit affordability.

- **Access to finance innovation** across the value chain is likely to be one of the key drivers to growth of the sector. Easier access to finance on the supply side of the value chain would also ensure reductions in cost of production, which would then be passed on to the consumer.

- **Certification, testing, and standardisation** centres need to be established to ensure that the products sold in the market conform to acceptable standards. This would serve to greatly limit the amount of counterfeit and low-quality products circulating in the market and boost consumer confidence.

- **Awareness creation i**nitiatives through partnerships with non-governmental organisations (NGOs) and other not-for-profit groups would help improve uptake. In addition, workshops need to be conducted for other stakeholders, such as financing institutions, so that they are better informed to fund solar projects and products.

- **A shift in national policy focus** toward developing a complete ecosystem rather than a focus on pure capital subsidies to improve immediate affordability is the key to creating a sustainable market. In addition, the policies enacted should not be limited through the imposition of domestic content requirements where subsidies are available only for goods manufactured domestically.

- **Relaxation of duties/taxes** would be required, especially in countries across Africa, where the rates are very high. In addition to the reduction in duties and tariffs, it must be ensured that revisions made to these are communicated to all individuals in charge of imposing these duties/taxes. This would greatly improve affordability, as the savings would be passed on to the consumer.

- **Standardisation practices should be revised** to ensure that there is sufficient room for product customisation based on individual consumer preferences without sacrificing quality.

Research indicates that the trend in Africa, where the grid expansion fails to keep up with the population growth, will continue until 2030. It is expected that the number of people without electricity access in Asia will fall from 630 million in 2010 to less than 335 million in 2030. However, the corresponding numbers for Africa is expected to increase by 11 per cent to 655 million in 2030, indicating that the present course of action is not sufficient in various nations across Africa. Thus, it becomes imperative for the nations to undertake sweeping changes, taking into account all the pitfalls to ensure better access to energy.

Chapter 1

Context - the Problem and Importance of Access to Energy and Trends

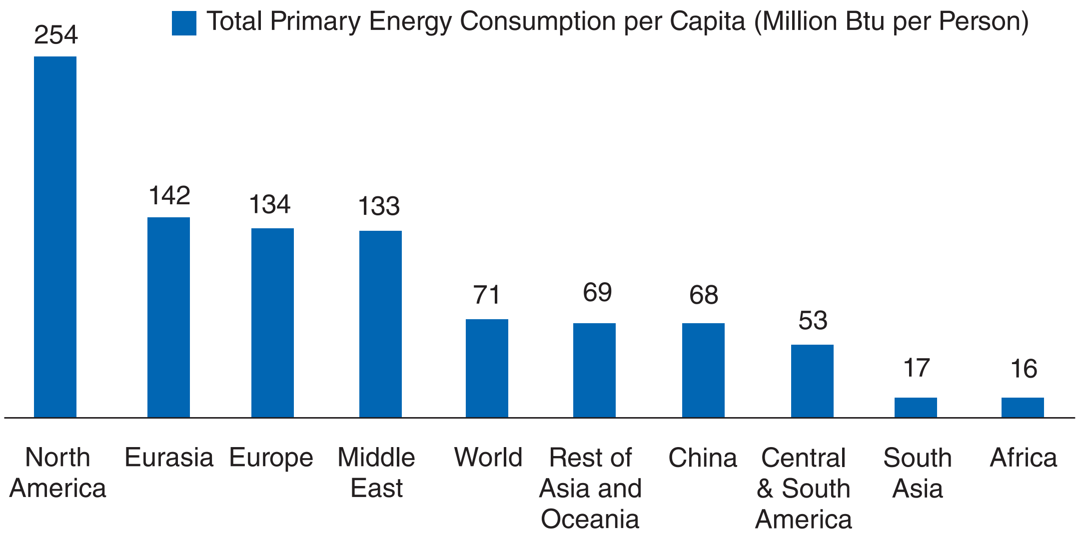
The importance of energy access in poverty reduction and sustainable development is well acknowledged. Access to cleaner energy leads to better health directly as well as indirectly by mitigating harmful impacts on the environment, productivity, energy security, and access to information. This, in turn, leads to social, economic, and human development.

Organizations like UNDP and the International Finance Corporation (IFC), a part of the World Bank Group, have done commendable work in the area of improving energy access in developing countries and have released periodic reports on the subject. This paper highlights several insights from UNDP and IFC publications.

1.1 Geography and Energy Access

Energy consumption per capita (represented below as Million BTU[2] per person) is unevenly distributed geographically, as can be seen from Figure 1.1 below.

Figure 1.1 Total Primary Energy Consumption Per Capita in 2009 (Million BTU per Person)



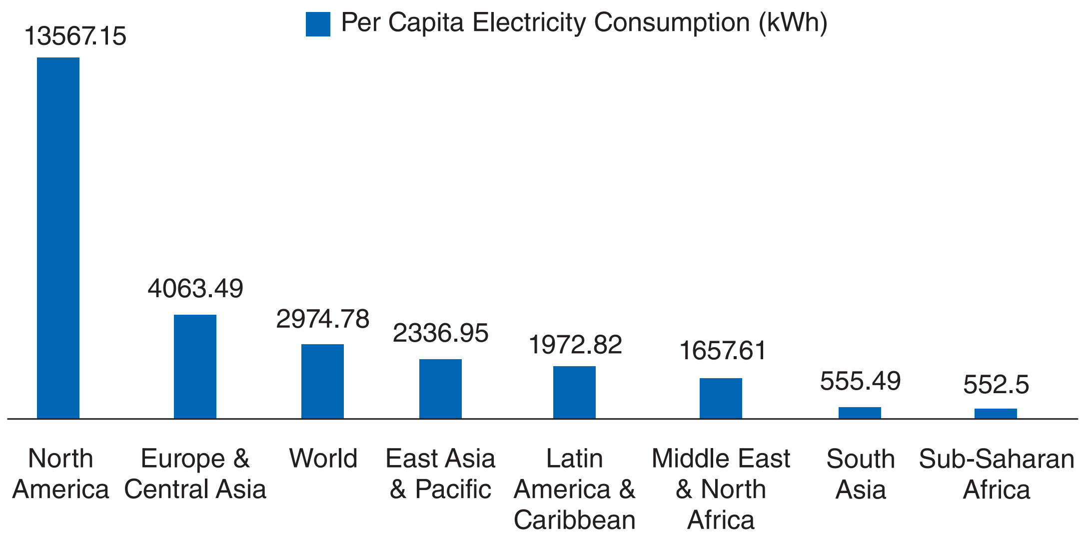
Source: Energy Information Exchange (EIA), www.eia.gov

At one extreme, Africa and South Asia, comprising Bangladesh, Bhutan, India, Nepal, Pakistan, and Sri Lanka, have the lowest consumption per capita at about 16 million Btu per person. At the other extreme, the corresponding number for Canada and the US are 390 and 308 million Btu per person, respectively.

Latin America fares better than Africa and South Asia, with a per capita consumption of 53 million Btu per person. China and the rest of Asia and Oceania have a per capita consumption close to the world average, while Europe, Eurasia, and the Middle East each have approximately double the world average per capita consumption.

A similar pattern can be seen in per capita electricity consumption. Figure 1.2 below shows the huge inequality in energy consumption, where the per capita consumption in North America is almost 25 times that of South Asia or sub-Saharan Africa.

Figure 1.2 Per Capita Electricity Consumption in 2010 (kWh)

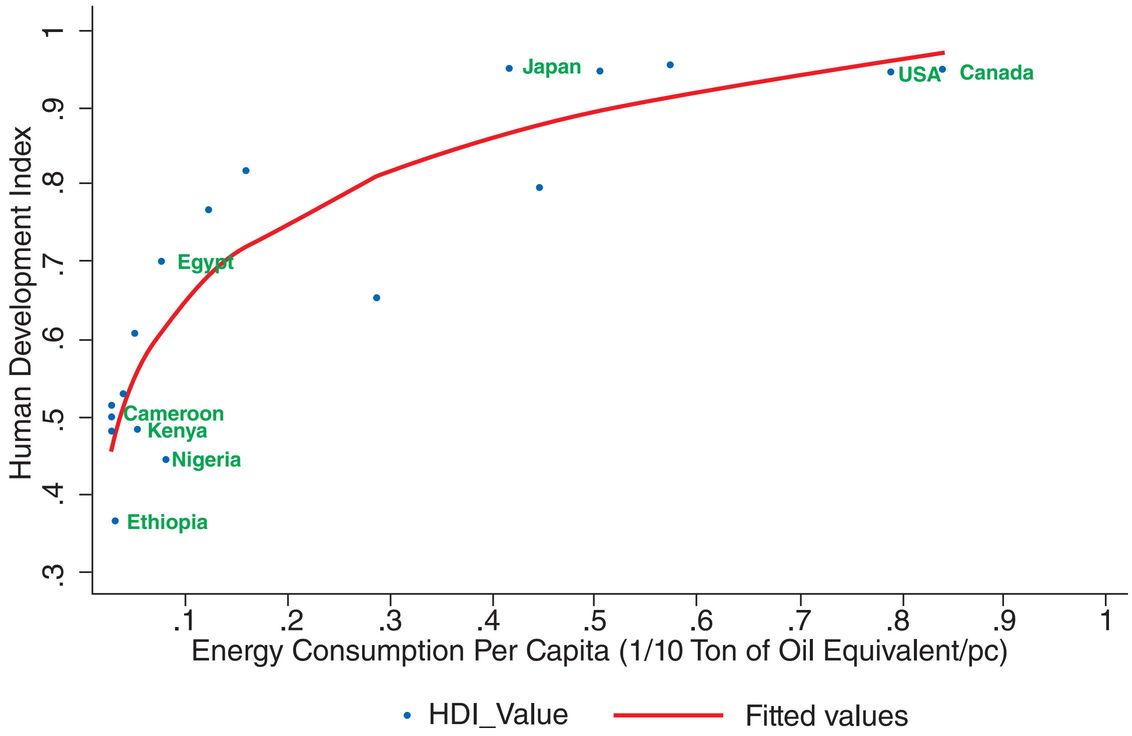


Source: World Bank, 2011

1.2 Energy Access and Human Development

It has been observed that there is a strong correlation between HDI rankings and per capita energy consumption. Figure 1.3 from the Human Development Report 2007/08 by UNDP[3] illustrates the point.

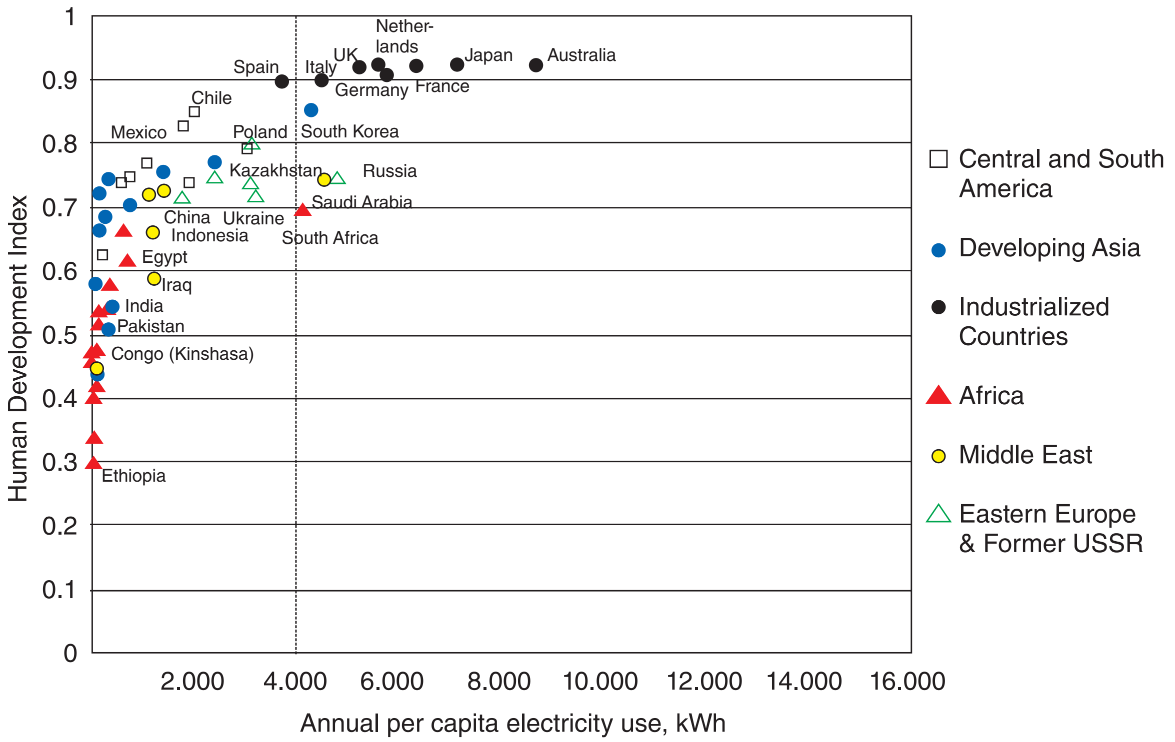
Figure 1.3 Human Development Index vs. Energy Consumption Per Capita



Source: Human Development Report 2007/2008, UNDP

A study conducted by Pasternak in 2000 for the US Department of Energy (DOE)[4] highlights that the correlation between HDI and per capita electricity consumption is a better metric than the correlation between HDI and per capita energy consumption. One of the key findings of the study is that HDI reaches a maximum value when the electricity consumption crosses the threshold value of 4000 kWh/person/year. The results of the study are given below.

Figure 1.4 Human Development Index vs. Annual Per Capita Electricity Use

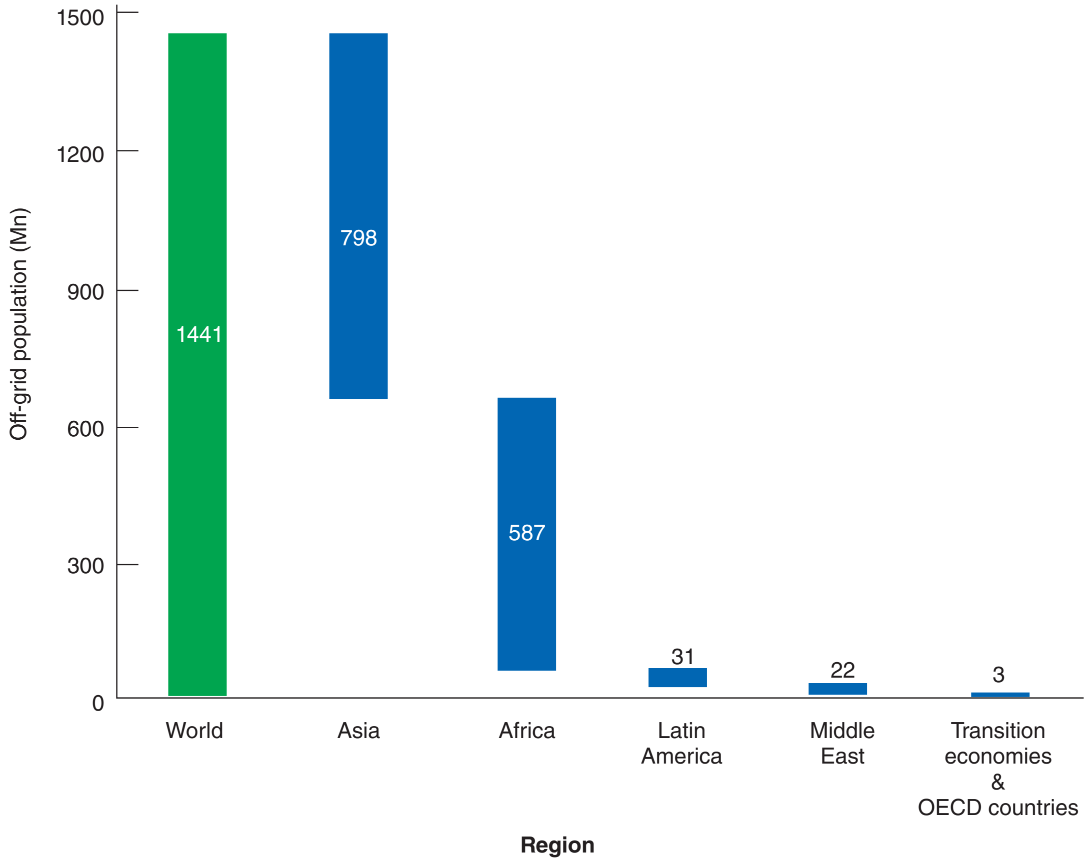


Source: Global Energy Futures and Human Development: A Framework for Analysis, Alan D. Pasternak, October 2000

The study goes on to say that no country with annual electricity consumption below 4000 kWh/person/year has an HDI value of 0.9 or higher, and similarly, no country above 5000 kWh/person/year has an HDI value lower than 0.8. The study was done for the 60 most populous countries comprising 90 per cent of the world's population.

One notable insight from the study is that, barring a few countries like South Africa almost every country in Africa has very low per capita electricity use per year and a low HDI ranking. The IFC estimates that close to 600 million people in Africa (about 70 percent of the continent's population) did not have access to electricity as of September 2012. In Asia, almost 800 million people do not have access to electricity.[5] Figure 1.5 below summarises the situation.

Figure 1.5 Access to Electricity by Region[6]



Source: Lighting Asia: Solar Off-grid Lighting, IFC, February 2012

The UNDP defines energy poverty as the "inability to cook with modern cooking fuels and the lack of a bare minimum of electric lighting to read or for other household and productive activities at sunset." A study conducted by Modi et al. in 2005 on the millennium development goals (MDGs) states that worldwide, there are 2.4 billion people who use traditional biomass fuel for cooking.

These 2.4 billion people along with the 1.5 billion people with no access to electricity can be considered as suffering from 'energy poverty.'

Table 1-1 Number of People Relying on Traditional Biomass for Cooking and Heating in Developing Countries

	Million	% of total population
China	706	56
Indonesia	155	74
Rest of East Asia	137	37
India	585	58
Rest of South Asia	128	41
Latin America	96	23
North Africa/Middle East	8	0.05
Sub-Saharan Africa	575	89
Total, Developing Countries	2,390	52

Source: Modi et al (MDG 2005)

1.3 Urban Versus Rural

Even in the areas where most of the 'energy poor' live, inequalities in energy access are observed along multiple dimensions. One dimension is the urban vs. rural divide. In Africa, only 26 per cent of total households are electrified, but this is not uniformly spread. While about 51 per cent of the urban population is electrified, only 8 per cent of the rural population has access to electricity (Africa Energy Poverty – G8 Energy Ministers Meeting, 2009). In India, 94 per cent of urban households were electrified, while only 57 per cent of rural households were electrified.[7]

1.4 Energy Poverty and Gender

Men and women are not equally affected by the lack of energy access, especially in rural areas. Typically, poor people have to rely on biomass for cooking and other heating purposes. In most developing countries, especially in Africa and Asia, the responsibility of household chores, including cooking, falls on women. Since they rely on biomass, women have the added responsibility of collecting the biomass (firewood, dung, charcoal, agricultural crop waste, cattle dung etc.) used for cooking. Collection of biomass can consume a lot of time, depending on the geography. Moreover, in many of these cultures (Asia and Africa), cooking food is a lengthy process, ranging from a minimum of 30 minutes to as much as 3-4 hours.[8]

1.5 Effect of Lack of Energy Access

The lack of access to good-quality energy severely impacts the lives of the poor people, especially women, in several ways.

1.5.1 Health

Burning biomass and kerosene for cooking and lighting causes indoor pollution. The problem is aggravated, since most cook-stoves used are very inefficient, leading to the emission of carbon monoxide, which is a major health hazard. The high concentration of particulate matter leads to acute respiratory infections (ARI), chronic bronchitis, and chronic obstructive pulmonary disease (COPD). The risks of lung cancer, birth of underweight babies and other related diseases have been observed to increase.[9]

It is also very important to note that a huge amount of money is spent on kerosene. According to an IFC study in 2012, the off-grid population in Africa spends about USD 10.5 billion on kerosene for lighting purposes every year. In Asia, the corresponding number for a group of seven countries is USD 3.77 billion. The countries include Bangladesh, Cambodia, Indonesia, Nepal, Pakistan, and Philippines. In India alone, annual spending is USD 2.22 billion.[10]

Since the lighting produced by kerosene is usually dim and without adequate lumens, children who study using kerosene lamps are highly prone to eyesight impairment.

In addition to these health issues, it is estimated that inhalation of indoor smoke from the solid fuels leads to about 1.6 million deaths every year (60 per cent of them are females) in developing countries.

1.5.2 Impact on women

As mentioned previously, in most developing countries, the collection of biomass for cooking is the responsibility of women. Therefore, women and girls spend a significant part of their day time and energy collecting fuel, like firewood. As Figure 1.6 below shows, there is a significant disparity between men and women in the time spent on wood collection. Women spend anywhere between two to nine times the time spent by men on wood collection. This limits the time available to them to engage in other economically productive activities or in socializing, which affects their quality of life.

Figure 1.6 Time Spent Fetching Wood and Water in Rural Areas (Sub-Saharan Africa) (Average hours per week spent)

	Guinea (2002-03)	Madagascar (2001)	Malawi (2004)	Sierra Leone (2003-04)
women	5.7	4.7	9.1	7.3
men	2.3	4.1	1.1	4.5
girl	4.1	5.1	4.3	7.7
boys	4.0	4.7	1.4	7.1

Source: Human Development Report. Sustainability and Equity: A Better Future for All, UNDP, 2011

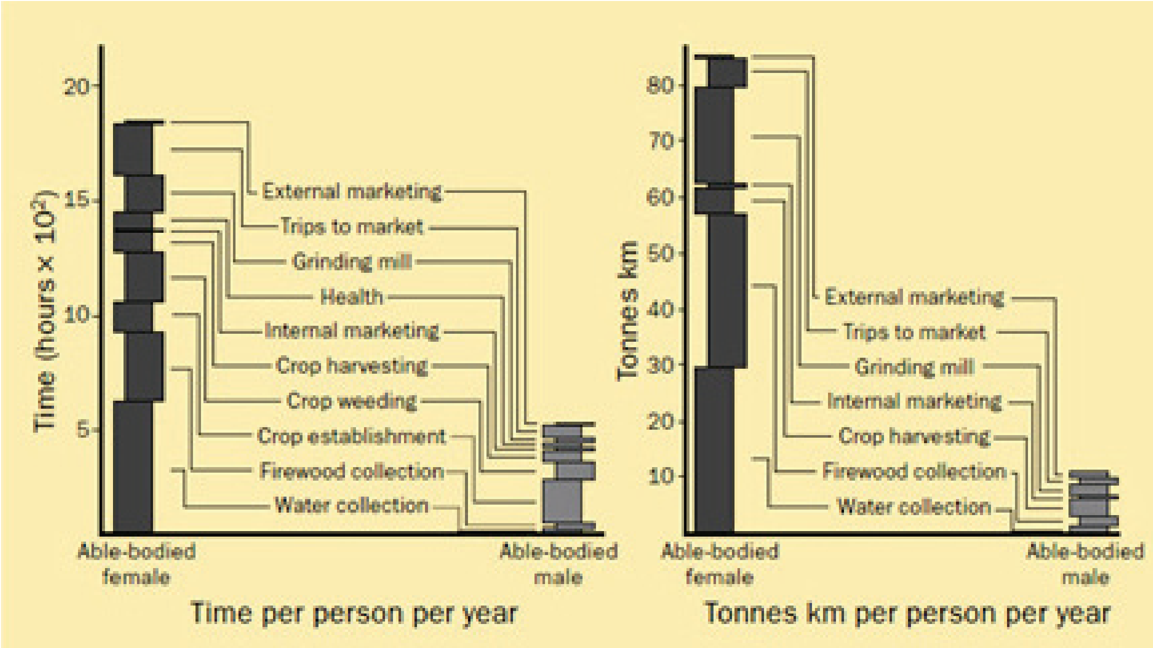
It has been estimated that women on average make up 43 per cent of the agricultural labour force in developing countries. A report published by WomenWatch (UN) states that female employment in agriculture is consistently lower than that of males in developing countries.[11] Studies have shown that if women had similar access to productive resources as men, they could increase yields on their farms by 20 to 30 per cent,[12] indicating that there is a significant opportunity cost associated with the reduced amount of hours available for women to carry out economically productive work.

Once collected, the biomass needs to be carried to homes on foot. It is reported that each woman carries up to 20 kilograms of firewood over a distance of five kilometres every day.[13] Carrying heavy loads on their backs or heads can lead to back injuries, sometimes causing irreversible damage. During fuel collection and transportation, women also are prone to cuts, animal and snake bites, falls, and sexual attacks.[14]

1.5.3 Loss of productivity

In rural India, it is estimated that on average about 37 hours per month is spent for collection of wood. An estimate from Tanzania is given below, which shows the disparity between men and women on the time spent on wood collection.

Figure 1.7 Time Spent and Transport Burden in Tanzania for Wood Collection



Source: Modi et al MDG (2005)

It is clean from the image above that women are more affected than men when it comes to energy access. This leaves women with very little time to pursue other economically productive activities. An example of the magnitude of loss that can be expected is provided in section 1.5.2 above, which states that yields in farm lands, for example, could improve by anywhere between 20 and 30 per cent if women had a comparable amount of time available to contribute towards cultivation as men.

1.5.4 Education

Young girls also have to forego education in order to help their mothers in fuel collection, fetching water, and participating in agricultural work. Lack of energy access also leads to poor quality of schools, which become unable to attract teachers of good calibre.

For instance, a study undertaken by German Society for International Cooperation (GIZ) in Uganda, found through the survey data that the activity most hampered by the lack of electricity (lighting, in particular) was reading or studying (on a scale of 0 to 1, this particular activity scored 0.9). In a separate field test conducted using solar lanterns in Lira, Uganda by GIZ, it was shown that the availability of solar lighting systems led to an increase in the share of children using evening hours for studying by about 25 per cent. The field test further highlighted the fact that the children could now safely shift their studying time from the early morning hours to the evening. It was shown that "while children in only 35% of the control group households use the evening hours for reading or studying, their share in households that use a solar lamp is as high as 50%."[15]

1.5.5 Economic impact

The harmful effects of using traditional fuel sources on the health of the consumer have been discussed in section 1.5.1. It should be noted that while considering the lifetime cost of traditional fuel sources, externalities such as this are not taken into consideration. Adverse health consequences are associated with added expenses either by the consumer or the government supporting the consumer to treat the health issues that arise. If one were to internalize these expenses into the lifecycle cost of traditional fossil fuels, the cost of using traditional fuels would be much higher than renewable energy based systems. Thus, using fossil fuels as the primary energy source has a negative impact on the financial health of both the consumer and the society as a whole. Another perspective is that the adverse health consequences could also have associated opportunity costs to the extent that end users are unable to undertake productive work, owing to health issues, thereby reducing economic throughput in the region.

Poor people usually end up paying higher unit costs for energy than higher-income people. This can be attributed to the usage of inefficient items, like candles, kerosene, firewood, and other biomass. The use of traditional, inefficient cook-stoves aggravates this problem.

The cost competitive nature of traditional fuel sources is mainly attributed to the subsidies they receive. If the subsidies for these fuels, such as kerosene, were removed, the life cycle cost of fossil fuel sources tends to be much higher than renewable energy based systems. Thus, the cost to the institution providing the subsidy is much higher in the case of fossil fuels compared with subsidies provided to renewable energy based systems. This issue is discussed in detail in section 3.7.3.

A more direct impact on the economy is felt due to the loss of productivity incurred due to sourcing of fossil fuels for primary energy use as discussed in sections 1.5.2 and 1.5.3.

1.5.6 Environmental

The most obvious effect of the use of inefficient and polluting energy sources, like biomass and kerosene, is on the environment. These energy sources emit GHG, including Co2, CO, SOx, NOx, etc., during combustion. Traditionally, in most sub-Saharan African countries and rural areas in India, the dominant fuel source for cooking and lighting has been wood fuel, i.e. wood gathered from nearby locations and burnt to produce either heat or light. The process of burning wood in its natural state almost always results in incomplete combustion, thereby producing a higher range of pollutants compared with more efficient sources, such as liquefied petroleum gas (LPG) which can be burned close to completion.

One measure that highlights the degree to which each fuel has an impact on the environment is termed the k-factor.[16] Simply put, the higher the k-factor the more polluting the fuel. The table below shows the k-factors of some commonly used fuel sources.

Table 1-2 K-Factors of Various Cooking Fuels

Fuel	k-factor
Woodfuel	0.1-0.2
Kerosene (wick stove)	0.051
Kerosene (pressure stove)	0.022
LPG	0.0231
Biogas	0.00562

Source: Smith et al., 2000a

Another major impact is on vegetation and forest cover. Uncontrolled biomass harvesting for energy generation leads to deforestation and land degradation, which is evidenced from the rapid rate of deforestation in sub-Saharan Africa, which results in a net increase of carbon dioxide in the atmosphere. Even if wood fuel were to somehow be harvested sustainably, it would never be carbon neutral, owing to the incomplete combustion associated with it.

1.6 Reasons for Energy Poverty

1.6.1 Resource endowment and allocation

Compared with other Asian countries, South Asia has very limited energy resources, and energy access is a problem. For instance, India and Pakistan have net energy imports of about 25 per cent; Sri Lanka imports a whopping 45 per cent of its total energy requirement. At the same time, a country like China, which is rich in natural resources, imports only about 8 per cent of its total energy requirement (Source: World Bank data). However, a high indigenous energy supply does not necessarily translate to high energy access. For example, Africa as a whole is energy rich, and countries like Algeria, Angola, Libya, and Nigeria are among the top oil producers in the world. However, as mentioned previously, energy access in Africa, especially in sub-Saharan countries, is one of the lowest in the world. According to a report prepared by Practical Action (2005), Africa produces about 7 per cent of world's commercial energy but consumes only 3 per cent of global commercial energy.[17]

1.6.2 Ineffectiveness of policy support

Globally, four types of policy and regulatory mechanisms are used by governments to support renewable energy:

1. Feed-in tariffs
2. Quotas or obligations similar to renewable purchase standards (RPS) in the US
3. Competitive tendering for purchase of renewable power at a premium price
4. Financial incentives, like subsidies, grants, and tax exemptions

Most of the people without energy access live in rural areas with very limited electrification. The lack of financial and/or technical feasibility has resulted in this low electrification rate. It is estimated that over 65 per cent of the population in sub-Saharan Africa does not have access to electricity, while the number in India stands at about 25 per cent. Of the percentage specified, the rural to urban population rate is about 4:1 in the case of sub-Saharan Africa, while it stands at an astonishing 12:1 in India.[18] Additional information on this subject and the progress made in this area is presented in section 1.8.

In the absence of a grid, most policy and regulatory support in Africa and South Asia relies on the fourth type mentioned above — financial incentives. Below is the list of a few countries in Africa that have used some of these mechanisms.

Table 1-3 Examples of Integrated Liberalization and Sustainability Initiatives in Africa

Country	Renewables Policy (Year Enacted)	Target	Mechanism Class*
Botswana	10th National Development Plan 2009-2016 – NDP10 (2009)	Multiple RE Sources	4
	National Photovoltaic Rural Electrification Programme (1997)	Solar thermal and Solar PV	4
	Botswana Energy Master Plan (1996,2003)	Solar PV, Multiple RE Sources	4
Ghana	Ghana National Energy Policy (2010)	Solar, Hydropower, Geothermal, Multiple RE Sources, Power, Bioenergy, Biofuels for transport	4
	National Electrification Scheme (2007)	Wind, Solar, Bioenergy, Biomass for power, Multiple RE Sources	4
	Ghana Energy Development and Access Project – GEDAP (2007)	Wind, Solar PV	4
	Renewable Energy Services Programme – RESPRO (1999)	Solar, Solar PV	4
Kenya	Solar Water Heating Regulations (2012)	Solar Thermal	2
	Revised Feed-in-Tariffs for Renewable Energy (2010)	Wind, Bioenergy, Biofuels for transport, Bioenergy, Biomass for heat, Geothermal, Hydro, Solar	1
Mauritius	Sugar Industry Efficiency Act (1991)	Biomass, Bagasse co-generation	1
Nigeria	Nigeria Renewable Energy Master Plan	Wind, Bioenergy, Biomass for power, Solar PV, Hydropower	4
Uganda	Renewable Energy Policy 2007-2017 (2007)	Solar Thermal, Bioenergy, Geothermal, Hydropower, Multiple RE Sources for Heat and Power	4,1
	Renewable Energy feed-in tariff (2011)	Wind, Bioenergy, Bioenergy, Biomass for heat, Geothermal, Hydro, Solar	1
	Solar Power Subsidy (2007)	Solar PV	4
	Energy for Rural Transformation Program Phase II and III (2002)	Solar Thermal, Bioenergy, Biomass for power, Solar PV	4

** 1. Feed-in tariffs*
2. Quotas or obligations similar to renewable purchase standards (RPS) in the US
3.Competitive tendering for purchase of renewable power at a premium price
4. Financial incentives, like subsidies, grants,and tax exemptions
Source: International Energy Agency (IEA), RESolve Analysis

Similarly, the policy environment for selected countries in Asia is given below.

Table 1-4 Sustainability and Energy Access-Related Policy Environment for Select Countries in Asia

	Overall policy environment and government support (energy access policies, subsidies on conventional fuels etc.)
India	Low/no import duties and favourable taxation policies negated by huge subsidy on kerosene
Bangladesh	Insignificant subsidy on kerosene; Low/no import duties; Favourable taxation policies
Nepal	No subsidy on kerosene; Low/no import duties
Cambodia	No subsidy on kerosene; Import duties and taxes levied
Indonesia	Subsidized kerosene
Pakistan	Political instability; High import duties
Philippines	Taxation

Source: IFC – Lighting Asia: Solar Off-grid Lighting, February 2012

The IFC study recommends that giving out direct subsidies to reduce end-consumer prices is not the most effective way to promote solar energy. The best option is to strengthen the whole value chain through policy intervention and subsidies. A more detailed discussion on the ineffectiveness of policy support in India and Africa is presented in Chapter 3.

An important observation is that kerosene is highly subsidized in many countries (including India and sub-Saharan Africa). While this helps improve energy access, usage of kerosene leads to several problems as explained previously.

1.6.3 Financing

One major bottleneck for improving energy access, mainly through off-grid solar systems, is the high upfront cost and relatively long payback periods. Since people with very little energy access also tend to be very poor, they cannot afford these systems without attractive financing options. Moreover, due to the highly challenging, fragmented market, large enterprises refrain from entering the market to provide energy products and services like solar systems. One reason could be that they find it a better proposition to invest in more concentrated and homogenous markets. This leaves the market to small and medium-sized enterprises (SMEs), which overcome many obstacles but find it difficult to scale up, owing to lack of resources. In order to improve energy access, financing options should be made available to SMEs also.

1.7 Challenges to Expansion of Grid-Tied Systems

In many cases, energy access is limited, owing to the lack of access to a central electricity grid. As mentioned in Section 1.3, only 8 per cent of the rural population in Africa has access to the grid, while in India, only 57 per cent of rural households are electrified. Rural electrification can lead to improvements in energy access, provided the country has enough power generation capacity. Recognizing the importance of electrification, countries like India have set very aggressive rural electrification targets. India has a separate public sector enterprise called Rural Electrification Corporation Limited (RECL). Its mission is "to facilitate availability of electricity for accelerated growth and for enrichment of quality of life of rural and semi-urban population." More important, the Indian Government has set up an ambitious programme to electrify villages and provide energy access to all rural households. The programme, called *Rajiv Gandhi Grameen Vidyutikaran Yojana* (RGGVY) was launched in April 2005 and is being administered by the RECL. While the RGGVY had initially set an aggressive target of electrification of 100 per cent of households by 2012, this target remains largely unfulfilled.

Rural electrification in India, and in many other developing countries, faces several challenges. The World Bank has identified the following three challenges:

- High cost of electrification
- Policy and regulation
- Supervision and service quality

a. High cost of electrification

One of the reasons for the high cost of electrification is geography. If a place is an island or is surrounded by water, like rivers, or has a hilly terrain, laying transmission lines can be an enormous challenge and requires huge budgetary outlays. Moreover, the load (or the demand) will be highly distributed. The low population density also leads to low load factors. This can create additional challenges in grid-management. It is also important to note that many of the poor who are provided grid access may not be able to afford the electricity.

b. Policy and regulation

Since a majority of the consumers in the rural areas are poor, the government might be required to provide power to these consumers at tariffs that are below the full cost of service. In some cases, politics might lead to the supply of free power to influential farmers, which might be cross-subsidised in the form of higher tariffs elsewhere. Neither of the above cases is financially sustainable from the perspective of the power distribution company, unless it is backed by strong financial support from the government. In the absence of such policy and regulatory support, there will be no incentive for the utility companies to extend the grid to villages.

c. Supervision and service quality

This refers to the operations and maintenance of the grid in rural areas. Since the rural areas are sparsely populated, grid management at the tail end, or the last mile, could be very difficult. Since it is quite difficult to persuade trained engineers to work in rural areas, it is a big challenge for the utility companies to monitor the performance of the grid and also to maintain it. This again acts as a disincentive for utility companies to go for rural electrification.

1.8 Progress

According to the International Energy Agency (IEA) World Energy Outlook report, a household with adequate energy access is defined as “a household having reliable and affordable access to clean cooking facilities and a first electricity supply connection, with a minimum level of consumption (250 kilowatt hours [kWh] per year for a rural household and 500 kWh for an urban household) that increases over time to reach the regional average.”

Table 1-5 Electrification Rates as a Percentage of Total Population

	Population without electricity million					Electrification rate %				
	2002	2005	2008	Difference (2005 - 2002)	Difference (2008 - 2005)	2002	2005	2008	Difference (2005 - 2002)	Difference (2008 - 2005)
Africa	535	554	589	19	35	35,5	37,8	40	2,3	2,2
North Africa	9	7	2	-2	-5	93,6	95,5	98,9	1,9	3,4
Sub-Saharan Africa	526	547	587	21	40	23,6	25,9	28,5	2,3	2,6
Developing Asia	1019	930	809	-89	-121	68,7	72,8	77,2	4,1	4,4
China & East Asia	221	224	195	3	-29	88,1	88,5	88,5	0,4	1,7
South Asia	798	706	614	-92	-92	42,8	51,8	51,8	9	8,4
Latin America	46	45	34	-1	-11	89,2	90	90	0,8	2,7
Middle East	14	41	21	27	-20	91,8	78,1	78,1	-14	11
Developing countries	1615	1569	1.453	-46	-116	65,5	68	68	2,8	3,7
Transition & OECD	7	8	3	1	-5	99,5	99,5	99,5	0	0,3
World	1623	1577	1.456	-46	-121	73,7	76	76	1,9	2,6
	Urban electrification rate %					**Rural Electrification rate %**				
	2002	2005	2008	Difference (2005 - 2002)	Difference (2008 - 2005)	2002	2005	2008	Difference (2005 - 2002)	Difference (2008 - 2005)
Africa	62,4	67,9	66,8	5,5	-1	19	19	22,7	0	3,7
North Africa	98,8	98,7	99,6	-0	0,9	87,9	91,8	98,2	3,9	6,4
Sub-Saharan Africa	51,5	58,3	57,5	6,8	-1	8,4	8	11,9	-0	3,9
Developing Asia	86,7	86,4	93,5	-0	7,1	59,3	65,1	67,2	5,8	2,1
China & East Asia	96	94,9	96,2	-1	1,3	83,1	84	85,5	0,9	1,5
South Asia	69,4	69,7	88,4	0,3	19	32,5	44,7	48,4	12	3,7
Latin America	97,7	98	98,7	0,3	0,7	61,4	65,6	70,2	4,2	4,6
Middle East	99,1	86,7	98,5	-12	12	77,6	61,8	70,6	-16	8,8
Developing countries	85,3	85,2	90	-0	4,8	52,4	56,4	58,4	4	2
Transition & OECD	100	100	100	0	0	98,2	98,1	99,5	-0	1,4
World	90,7	90,4	93,4	-0	3	58,2	61,7	63,2	3,5	1,5

Source: Alliance for Rural Electrification

From the table above, it can be seen that the region – Developing Asia, especially South Asia, has made huge strides in all four areas mentioned above. However, the case of Africa is slightly different. While Africa has improved the electrification rate by about 2.2 per cent, the population without electricity has gone up. In fact, it is widely expected that the grid expansion will fail to keep pace with population growth for the foreseeable future.

Table 1-6 Number of People without Energy Access (2010) and IEA Projections for 2030

	2010				2030			
	Rural	Urban	Total	Share of population	Rural	Urban	Total	Share of population
Developing countries	1081	184	1265	24%	879	112	991	15%
Africa	475	114	590	57%	572	83	655	42%
Sub-Saharan Africa	474	114	589	68%	572	83	655	48%
Developing Asia	566	62	628	18%	305	29	334	8%
China	4	0	4	0%	0	0	0	0%
India	271	21	293	25%	144	8	153	10%
Rest of developing Asia	291	40	331	31%	161	20	181	14%
Latin America	23	6	29	6%	0	0	0	0%
Middle East	16	2	18	9%	0	0	0	0%
World	1083	184	1267	19%	879	112	991	12%

Source: World Energy Outlook 2012, IEA

The World Energy Outlook 2012 predicts that the trend in Africa where the grid expansion fails to keep up with the population growth will continue until 2030. According to the report, the number of people without electricity access in Asia will fall from 630 million in 2010 to less than 335 million in 2030. However, the corresponding number for Africa is expected to increase by 11 per cent to 655 million in 2030.

Chapter 2

Mapping of Technologies and Raw-materials/Inputs Used in Manufacture of Clean Energy Equipment

Energy access, especially per capita energy consumption, can be increased in two major ways— distributed power generation and energy efficiency. Unlike the conventional fuels, like coal and oil, which are not available everywhere, some form of renewable energy source is present in nearly every environment. Renewable energy sources include solar; wind; biomass; small hydro; ocean energy (wave and tidal); and geothermal energy. Of these, solar energy is omnipresent, followed by biomass. However, other sources of renewable energy are available only in certain geographies. For example, high wind speeds are not present uniformly across a particular geography. Similarly, small hydro is present only in rivers with relatively good hydraulic heads.[19] Ocean energy can be harnessed only along the coasts, and geothermal energy is also limited by geography.

Not surprisingly, solar energy and biomass have been the most commonly harnessed energy sources uniformly across the world since time immemorial. Even today, the heat from sunlight is being used for drying clothes, vegetables, and food items. As discussed in Chapter 1, biomass (firewood, agricultural waste or crop residue, cattle dung, etc.) plays a very important role for the energy poor in Africa and South Asia.

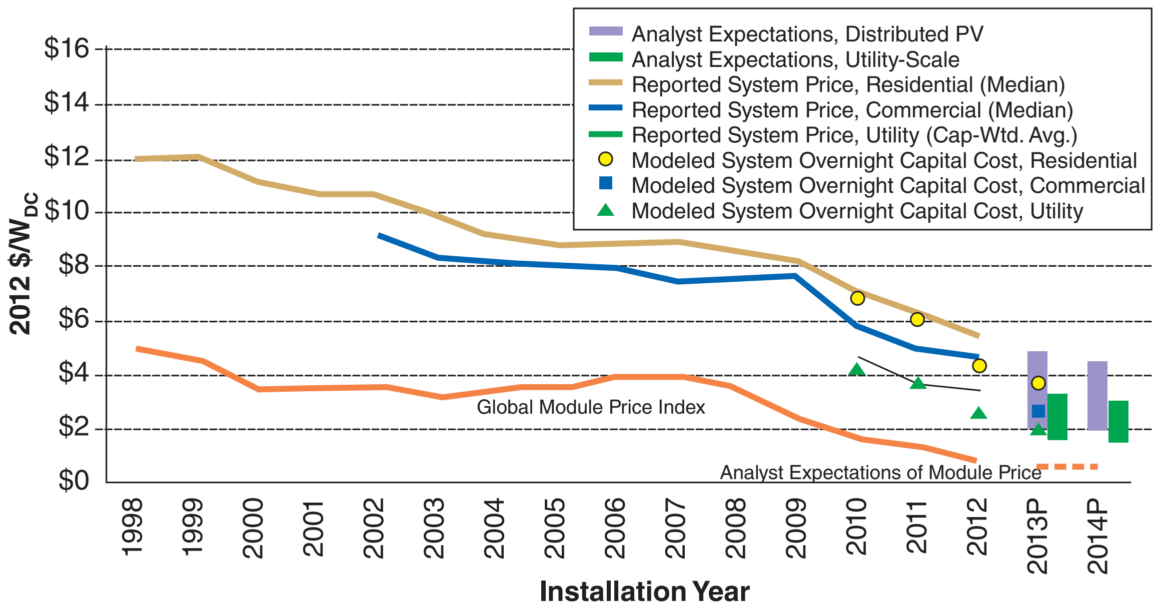
The rest of this paper will focus only on solar energy, owing to the influence of cross-border trade on solar and its impact on improving energy access.

2.1 Solar Energy

Solar irradiation has two components—heat and light. The heat of solar irradiation is captured directly and used to heat water or other fluids. The technology used to harness the heat of solar irradiation is commonly referred to as solar thermal technology. At the same time, the particles of light or the photons are converted to electricity by the semiconductors present in the photovoltaic (PV) panels. Since solar thermal technology is quite mature and is largely unaffected by the dynamics of the global supply chain, only solar PV technology will be considered.

While PV technology is about 50 years old, until recently, it was used only in special applications, like space. This restricted usage can be attributed to the high cost of PV systems. However, that has changed dramatically over the last four or five years, as PV system prices have declined significantly, with prices halving in some segments, making solar energy affordable to a vast majority of the global population. The price of residential solar systems, for instance, fell from about USD 9 per Wp in 2007 to about USD 5 per Wp in 2012. Similarly, the price of commercial solar systems fell (quite sharply) from about USD 8 per Wp in 2007 to about USD 4 per Wp in 2012.[20] One of the reasons for the sharp decline in the price of PV systems is the globalization of the entire value chain—from research and development (R&D) to product development and.

Figure 2.1 Average US PV System Prices Over Time



Source: National Renewable Energy Laboratory, Lawrence Berkeley National Laboratory (US), July 2013

Europe, especially Germany, started promoting solar PV in a significant way during the mid-1990s, as part of its targets to increase the share of renewable energy in the total energy pie. It is important to note that the promotion of renewable energy was driven more by environmental concerns than energy security or energy access, which was available to most of the population in this zone.

The attractive incentives provided in the form of feed-in-tariffs (FiTs)[21] for power projects by Germany initially and later by some other European countries led to the commercialisation of solar PV, which was until then restricted mostly to laboratories. A strong eco-system emerged as a result of the aggressive policy and regulatory support from Germany, and it covered the entire value chain, from R&D of materials and manufacturing processes, components manufacturing to system integration and project development. As of 2012, it has been estimated that about 65 countries have adopted a FiT mechanism in some form, driving at least 64 per cent of the global wind and 87 per cent of the global solar PV capacity.[22] The cumulative effect was that significant improvements were made both in terms of increased efficiency of solar PV systems and reductions in costs. Some of the constraints involved while devising an effective FiT strategy include:

- Investor security
- Energy access
- Grid stability
- Policy cost
- Electricity price stabilization
- Electricity portfolio diversity
- Administrative complexity
- Economic development and job creation

The dynamics of the PV industry changed dramatically when Chinese companies ventured into PV manufacturing. With the scale and the vertical integration they were able achieve in relatively short periods of time, Chinese companies were able to achieve significant cost reductions, which enabled them to gain significant market share in the global PV market. In 2011, eight Chinese companies were among the top ten PV manufacturers and combined Chinese and Taiwanese companies had about 40 per cent of global PV production capacity.

The positive effect of the cost reduction of PV has been the widespread adoption of the technology. This has been especially true in the off-grid space in remote villages.

2.1.1 Technology and components

Off-grid solar PV systems have the following components

- A lamp - either compact fluorescent lamp (CFL) bulb or light-emitting diode (LED)
- An in-built battery for energy storage. There are different types of batteries
    - Lead-acid batteries
    - Lithium-ion batteries
    - Nickel-metal hydride cells
    - Nickel-cadmium
- A solar PV module, which recharges the battery. The PV module is usually a stand-alone unit and in some cases integrated to the SPL. The solar PV technology could be crystalline silicon (c-Si) or thin film (TF).

Based on their scale, off-grid PV systems can be divided broadly into three different categories:

a. Individual solar lighting appliances—mostly lanterns, lamps, torches, or any other portable lighting device.

b. Solar off-grid home electric systems—typically consisting of a few lights, fans, and low-load appliances that are powered by solar.

c. Solar mini-grids serving a community/cluster of households or a village—These are larger systems that generate power at a community level.

The category (a)—individual solar lighting appliances—is relatively simple and has been considered the low-hanging fruit by manufacturers and distributors/retailers, which is why there is a larger number of players in this category relative to the other two categories. Category (b) is tougher, given that such systems are quite unaffordable for the low-income population and attractive financing options that mitigate the challenge of upfront payment for procuring the system are lacking. Category (c) is more complex, but may become the long-term solution to the problem of energy access with sufficient investment from the private sector for development of infrastructure.

2.1.2 Individual solar lighting applications or solar portable lights

Individual solar lighting devices are mostly portable can be broadly classified under two categories: basic lanterns and multifunctional lanterns.

Basic lanterns

The function of basic lanterns is to provide light for certain durations. These can further classified as

a. Torches/flashlights – This is used when someone is moving around in the night and helps navigation. Today, mostly incandescent torches powered by batteries are used. After usage, the batteries are thrown away without proper recycling, which poses significant environmental and health risks.

b. Reading/task lights – Normally used either in homes by children for studying or by adults who are engaged in activities like weaving, embroidery, etc.

c. Lanterns/ambient lights – These devices are used to light mostly indoors during the night and provide multi-directional lighting.

The range of light output and the corresponding range of solar power ratings for basic lanterns is 0.25-4 Watt Peak (Wp).[23]

Multifunctional lanterns

These devices act not only as lights, but also have added features like charging options for mobile phones, radios, fans, and other devices. These are typically more expensive and less affordable for the low-income population.

The range of light output and the corresponding range of solar power ratings for basic lanterns is 4-10 Watt Peak (Wp).[24]

2.1.3 Solar off-grid home electric systems or solar home systems

The main difference between the SHS and the lanterns is that solar PV panels are separate from the lights and/or other devices. They are also bigger in size and hence, costlier.

The SHSs can also be broadly divided into three categories—Basic SHS, multifunctional SHS, and advanced SHS.

Basic SHS

The basic SHS is meant only for lighting applications. Their advantage over lanterns is that these systems are more flexible and provide more ambient light.

Multifunctional SHS

These systems are bigger and in addition to lighting, multifunctional SHS have the functionality of mobile phone charging and power for running heavier loads for radio, television, etc. The size of these systems is typically in the range 10-40Wp.

Advanced SHS

The advanced SHS are very large systems with ratings of more than 40 Wp and power anything over and above mentioned the needs in the multifunctional SHS category (e.g. multiple lights, multiple fans, colour television, etc.)

2.1.4 Solar mini-grids serving a community, cluster of households, or a village

Mini-grids are stand-alone local grids that produce power and distribute the power to households and businesses in the locality. These micro-grids are not connected to a central grid, and the power generation could be from multiple sources—solar, biomass, or any other renewable energy.

In case of solar mini-grids, the size of the system can be as high as a few hundred kilowatts-peak (kWp).

2.1.5 Comparison of off-grid PV systems

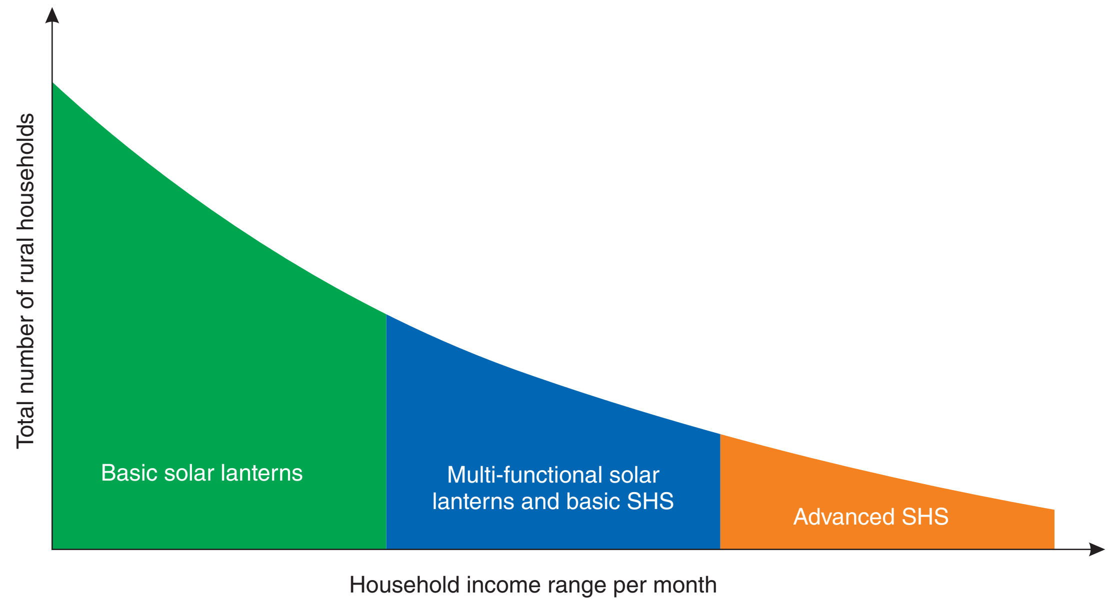
The choice of these technologies by end users depends on broadly two parameters—affordability and density of population.

Affordability

As mentioned previously, each of the three different technology types appeal to different market segments. Low-income groups would be buying SPLs, since they are the most affordable of the three types. The potential market for solar home systems is more among higher-income customers. The attractiveness of the third type—mini-grid—will depend on the unit cost of energy.

The figure below, from the report, *Lighting Asia: Solar Off-grid Lighting*, released by the IFC in early 2012, depicts the relationship between family income and market potential, mainly for SPL and solar home systems.

Figure 2.2 Off-grid Solar Lighting Market Segment in Asia



Source: Lighting Asia: Solar Off-grid Lighting, IFC, 2012

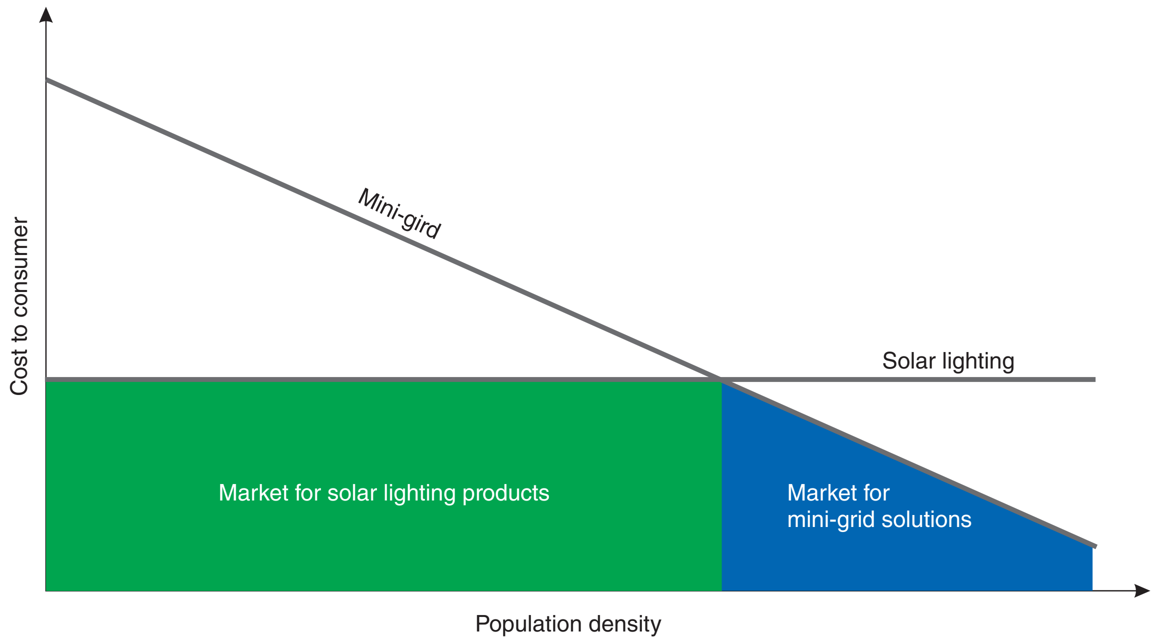
Even though the figure above is for Asia, it can safely be assumed that the relationship holds true for Africa as well.

Density of population

Mini-grids become cost competitive with other technology types (SPL and SHS) only in regions that have high population densities, as a single investment in infrastructure can accommodate a larger user base resulting in advantages offered through economies of scale. According to the ***Lighting Asia: Solar Off-grid Lighting***, when the population density is low, the SPL and SHS are more economical than mini-grids. However, above a certain population density, mini-grids become a better economic option than the stand-alone solar products, since the unit cost of energy decreases.

The report highlights this correlation in the figure below.

Figure 2.3 Market Potential for Solar Off-grid and Mini-grid Solutions



Source: Lighting Asia:Solar Off-grid Lighting, IFC, 2012)

The relationship is applicable for both Asia and Africa.

2.1.6 Examples and case studies

While the three categories of off-grid solar systems cater to different market segments, SPL and SHS can be grouped together as solar products. On the other hand, mini-grid is a system and the business case for a mini-grid is based on the sale of electricity. In this section, some examples from both categories are highlighted.

Solar Portable Lamps (SPL) and Small Home Systems (SHS)

These products, being the most affordable, have been able to penetrate the renewable energy based products market (especially the bottom of the pyramid) at a good rate. However, in many cases, despite policy support from the government in the form of subsidies and grants, these devices still remain out of reach for poor people, owing to cost. The presence of micro-financing institutions (MFIs) help in mitigating the high upfront cost, but lending by MFIs is still at a nascent stage.

In several other cases, the devices procured are not fully utilized, owing to a lack of proper after-sales service. Influxes of low-quality products and lack of awareness among end consumers are also major problems. Despite these challenges, the market is expected to grow, especially in Asia and Africa.

The total sales of off-grid lighting products in some of the Asian countries with the highest off-grid populations are estimated to be between 4.5 – 7.6 million in 2012. A breakdown is provided below.

Table 2-1 Sales Figures for Off-grid Lighting Products in Asia

Countries	Solar Lantern Sales [i]	Solar Home Systems Sales [i]
India	2.3-3.2 million	1.0-1.2 million
Indonesia	NA	260,000
Bangladesh	NA	680,000
Nepal	NA	229,000
Philippines	Approx. 3,000	40,000
Pakistan	NA	NA
Cambodia	10,000	10,000-20,000
Total	2.3-3.2 million	2.2-2.4 million

[i] Table includes both subsidized products sold as well as unsubsidized products

Source: Lighting Asia – Solar Off-grid Lighting, IFC

According to the IFC, more than 2.5 million people used off-grid lighting products in Africa in 2012.

Since high upfront cost is a major bottleneck to the penetration of these solar products, different business models have emerged. Some of the most prominent models highlighted by the IFC are given below.

a. Fee-for-service/rental model for solar products—Companies involved: SELCO, Barefoot, Schneider and TERI (Lighting a Billion Lives Programme (LaBL)) in India; Sunlabob in rural Laos, Soluz operations in Central America, Mali ESCO and BPC Lesedi in Botswana in Africa. This is by far the most successful model, especially the LaBL in India. However, the model is still in nascent stages in Africa.

b. "Pay-as-you-go"—Simpa Networks and SELCO, Gram Power in India

c. Acquisition of solar off-grid lighting products through remittances. Under this mechanism, loans are offered to people working in urban/semi-urban areas to procure renewable energy systems for use by their families who live in off-grid villages. A banking institution makes the upfront payment to the supplier who installs the system in the villages. Following this, loan repayments are collected by the bank from the working people in urban/semi-urban areas. For instance, the FOMIN project in Honduras and Haiti employs this method.

d. Financing SHS through monthly payment deductions—Piloted among palm oil farmers in Indonesia

e. Increase affordability through modular design where a customer can purchase a basic system with say a single light and then add additional lights or other accessories (additional modules), such as mobile chargers to the system as and when they are able to afford this. This lowers the high upfront capital cost by spreading it across multiple years. Sundaya in Indonesia has adopted this modular construction approach for its solar lighting products.[25]

Mini-grid

As previously noted, population density is a key condition to make a business case for mini-grid. In the case of mini-grids, an entrepreneur will invest in the infrastructure, and the revenue will be made in the form of sales of electricity. Solar mini-grids are at a very infant stage, and are the subject of experiments in Asia, mainly India. Some of the companies involved in the roll-out of mini-grids are Minda NextGen Tech; Gram Power (which uses prepaid meters); Micro-grid Power; and The Energy Research Institute (TERI) among others.

Chapter 3

The Domestic Regulatory Landscape and Important Eco-System Elements for Provision of Access to Energy

3.1 Introduction

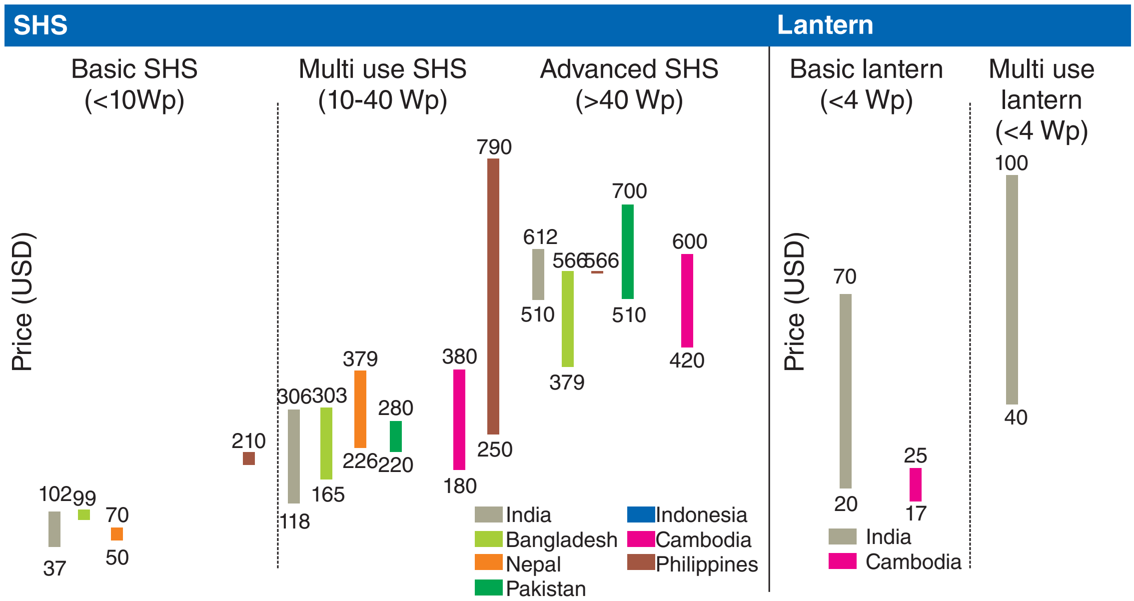
The policy and regulatory landscape in a country plays a major role in influencing the diffusion of energy among citizens in general and the choice of sustainable energy sources for energy security and access in particular. To understand why policy/regulation plays a vital role, one need only look at some of the significant challenges that stifle the uptake of renewable energy as a sustainable solution to energy security. Some of the challenges include:

- The high upfront or capital cost of renewable energy devices and systems.
- The need to ensure fair pricing of the products by fostering competition and trade, thereby transferring cost savings to end consumers.
- The need to target consumer segments' poor access to finance.
- Market dynamics favouring conventional energy sources.
- Enabling access to the required technology and expertise while at the same time ensuring the product or service fulfils certain criteria, such as quality of instance.

3.2 Combating High Capital Costs

The high upfront cost associated with a typical sustainable energy source is usually one of the main deterrents that dissuade consumers from adopting said technologies. For instance, in India a basic solar lantern costs anywhere from USD 20 to USD 70. Similarly, depending on the complexity of the system, an SHS system has costs ranging from USD 35 to USD 100 for a basic system up to USD 500 to USD 600 for more complex systems in India (refer to figure 3.1 for exact numbers).

Figure 3.1 Price Range of Solar Off-grid Lighting Products in Asia



Source: Lighting Africa, IFC, June 2010

The people who lack access to energy are usually those who live on daily wages, and the costs above suggest that it is more likely for such a consumer to adopt a solar lantern as opposed to a SHS. Even though the price of the lantern might appear to be low, for people living at or below the poverty line in developing countries, these expenses might be considered superfluous in the absence of adequate financial support.

Different countries have adopted different strategies to combat the high capital cost of these systems. The most common methods adopted include a flat capital subsidy offered (usually a percentage-based subsidy); completely doing away with any subsidy mechanisms and giving the product for free to those consumers who cannot afford them or providing soft loans that do not overburden the consumer.

3.2.1 Flat capital subsidy and its impact

As mentioned previously, the capital subsidy offered is a flat one. In India, the maximum subsidy offered is in the range of 30 per cent to 90 per cent of the capital cost, depending on the geographic area in which the consumer is located.[26] Typically, however, the subsidy to be provided to the end consumer is calculated by normalizing the costs to an INR per Watt-peak (Wp) number, i.e. the cost of the system with the final subsidy offered to the consumer being in an INR per Wp basis. What this necessarily means is that a higher capacity system would entail a higher quantum of subsidy. However, this mechanism ensures that the financial remuneration (as a percentage of capital costs) tends to remain the same irrespective of system size.

The capital subsidy mechanism implemented (as it is in India) has the following associated problems.

1. The capital subsidy offered per Wp is calculated based on what the government assumes is the most accurate price for said product. This is termed the benchmark price. However, all products are not made the same and tend to have different cost structures. This might also lead to a situation where the benchmark price assumed is not an accurate representation of the ground realities. For instance, the central policy regulator for renewable energy systems, MNRE, assumes a benchmark price of USD 6.5 per Wp for SHS systems, while systems readily available in the market tend to cost much more – about USD 15 per Wp to USD 17 per Wp. This leads to a scenario in which the capital subsidy offered might not be enough to adequately cover the installation cost, thus stemming uptake.

2. The subsidy offered in most cases is not upfront. The installer/distributor of the SHS/solar products usually does not take into account the capital subsidy while charging the consumer, and it falls on the consumer to procure this subsidy. This could result in a scenario where the consumer is unaware that a subsidy is on offer. The other issue with such a system is that the consumer is required to complete a large amount of paperwork and wait for extended periods (this could be anywhere from one month to six months) to secure reimbursement from the government body in charge of subsidy disbursements. The consumer perceives this to be cumbersome, which leads to him or her to opt out of purchasing the system altogether.

3. Capital subsidy also has the adverse effects where even high-quality products with superior performance have a hard time getting sold, because the consumer is willing to purchase the product only if it qualifies for a subsidy.

3.3 Access to Finance

Access to finance is perhaps the most important factor that affects the proliferation of sustainable energy sources as a solution to energy access and energy security. Access to finance (or the lack thereof) is not only a concern for the end consumer, but also for the companies that are involved in the manufacture, distribution, and sale of the product.

3.3.1 Upstream issues

Starting at the top of the value chain, manufacturers face the issue of securing the funds required for setting up manufacturing facilities. Usually, the lending offered for these ventures comes with very high interest rates. In regions, such as India and Africa, the interest rates associated with securing loans to fund the capital expenses associated with these facilities are anywhere from 12 per cent to 50 per cent. Extremely high interest rates also affect the cost of products, as these financing costs are then transferred on to the end consumer, thereby inflating prices.

While the capital cost, in itself, seems prohibitive, it is not insurmountable. Once this issue is addressed though, another more important issue emerges—securing working capital for procuring the raw materials required for manufacture. Working capital requirements also affect wholesalers and distributors. Since these companies are mostly SMEs, they are offered little credit from the manufacturers. Furthermore, for SMEs in regions such as India, the debt requirement is usually less than USD 1 million—an amount that is lower than the typical lending levels.

In addition, the spurt in demand for sustainable energy devices started fairly recently in regions such as India. The relative nascent nature of the industry as a whole is a concern for most financing institutions. For instance, the financial institutions in India require companies to show at least three years of profitability before they are awarded funding. A similar scenario exists in Africa. For example, in Nigeria, banks prefer to lend to growing businesses, which makes it difficult to obtain start-up financing without prior sales records.[27] This greatly reduces the chance to raise the funding that may be required to meet working capital requirements.

Another issue is the fact that sustainable energy devices seldom see huge sales numbers, especially in Africa. Because of this, most retailers keep stock of these products on a consignment basis, under which payment for the product is made only after the sale has been completed. This puts a huge strain on the working capital requirements of the suppliers, which further adds to the perceived risk and, in turn, has a direct impact on the willingness of financial institutions to lend, and when they do lend, the interest rates tend to be rather high.

Finally, different service providers use varying business models, and there is no one model that is adopted globally. This increases the risk perception held by banks as they do not have sufficient understanding of the products and services, as the sector is relatively nascent. This issue is rampant in both India and Africa where banks have limited understanding of the solar market and hence are very apprehensive with regards to financing the sector. In India, the issue is being combated by providing sufficient training to local bank mangers through training programmes organized by the MNRE and NABARD across the country.

3.3.2 Downstream issues

The product retailers and the end consumers comprise the downstream segment of the value chain. Retailers are usually small outlets that sell the product to the consumer. Retailers, much like the distributors and wholesalers, have the issue of securing credit on products. The products that they sell have to be purchased with the cost sunk into the business. The issue here is twofold:

1. Due to their very nature, retailers are not large entities. This translates to them having very little capital to start the business. This, in turn, leads to the issue where the retailers do not generally hold a large inventory of items, and if the demand for a particular product suddenly spikes, they are unable to keep up with the demand, owing to supply chain issues and time delays associated with sourcing.

2. Retailers are the ones most readily exposed to the end consumer. The end consumer, as discussed previously may not always be able to pay upfront for the products. Retailers might offer to sell the products on monthly instalments, leading

to the next big issue—non-payment or delayed payment by the end consumer due to their poor financial condition, which has an immediate impact on the profitability of the business.

Access to finance for the consumer is perhaps the biggest issue, as a business can only sustain itself if the product/service it offers is consumed. As mentioned previously, most of the target audience for these products tends to have very little credit history or capacity to pay huge upfront amounts (even after accounting for the capital subsidy). In such situations, the only option is to go for loans, so that upfront payment can be made to the smaller retailer (thereby reducing the retailers' risk). One of the most common ways employed is to offer soft loans, i.e. low interest rate loans that do not overburden the consumer. For instance, in India, an end consumer (provided he is an individual and not a business entity) can access soft loans for the amount he owes at a rate of 5 per cent. The way these loans function is as follows:

1. Consumer approaches any banking institution for a loan;
2. Bank verifies the loan is for the procurement of a sustainable energy device;
3. Once the verification is complete, the loan is sanctioned to the end user;
4. A refinancing institution, which in case of India is the National Bank for Agriculture and Rural Development (NABARD) pays back the financing institution and recoups its expenses by charging a low interest rate to the consumer.

In practice, however, there are some issues. Due to the aforementioned issue regarding lower capital subsidies resulting from the improper estimation of product prices, the consumer usually has to opt for a larger quantum of debt. In this scenario, the consumer is eligible for soft loans only for an amount that is less than the actual price of the product. Thus, the consumer has to secure an additional loan to cover the rest of the product price. This additional loan is usually at a higher interest rate, which tends to overburden the consumer.

The other issue is that the refinancing institutions are often ill-equipped to handle the task of supplying loans for sustainable energy systems, as most of the employees have not been brought up to speed on the nuances of sustainable energy systems. This issue is compounded by the fact that the refinancing institution is part of the system that is expected to spread awareness of these systems and encourage consumers to opt for the loans in order to afford the products and services.

3.3.3 Micro-financing

Micro-financing institutions (MFIs) could play a major role in increasing the affordability of sustainable energy systems in most developing nations. Although there are many MFIs in countries, such as India, and in Africa, their impact on the segment is not readily felt. Most MFIs have an extremely conservative approach toward financing the sustainable energy segment (particularly small-scale off-grid products). One of the main reasons for this may be their lack of understanding of the market and technology. MFIs feel the high transactional and operational cost in extending credit to consumers at the bottom of the pyramid, especially in the wake of low demand for such products, is not warranted. On the flip side, the remote nature of the locations where the demand for these products is usually high does not lend to the establishment up branch offices that can cater to the local consumer base.

3.3.4 Innovative business practices

The whole financing issue can be sidestepped to a reasonable extent by employing innovative business practices that ease the financial burden on the end user as well as the retailer. Some of the more innovative business practices employed include:

1. A rental model where the consumer pays a small rental fee for the use of solar lanterns. The downside of course is that

though sustainable energy technology gets perpetuated through the community, users can be become jaded if substandard products are rented out, thereby limiting the possibility of a future purchase of the off-grid solution. On the up side, the consumer is freed of any maintenance and service related issues.

2. A 'pay-as-you-go' or 'pay-per-unit' model in which the consumer is only required to pay for every unit of electricity consumed. The advantage here is the large upfront cost usually associated with setting up say an SHS system is borne by the system integrator. In some cases, the model is taken a step further where once enough money has been paid back to the system integrator over time, system ownership is transferred to the end user who then gets complete control over all energy generated. This model has been taken a step further in India where a start-up known as Simpa seeks to leverage the booming mobile phone market in rural areas. The consumer can top up his prepaid energy meter through mobile airtime distributors and use the energy generated until his balance runs out. This new concept also overcomes two significant issues, namely payment collection and setting up distribution centres at the last mile areas.

3. The United Nations Environmental Programme (UNEP) has proposed a system of financing SHS systems using monthly payroll deductions on behalf of the financing institution. The UNEP recommendation was made for farmers looking to setup SHS systems in Indonesia.

3.4 Standardization

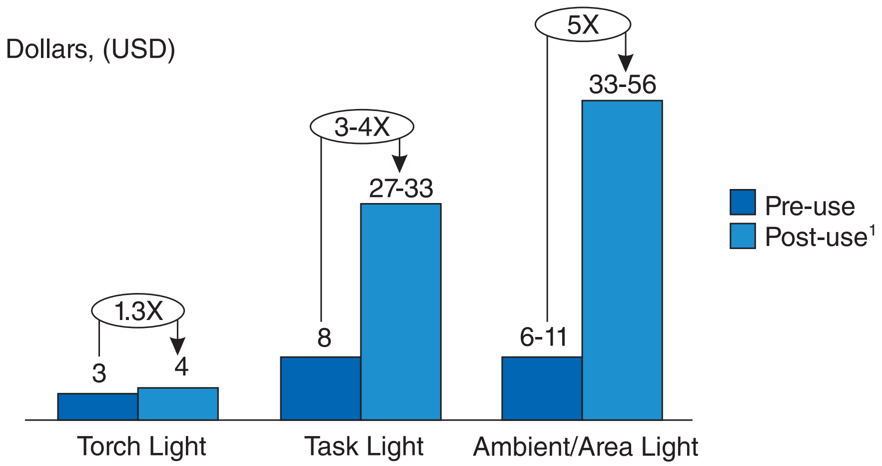
3.4.1 Certification and testing

Since the target market segment for most off-grid products is the low-income group, which considers an investment on off-grid products to either be one time or at the very least a long-term investment, ensuring that the products conform to the highest standards translates to improving product longevity.

Figure 3.2 Customer Willingess to Pay for Higher-Quality SLPs

Willingness to pay increases substantially on exposure to quality solar portable lighting products

Customer willingness to pay for quality SLPs: Pre-use vs. Post-use



Post-use rise in willingness to pay indicates the strong value proposition of SLPs, but also demonstrates the need for customer education.

Source: Lighting Africa, IFC, June 2010

In a study conducted by IFC for the report *Lighting Africa* it concluded that the willingness to pay increases greatly after the consumer has used a quality product. This also suggests that the consumer is willing to pay a higher quantum of money (anywhere between three and five times the original price) for a product of superior quality that does not break down often. This is great news considering how little the end user has to pay in the long term by serving to overcome the scenario highlighted by Captain Samuel Vimes' 'boots' theory of socioeconomic unfairness, which states that a low-income person tends to spend more on a pair of boots (as opposed to a more affluent person who can afford boots of higher quality) over the course of his life, since he often procures cheap, low-quality boots that are readily affordable at his income level, but require regular replacement while a rich person's investment tends to last much longer, thereby lowering the total money spent on boots over time.

The quality of a product can be ensured by employing designated testing centres, which can grade and certify the product. In India, all off-grid products seeking to secure subsidies have to be graded and certified by one of the many testing centres approved by the Ministry of New and Renewable Energy (MNRE). Since most consumers' purchase decisions are heavily influenced by the availability of subsidies, almost all manufacturers/distributors in the country are forced to ensure that their products are certified, thus ensuring quality.

In some countries in Africa, however, there are no regulations that govern the standards of the products that can be sold domestically. Countries that do have technical specifications and regulations, such as Morocco, South Africa, and Tunisia, have witnessed significant gains in market shares for domestic manufacturers. For instance, in Tunisia, the technical specifications and regulations have resulted in seven to eight local manufacturers gaining 80 per cent of the local market share while side-lining cheap but inefficient Chinese imports.

In addition, most countries in Africa lack sufficient testing facilities, while the test bodies in countries that did have them were considered to be bureaucratic and slow to respond. Furthermore, the tests conducted in these testing centres did not fully address the key factors that influence the quality of the end product. As a result, Africa is plagued with low-quality products that often break down, dissuading customers who then prefer to use standard lighting/heating systems, such as kerosene stoves and lamps in spite of the health risks they pose.

3.4.2 Adverse impacts of standardization

While standardization of systems ensures quality, it can at times also be detrimental to the segment. For instance, in India, MNRE guidelines dictate that in order for an off-grid system or product to be eligible for a subsidy it has to conform to certain guidelines that limit the choice of components, such as specifying the wattage of solar panels, battery sizes, and fixtures to be used for off-grid products.[28] This has a twofold effect—products can no longer be customized to better suit consumers' requirements since they would not conform to standards. It has been shown that customizing products or using a modular design for off-grid systems to match the consumer's requirement can lead to significant cost savings. In this scenario, however, the cost savings cannot be passed on to the consumers as in doing so the consumers are deprived of the savings from subsidies, which tends to make the solutions unattractive. Also, superior-quality components that might offer better performance cannot be employed as they might violate the standards specified.

3.5 Consumer Awareness

In a rapidly evolving market such as this, awareness creation is one of the most important factors that determines the success of a product/service. In addition to awareness creation on the favourable impact of the use of sustainable energy off-grid products, it is more important to educate consumers on the detrimental impact of traditional power systems, in particular the use of kerosene as an energy source. Studies indicate that a significant portion of the African population has limited to no awareness of the negative impacts related to the use of kerosene and other fossil fuels on health and the environment.

In India, the government has gone to great lengths to create consumer awareness. The MNRE has implemented a programme on information and public awareness, using electronic media; print and postal media; exhibitions and outdoor media, like hoardings, kiosks etc.; and other state specific nodal agencies in charge of policy and regulatory aspects of renewable energy technology in their respective states. The extensive awareness-creation campaign has had some positive influence on the uptake on sustainable energy sources, but not to the extent predicted. Even though the media campaign was extensive, the message has not permeated to the sections at the bottom of the pyramid, perhaps because of their lack of access to the aforementioned information outlets.

In the absence of awareness creation programmes undertaken by the government, the next most reliable form of information dissipation is likely to be through NGOs. Typically, NGOs operating in various countries would have already come up with distribution channels for other initiatives, which can be tapped for renewable energy systems too. These channels can also be used to dissipate information to the most remote corners of the country in which they operate, which are likely to be the hardest to reach areas not covered under other initiatives.

Manufacturers and other stakeholders in the value chain have understood the importance of partnering with NGOs, and hence many of the top companies in this sector have already partnered with the various NGOs across the world as they tend to have a positive influence on their business interests. It is vitally important that manufacturers and distributors leverage any advantage they can, because the off-grid product/services market is not a seller's market but a buyer's market. An example of this is TATA solar's tie up with the Ramakrishna Mission or D.Light's association with Southern Orissa Volunteer Association (SOVA) in electrifying villages in India.

3.6 Demand Drivers

3.6.1 Usage pattern

In a study conducted by GIZ, 80 per cent of the households surveyed in Uganda ranked availability of better lighting solutions as one of the main solutions that would improve their quality of life, and 65 per cent of the households identified better lighting conditions to be the top priority.[29] Such is the need for improved lighting that it ranked above better access to water in the survey. Though this might not be an accurate representation of the general consensus, it can be assumed that these results reflect the ground realities in most rural households with limited or no energy access.

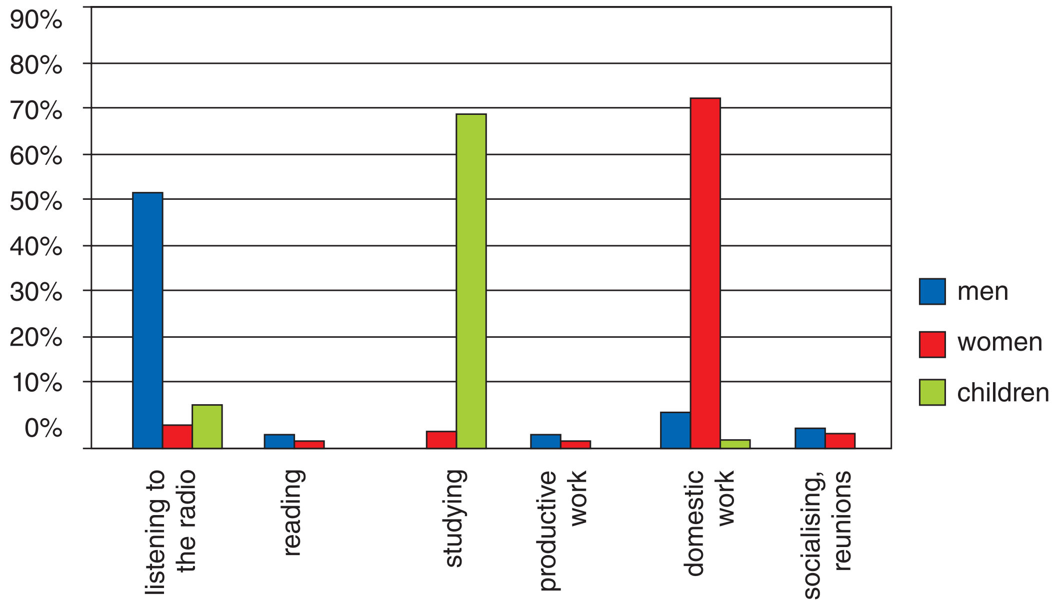
Most houses in off-grid areas or areas with limited access to energy use primarily hurricane lamps as the main source of illumination. In addition, there are two distinct usage patterns visible in these regions—one in the morning and one after dark.

Typically, the usage pattern for lighting purposes is as follows

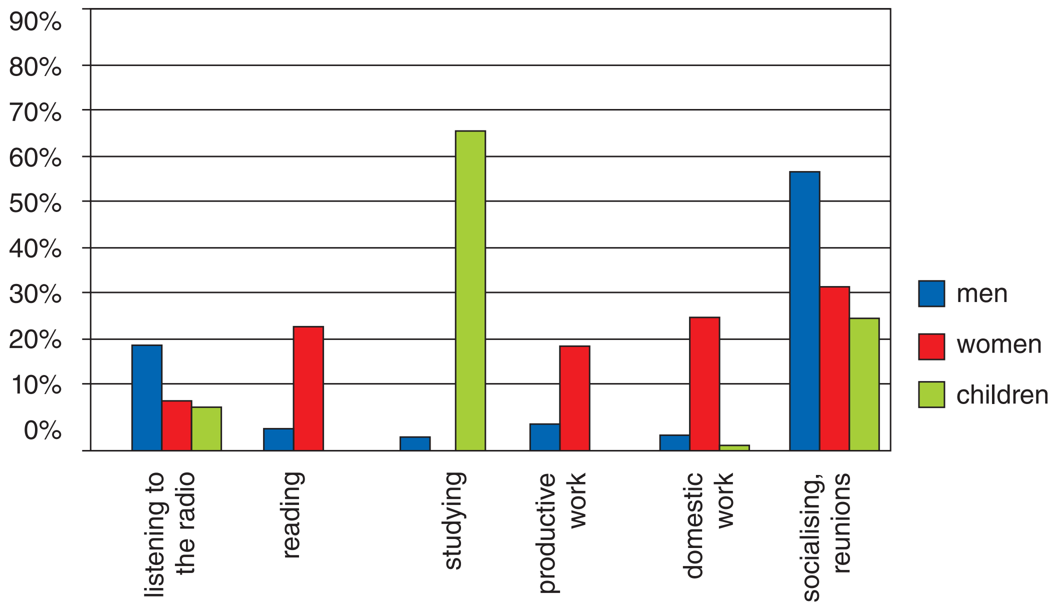
- Hurricane lamp – used for four hours a day placed on a table in the main room
- Wick lamp – usually used in the kitchen
- Flashlights – used for outdoor purposes

Figure 3.3 Morning and Evening Activities by Rural Household members in Uganda

Morning activities



Evening activities



Source: Solar Lamps Field Test Uganda, GIZ, July 2011

As can be seen from figure 3.3, the usage pattern differs across the members of the household as well as the time of the day. While men prefer to listen to the radio in the morning, the women of the household are engaged in domestic work, although both require energy use. The children's usage pattern for energy as well as light remains constant, as they require it only for studying. What is almost unanimous is the requirement of energy/light for socializing as well as reunions which more often than not are undertaken in the evening/night.

Lack of proper lighting conditions were shown to impede a number of activities, but the effect is most felt on the number of hours available for a child for studying as well as the number of hours available for the adults for reading. Thus, it is fairly evident that improved lighting conditions in a household could lead to better education not only among children, but also to help the literacy rate among adults.

It has been shown that improved lighting through the use of solar lanterns increased the time spent on studying by children by 10 per cent to 25 per cent. In the case of the adults, better lighting conditions have improved the time spent on reading by at least 10 per cent, as they are able to use both the morning as well as evening hours for reading. In addition, there has been a 5 -10 per cent improvement in the amount of productive work undertaken by adults as a result of improved lighting conditions.

3.6.2 Product preference

Product design

It is no secret that the target consumer segment in the regions under consideration prefers traditional lighting methods such as hurricane lamps, simple wick lamps, etc. In order to develop a solar product for these consumers, a good starting point would be to understand the operational characteristics of the typical lighting sources used along with their usage pattern and attempt to mimic their operational characteristics so that the switch to an alternate source is as comfortable as possible. Users would prefer to use products they are well acquainted with and hence tend to adopt solutions that mimic characteristics of say a hurricane lamp, as they are familiar with the way they are operated.

Since the users are unaccustomed to the modes of operation of new technologies, the product should almost always be accompanied by instructions on how to operate it. The instructions are expected to be clear, concise, and readily digestible. Further, clear representation on the switches that indicate when the product is on or off and an additional indicator for instances when the product is charging or discharging could further improve ease of use.

Quality perception

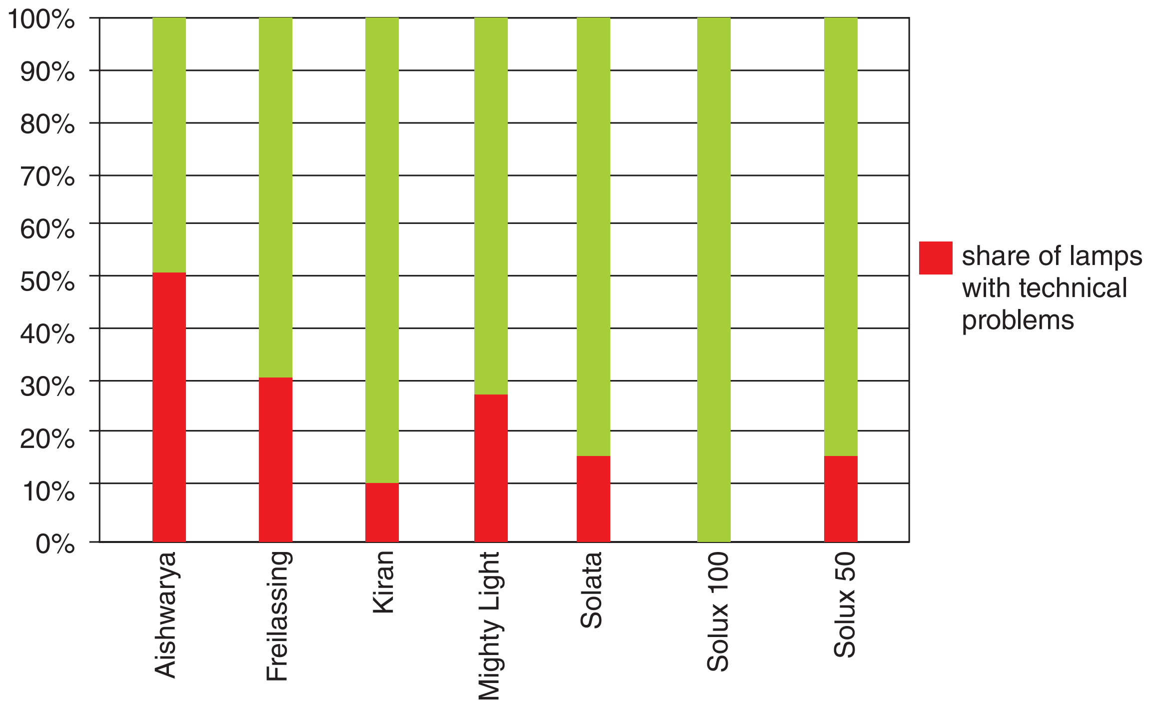
An average consumer in the target segment typically falls under one of two categories: an informed consumer and an uninformed consumer seeking to try an alternate solution for the first time. Quality perception among most users starts with where the product being sold has been manufactured. Many consumers, usually falling in the uninformed category tend to perceive that products "made in China" are usually of lower quality than those made in Germany.

The stigma attached to products made in China is not unwarranted and is usually the result of the user having used other products (related or unrelated) from the country and having it breakdown due to poor manufacturing practices employed, usually to reduce cost at the expense of quality. This scenario is equally true for both countries in Africa and India.

Figure 3.4 below shows the rate of fault occurrence during a three month period in which products were tested in Uganda. The product with one of the highest failure rates—Aishwarya—was manufactured in India, while the product with the lowest failure rate—the Solux 100—was manufactured in Germany. Real-life examples such as this only serve to supplement the perception that products manufactured in Western countries are of higher quality and better fault tolerance than those manufactured in eastern countries such as China or India.

Quality can be enforced through testing and standardization procedures and ensuring that the products are pass these tests while adhering to the standards specified. It is however imperative that the standards are set in such a way that does not cripple innovation and flexibility as discussed in section 3.4. Service centres should also be readily accessible to rectify any issues faced by the consumer to ensure minimum downtime.

Figure 3.4 Share of Solar Lamps with Technical Problems in Uganda



Source: Solar Lamps Field Test – Uganda, GIZ

Because the technology is almost alien, many users would consider solar devices to be fragile and would be more hesitant handling them than they would more traditional products. Thus, users need to be sensitized to the rugged nature of the product (while ensuring that the product is built to high standards to ensure ruggedness) so that they can handle these products as they would their go-to solutions.

Versatility and luminance

Most of the target consumers would consider the purchase of a solar product a one-time investment and thus would expect to get the most value for their money, especially as the product is relatively more expensive than the traditional solutions. Considering the way these products are usually positioned—either on a table on hanging from a wall, consumers prefer solar lanterns to offer a 360 degree horizontal light cone and luminance levels that are sufficient to illuminate the entire room as is the case with a traditional hurricane lamp.

It should be noted that good light quality is the most important choice factor after ruggedness and robust build quality. Even the light hue matters—there is a general preference for 'white' lights as opposed to 'warm' lights, which usually have a yellow tone. The 'white' lights give the perception of higher brightness levels, which is what consumers look for. Higher brightness levels can be achieved through the use of a good-quality illumination medium, i.e. LEDs or CFLs, which are more prevalent in the case of goods imported from the West.

Lighting preference can vary across geographies and usage patterns though. For instance, in India street hawkers and farmers had varied preferences. In the Indian market, consumers prefer LED lighting, owing to the lower power requirement and hence increased battery life. Use of LEDs is also beneficial, as LEDs are usually cheaper and offer greater efficiency. On the flipside, there are users who also prefer CFL lights, owing to the perception of greater brightness and better colour temperature. Having witnessed this phenomenon, SELCO in India designed their products based on the target segment in which the product is to be sold. They have specifically designed models using CFL lighting to target the micro-entrepreneur segment, as entrepreneurs felt that CFL lit up their stalls better.

In the case of lighting, a single room illumination is not the only scenario that can be envisaged. Users prefer to carry light sources with them when they are outdoors too. Thus, a multipurpose lamp that can be designed with this in mind to offer different modes of operation at different luminance levels, such as room lighting. A switch to change into a unidirectional lighting solution akin to a torch could prove to be immensely beneficial to the consumer, as it helps him or her use the product as a one-stop solution for diverse needs. It could enable the customer to forgo the need for a torch for instance. Further, the addition of carrying handles could help improve mobility as well as facilitate hanging the lamps from walls.

Section 3.6.1 above highlighted that consumers usually spend their time listening to the radio in the morning, thus adding bonus features, such as a built-in radio, for instance would greatly boost uptake. In addition, considering the cellular boom and the fact that most rural users would have to traverse long distances to recharge their cellular devices, an option to recharge their devices by connecting it to the lamp could prove beneficial. Nuances such as this would have to be identified and exploited to coax the consumer into buying the products. Some products in the market, such as the Freilassing, offer a radio option.

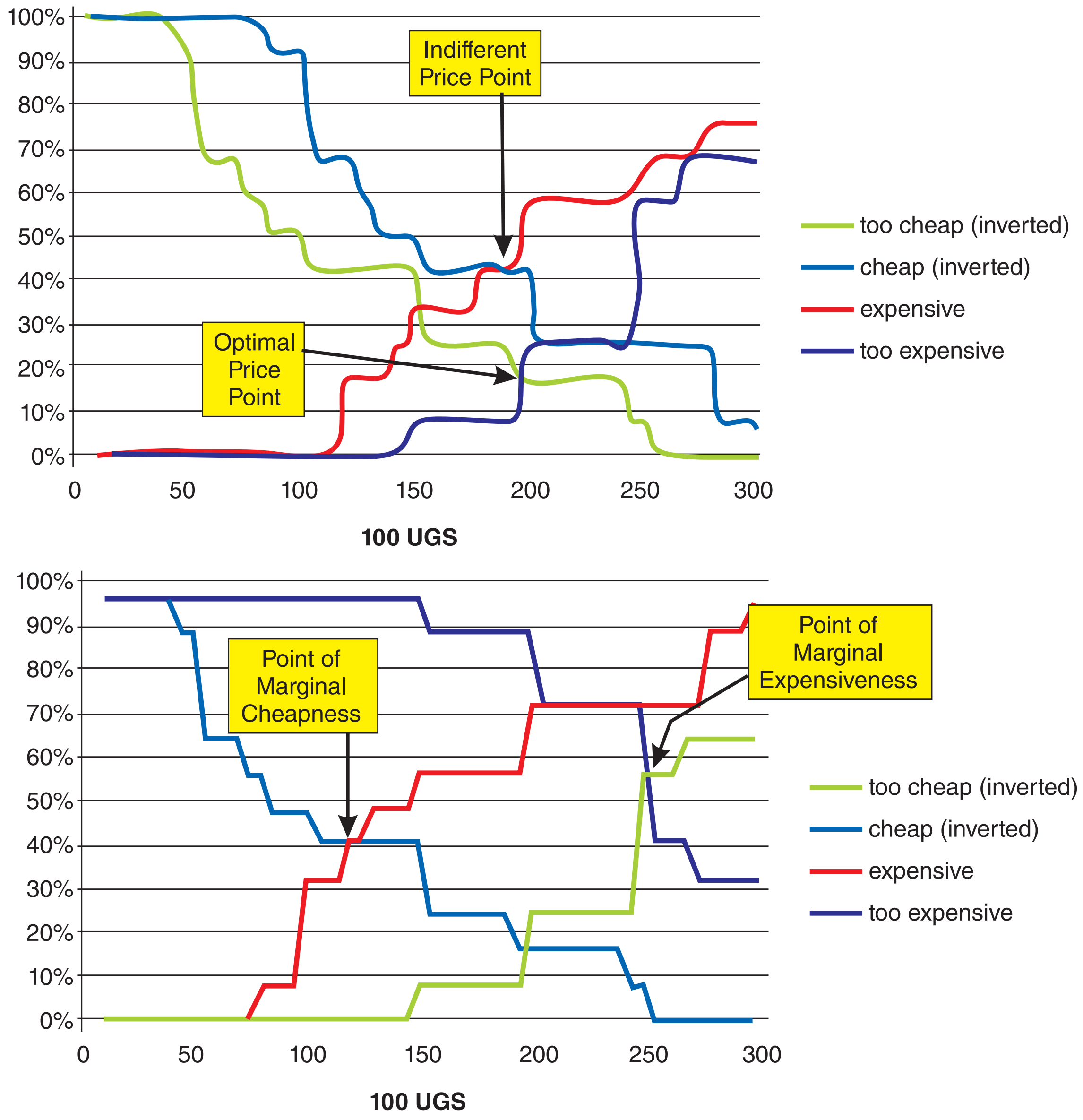
3.6.3 Price preference

Pricing the product can be a tricky process. The most obvious concern that should be addressed is that the product should not be priced so high that it remains out of the reach of the target consumer. In addition, the price point should be set in such a way that highlights the monetary benefit of owning the product—i.e. the product should have a readily visible short payback window in which the higher upfront price of the product is justified by the savings incurred by minimising operational costs that would have been incurred otherwise (for instance, instance procuring kerosene to fuel hurricane lamps, etc.). Savings are also a function of the quality of the product, as lesser availability of the product translates to greater use of the traditional fuel source. Thus, it is imperative that the quality of the product be adequate to make it economically viable.

The reality, however, is not so straightforward. Merely setting a low price for instance can prove to be detrimental. Consumers, even those with low purchasing power, often judge a product's quality and performance by price. Thus, an extremely low price point may give the impression that the product is automatically of lower quality.

The product supplier would thus have to strategically price the product using various frameworks, such as the Van-Westendorp Price Sensitivity Measure, which precisely takes into consideration the 'too cheap' price point and the 'too expensive' price point where the product becomes unattractive. For exercises such as this to be successful, the product manufacturer would have to venture into the market and interact with their target consumers to accurately gauge the variables associated with price. Figure 3.5 below showcases an example of this exercise. Please note that the horizontal axis represents the price point in whatever the local currency may be in the target region.

Figure 3.5 Example of Analysis of Van Westendrop Graphs for a Specific Product



Source: Solar Lamps Field Test – Uganda, GIZ

Chapter 3

3.7 Infrastructure

It is imperative that any policy adopted for the propagation of off-grid products and services is wholesome and encompasses the entire value chain without focusing on the last mile in a product life cycle alone. An approach such as this is not only beneficial to the consumers, manufacturers, distributors, etc., but also to the government implementing the policy, as it allows the government to scale down its involvement in the market once it becomes self-sustained.

A good example of the above-mentioned implementation can be seen in how Bangladesh handled the issue. The policy and regulatory measured adopted by Bangladesh encompassed the entire value chain. On the downstream side, the consumers were aided through the provision of soft loans and consumer interests were guarded by the implementation of rigorous quality control. On the other side, distributors and manufacturers were helped by the government, which provided marketing and promotion support and aided them with quality-control support. An adverse effect can be seen from how Indonesia implemented policy. In Indonesia, sustainable energy products were distributed freely without significant emphasis on developing a sustainable market. This ended badly, as it restricted the entry of private players, since all the products to be used were sourced through a tendering process. This has also resulted in many users opting out of the system after a certain period, perhaps owing to lack of continued support, as it was a one off deal.

3.7.1 Product distribution

The distribution channel is perhaps the most important part of the product life cycle, as it forms the bridge between the finished product and the end consumer. In addition, focus on product distribution in developing areas becomes all the more important, because it is the distribution part of the value chain where most developing countries, which are not manufacturers of systems, can realize social and economic gains (through job creation).

The *Lighting Asia* report has identified four distribution models used by private sector enterprises. These include:

1. Institutional partnerships—where the company ties up other profit-making entities or NGOs that have significant presence in rural areas. This is perhaps the most likely solution to be adopted as it provides access to the established distribution channels of the partner.

2. Company-owned branches—the company sends up a wholly owned branch in the target areas for marketing and sales of the product.

3. Micro-franchising—the enterprise identifies micro-entrepreneurs at a village level and provides them with the necessary tools and skillsets for product distribution and after-sale service.

4. Traditional distribution channel—a widely seen concept across various markets where the manufacturer sells his product to a distributor, who in turn might sell the product on through its own network of sub-dealers or employ other micro entrepreneurs to facilitate sales.

3.7.2 Service network

After-sales service is important, as it helps retain a customer base and reach a wider audience through word-of-mouth sales. This is beneficial not only to a profit-making entity involved in the market, but it also greatly increases adoption rates of these products in general.

Manufacturers opting to setup wholly owned branches for sales of their products have the upper hand when it comes to servicing. This is because the branches are better informed of the product and associated technology and equipped to handle any issues that may arise. At the same time, employing traditional distribution methods or going for micro-franchising tends to affect after-sales service if adequate training is not providing. This affects the manufacturer directly, as it might spoil the company image and undermine any branding efforts undertaken. In addition, poor experiences with such products because of the lack of after-sales services tends to affect the industry as a whole, as consumers are dissuaded from purchasing new solutions, instead opting to stick with their tried and tested conventional energy systems.

3.7.3 Grass-roots level organizations

The importance of grass-roots level organizations is highlighted best by the favourable outcome of Bangladesh's Infrastructure Development Company Limited (IDCOL) solar programme. The pivotal factor that contributed to the programme's success was its partnership with various community-based organisations (CBOs). These CBOs are village based and interact directly with the people in their respective rural regions. As such, they help tremendously in both awareness creation as well as product/ programme promotion, as the entities are deeply associated with the respective local population, suggesting that they might have already built a high level of trust among consumers. In India, as mentioned previously, TATA employed the help of local volunteer organizations to provide after-sales service in various villages, suggesting the flexibility of these CBOs to undertake not only sales, but also service.

3.8 Taxation and Competing Subsidies

3.8.1 Taxation

The components used in sustainable energy systems much like any other component that is being imported or sold is subject to taxation. Taxation of the components used in the product increases the production cost of these systems—an added cost that is then transferred to the consumer. It should be noted that the price of the components used in these systems account for about 50 per cent of the final product price. Considering the need for adoption of sustainable energy systems and the fact that the consumers who are most in need of these systems have lower purchasing power, most governments have opted to abolish the taxes on these components.

Import taxes and duties, however, remain high in some African countries, such as Rwanda and Ethiopia, where imports of assembled lanterns have very high value-added tax (VAT) of 18 per cent and 16 per cent, respectively. Though this form of taxation might encourage the setting up of local units for manufacturing of the components used in assembling a product (since the components can be imported tax free), it significantly affects proliferation of off-grid products, as such manufacturing units require significant investment, which is not readily available and hence the likelihood of a manufacturing unit remains low. In India, most products can be imported tax free. However, in order to qualify for the capital subsidy (which in the case of India is 30 per cent of product cost), the products need to be either manufactured or assembled in the country, which generally deters the import of pre-assembled products.

Other issues continue to persist in countries in Africa. For instance, even though tax and duties have been removed for sustainable energy products and associated components, the news has not propagated further down the hierarchy and to the people who actually implement the regulations in practice. The customs officials in some countries in Africa continue to impose taxes on these products most likely because they are not informed of these changes in regulations.

3.8.2 Domestic sourcing bias

As has been previously mentioned, creating a holistic domestic ecosystem is of prime importance to improve adoption rates and create a self-sustaining market. One of the methods adopted to achieve this goal is the imposition of a domestic content requirement (DCR). This is an issue most common in India rather than Africa. Under a DCR, it is stipulated that for a product to be eligible for a capital subsidy, it has to use components manufactured within the country. In India, for instance, the modules used in solar products, such as solar lanterns, mobile chargers, SHS systems, etc., have to be manufactured locally to be eligible for the subsidy. The imposition of this DCR has the following impacts:

- The subsidy is available only for domestically manufactured goods—thus, those products that are imported, even if they are of higher quality are ineligible for the subsidy. This absence of a subsidy results in a net increase in product price

- Another method adopted to dissuade imports and promote domestic manufacturers is the use of high import duties. Most recently, in India, the government is evaluating the imposition of anti-dumping duties (ADD) on solar modules imported from countries such as China and the US.[30] These duties are expected to be very high, so that the price of imported modules better matches that of domestically manufactured units. Thus, the manufacturer of a solar product may not always get the best (lowest) possible price for the components used in his product, which directly results in an increase in the cost of production. This translates to a price increase for the end consumer, thereby having an adverse effect on adoption rates.

3.8.3 Competing subsidies

It is a well-established fact that kerosene is the primary fuel source in most developing countries, including India and those in Africa. With this in mind, the governments of the various countries have heavily subsidized kerosene so that it is more affordable for the poorest people in rural areas. The not only creates a severe price disparity between kerosene and other sources of energy, but also increases the financial burden of government institutions significantly. In spite of this, sustainable energy products, such as solar lanterns, are able to compete on price with kerosene. However, since the savings are marginal, cost is not a sufficient incentive for customers to make the switch as they are satisfied with the status quo.

In view of the above-mentioned problem, it may be wise to channel the funds used for incentivizing kerosene and other fossil fuel sources to help better support renewable energy systems. This could include using the funds to not only provide direct capital subsidies to the systems, but also to support other initiatives, such as awareness creation undertakings that could improve user acceptance of the systems.

Chapter 4

The Relevance of Trade and Investment Policies for Supply-Chains: Issues, Challenges and Opportunities

4.1 Introduction

The previous chapter highlighted some of the crucial aspects that could improve the uptake of sustainable energy based products and systems and focused more on the consumer segment. However, this is only one side of the story. In order for these systems to reach a wider audience, the policy and subsidies should be designed in a way that focuses not just on the end consumer, but also on the service providers and manufacturers who facilitate the availability of said products and services.

In order for this to happen, policies and subsidies adopted should work to strengthen the entire value chain as opposed to just focusing on the end user. For instance, Bangladesh's solar programme aimed at developing a holistic ecosystem continues to garner interest while Indonesia's programme, focusing on free distribution of lanterns rather than the market as a whole has resulted in significant user dropouts. This highlights the importance of creating a policy that nurtures the growth of the eco-system rather than just focusing on the individual, so that the market is able to become self-sustaining.

4.2 Geography of Trade

Trade plays a very important role in facilitating energy access. The primary reason for this is that most countries do not have adequate infrastructure in place to support the manufacturing of renewable energy based products and systems. This is especially true in the case of countries that make up sub-Saharan Africa, as there is virtually no manufacturing base for the production of components that make up these products.

The interest in sustainable energy technologies and associated products has peaked in recent years. This surge in interest brought along with it a significant influx of a large number of players from diverse geographies, which has resulted in the consumer being spoilt for choice with the various range of products available. In addition, the growing interest from private players looking to 'ride the wave' has resulted in strengthening already established distribution channels as well as paving the way for setting up more channels to otherwise inaccessible locations. However, the significant growth also has the drawback of introducing heavy fragmentation of the market.

The *Lighting Africa* report[31] estimates that the market plays host to over 100 manufacturers worldwide with a vast majority of them falling in the category of small business entities characterized with an annual turnover of USD 150,000 to USD 5,000,000 and having limited product lines. The study indicates that globally, a significant portion of the manufacturers are headquartered in Asia—specifically India and China, which account for 40 per cent and 30 per cent of the manufacturing companies. China and India account for about 75 per cent of the products being distributed with companies from more developed economies, such as the US, Canada, Japan etc., accounting for about 20 per cent of product sales, specifically in developing nations across the world.

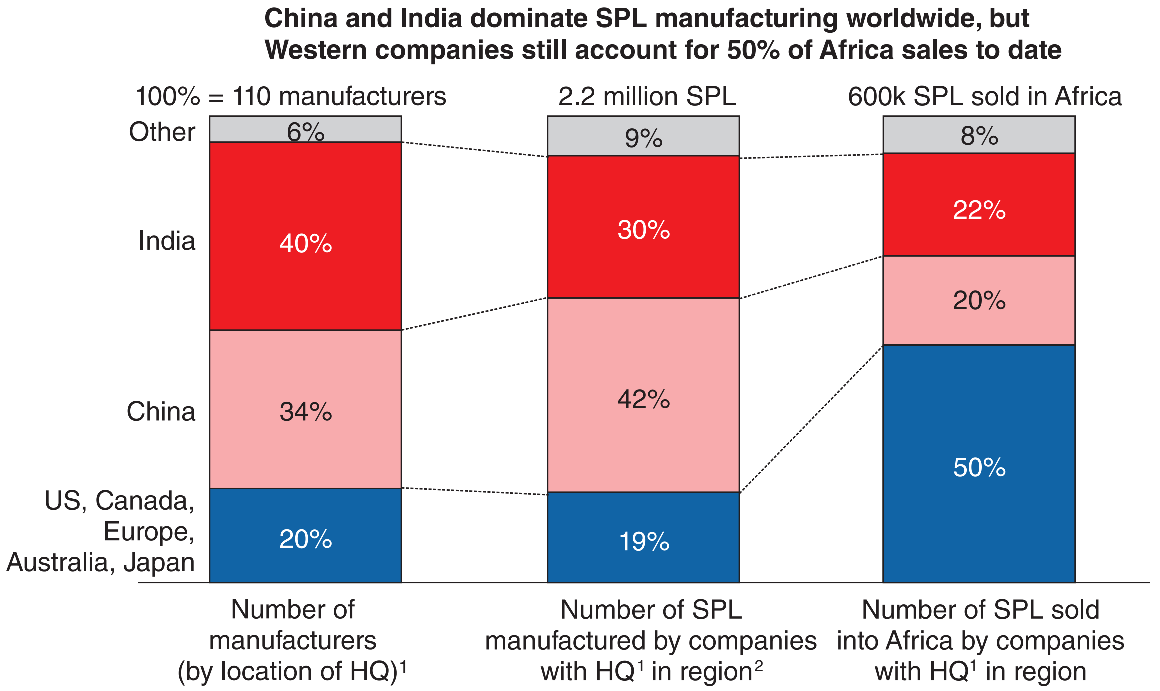
4.2.1 Africa

Africa, especially sub-Saharan Africa, has virtually no solar product manufacturing capabilities, which suggests that the needs of the consumer would have to be satiated through imports. With most of the manufacturing of solar products concentrated in Asia (India and China), one would assume that the African market would also be dominated by these players. The reality, however, is different. As can be seen in figure 4.1, 50 per cent of all solar lanterns sold in Africa come from developed countries, which, as mentioned previously, account for only 20 per cent of global SPL production. This indicates a strong bias in favour of north-south trade.

Though China and India tend to manufacture these products at lower costs, these countries are geographically located far away from Africa, which bears a negative influence on product price, as shipping and logistic charges are higher, which might negate the cheaper cost of the product as such. That being said, India still has a bigger presence in Africa than China, because many Indian enterprises have established operations in Africa in sectors other than solar product sales, such as mining, machinery and equipment, chemicals, textiles, paper, financial services, software, refineries etc., which can be tapped for supply of these products.

The other reason for this phenomenon is very likely consumer preference (i.e. the factors that dictate choice of some products in Africa), which favours products from Western countries—some due to valid technical reasons while others due to preconceptions. Some of these factors are discussed in the following sections.

Figure 4.1 Solar Portable Light Manufacture and Sales by Geography



1 Company is defined as being headquartered in a geography if the geography is the location of its top management staff, product

design team, and typically marketing and quality control divisions

2 Total SPL manufactured 2007-2010 Q1

Source: Lighting Africa, IFC, June 2010

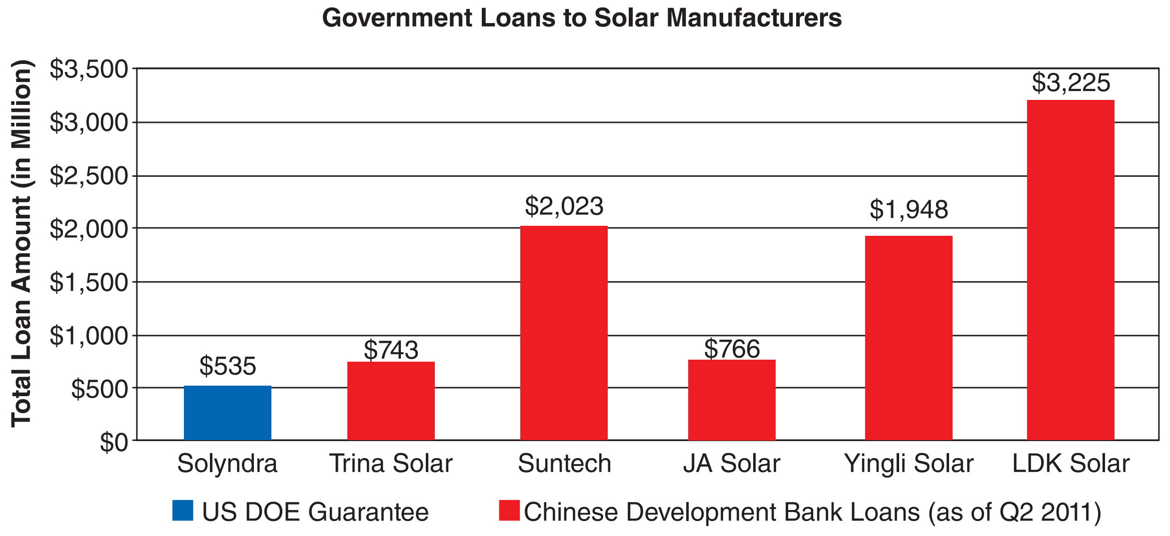
4.2.2 India

With over 75 million households with insufficient energy access, India probably represents the single biggest potential market outside of Africa. The advent of the National Solar Mission in India has provided the impetus for the sector to really take off. However, it should be noted that the sector is still fairly nascent, with significant activity taking place in the past three or four years. Within this small window of time, the number of players in this sector has mushroomed, resulting in a heavily fragmented market.

The sheer magnitude of the market in India is readily evident from the volume of solar product sales in India. It is estimated that cumulatively, about 2.3 to 3.2 million solar lanterns have been sold in the country thus far with an additional 1.0 to 1.2 million solar home systems sold.[32] These figures include both subsidized as well as unsubsidized product sales. While the ratio of the subsidized products to the unsubsidized products cannot be discerned, it is heartening to note that the market is not purely driven by subsidy alone. This has had a positive influence on manufacturers, as they then have the freedom to develop products that may not conform to the national standards but still are of good quality and have optimal performance.

As was highlighted in figure 4.1 above, India is home to a large number of local manufactures, including stalwarts such as d.Light and Reliance, that either manufacture the products from scratch or assemble them from components imported globally. Although this might suggest that most of the products sold in India are of Indian origin, a significant number of solar products, such as lanterns, are still imported for domestic use. This could be because of the lower cost of manufacturing in China, owing to the more subsidized manufacturing sector in China as opposed to India. Cost of module manufacturing is chiefly governed by the scale at which the modules are produced, i.e. the larger the scale, the lower the per-module cost. The cost of setting up large-scale facilities is rather high, and as such the debt requirement to fund these projects are also high. In China, the government offers large-scale loans through state agencies, such as the China Development Bank (CDB), which offers these loans at low interest rates and with long moratorium periods. The scale of loans is much larger than those offered in countries, such as the US for instance (see figure 4.2), thus putting companies like Suntech and LDK solar among the largest module manufacturers in the world. This translates to lower interest payments and thus better profits per module sold.

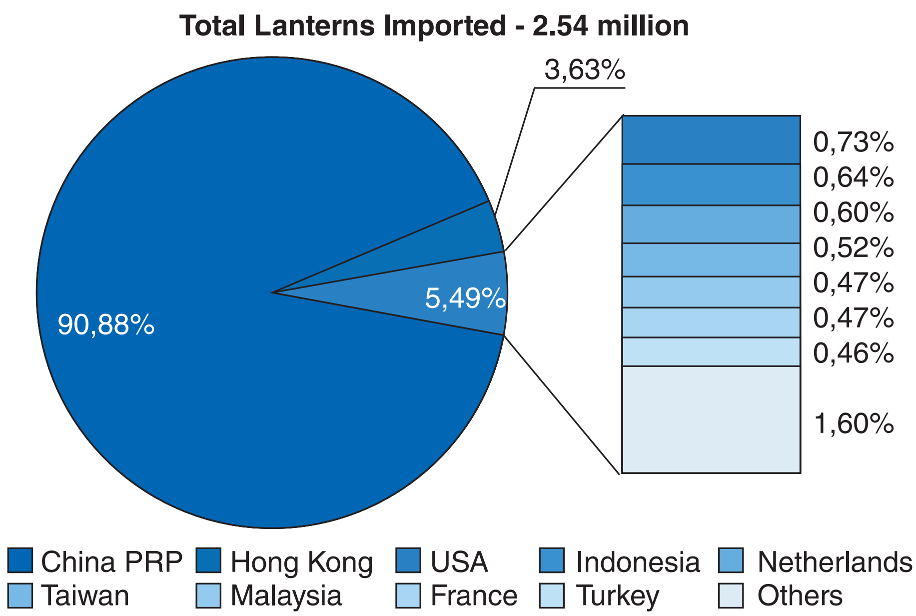
Figure 4.2 Government Loans to Solar Manufacturers



Source: GreenTechMedia, http://www.greentechmedia.com/articles/read/The-Reality-of-Chinas-Billions-in-Solar-Loans

In addition, geographically speaking, India is closer than China to countries in Africa. This greatly reduces the overhead that is generated due to costs associated with logistics, thus making it viable to import and sell the products in the country.

Figure 4.3 Solar Lantern Imports in India (2008-2012)

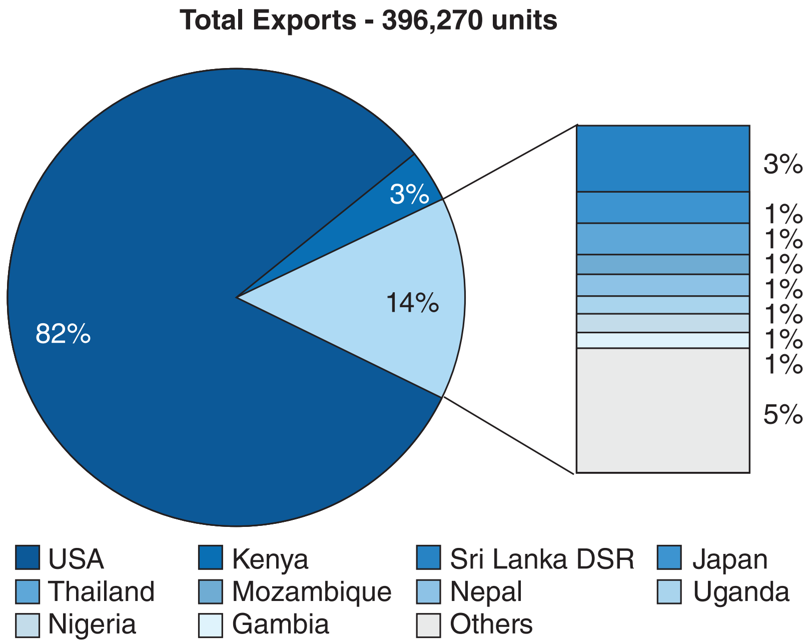


Source: Ministry of Commerce& Industry - India, RESolve Analysis

In the five-year period from 2008 to 2012, a total 2.54 million solar lanterns were imported in India.[33] It can be seen that this number is higher than the total number of lanterns sold in the country, which could be a result of various factors, such as excess inventory from lack of sales, imports from China for the purposes of rebranding and exporting to other foreign countries either in the West or other developing countries, such as those in sub-Saharan Africa. Figure 4.2 clearly suggests that China accounts for the lion's share of the import market in the country, accounting for about 91 per cent of the total imports with the US a distant second, accounting for about 4 per cent of the market.

The annual solar lantern market in India is estimated to be between 300,000 and 500,000.[34] The total imports in the country during 2011-12 were about 730,000, which might suggest that the entire domestic market is catered by imports or that there might not be a domestic manufacturing base that is capable of catering to the demand. This, however, is not the case as is evident from the export of these products in India.

Figure 4.4 Solar Lantern Exports From India (2011-12)



Source: Ministry of Commerce - India, RESolve Analysis

As can be seen from figure 4.4, the US is one of the primary export destinations for Indian manufacturers. India also supplies numerous countries in Africa, including (but not limited to) Kenya, Mozambique, Nigeria, and Uganda. While the amount of exports from India to Africa may be low, it should be noted that the entire baseline number of product sales in Africa is also low, with about 600,000 lanterns sold between 2007 and 2010,[35] which is about equal to the annual estimated solar lantern sales in India.

It can thus be concluded that as opposed to Africa, where the solar product market is primarily driven by north-south imports, the Indian market is driven by a mix of imports from China as well as through sourcing from domestic manufacturers within the country.

4.3 Taxes and Duties

Taxes and duties imposed on the products as well as the components used in the manufacture of the products are important, as these costs are eventually passed on to end users. To minimize the cost to end users to the best possible extent, tax and duties should be designed in a way that it is non-intrusive to both the consumer and the manufacturer. As discussed previously, the objective of any policy should be to develop an all-encompassing domestic ecosystem for the products.

Tax policy falls in a very small niche that encompasses both the manufacturing sector (development of an ecosystem) as well as the final subsidy to the end consumer (direct cost subsidy to the consumer). It is estimated that taxes and duties could contribute anywhere from 5 per cent to 20 percent to the final cost of the product, depending on the tax regime adopted in the country. Thus, if enforced properly, it ensures that the end cost to the consumer is lowered while helping to improve the bottom-line for the companies involved in the manufacturing of the products as it would be one less expense for the enterprise.

4.3.1 Trade-Flow and Tariff Analysis

This section analyses trade-flow and tariff information concerning a range of internationally traded products associated with technologies that facilitate access to clean energy (hereafter called CEG, for Clean Energy Good). More details on the methodology used as well some issues of data and classification are provided in Annex 1. Annex 2 shows most-favoured nation (MFN) applied tariffs by major importing countries for selected energy access products.

Some data are also presented for Africa as a region, in particular, on imports. One problem is that many African countries do not regularly report trade data to the United Nations Commodity Trade Statistics Database (COMTRADE) (see Table 4-6). Therefore, data were also obtained based on export figures reported by Africa's trading partners (Table 4-7). It would appear that Table 4-6 better reflects solar imports of countries such as Morocco and Kenya.

Some data are presented (in Table 4-8) for countries with large populations without access to energy. It is based on the REN21 Renewables 2012 Global Status Report, Table R17. Countries with more than 5 million people without access to energy were selected. Table 4-8 excludes Ethiopia and Sudan, as no data on import duties could be found.

Trade Flows in Selected Energy Access Products

Table 4-1 Non-electrical Lamps and Lighting Fittings (HS 940550): Top Traders (2012)[36]

Imports		Exports	
Reporter	USD thousands	Reporter	USD thousands
All reporters (excl. intra-EU)	969871	All reporters (excl. intra-EU)	1110368
EU27 (2011)	402840	China	968281
United States	384639	EU27 (2011)	69006
Canada	50837	United States	27235
Norway (2011)	27621	Chinese Taipei	18397
Australia	25807	India	13369
Switzerland	23934	Mexico	9915
Turkey	13807	Singapore	6550
Russian Federation	12121	Turkey	5847
India	10708	Israel	3164
Singapore	10444	Korea, Rep.	2910
Brazil	8437	Thailand	2574
Japan	8295	Switzerland	2179
Mexico	6339	Australia	1410
South Africa	5706	New Zealand	1243
Israel	5635	Malaysia	985
Korea, Rep.	5146	Canada	923
Chile	4423	South Africa	898
China	4153	Indonesia	825
Developing countries	100987	Developing countries	1032456
Africa (2012)	9170	Africa (2012)	1512
Africa (2011)	19454	Africa (2011)	1324

Source: COMTRADE, using WITS

Table 4-2 Africa: Imports of Non-electical Lamps and Lighting Fittings HS 940550 (based on export data of trading partners) (USD Thousands) (2010-12)

	2010	2011	2012	2010-2012
Africa	49406	58742	45196	153344
Nigeria	6882	9895	5603	22380
South Africa	5449	6863	8915	21226
Ghana	8170	9847	2604	20620
Egypt, Arab Rep.	3751	4775	2548	11074
Kenya	2727	2600	2625	7952
Libya	1952	916	2949	5816
Tanzania	1479	2441	1812	5733
Algeria	1992	1981	1748	5721
Angola	1808	1422	1756	4986
Morocco	2411	1651	823	4885
Congo, Rep.	1340	1353	1752	4445
Tunisia	1293	1456	956	3704
Togo	874	1131	1485	3490
Burundi	23	3334	7	3364
Cameroon	768	1224	1202	3195
Ethiopia	850	1541	776	3167
Congo, Dem. Rep.	1184	575	523	2282
Mozambique	462	500	915	1877
Chad	1647	37	175	1859
Benin	319	767	438	1524
Gabon	357	620	379	1356
Mauritius	467	426	353	1246
Somalia	12	288	848	1148
Cote d'Ivoire	455	340	185	981
Sudan	2	29	754	786
STP	289	453	1	742
Senegal	215	265	250	729
Zimbabwe	162	275	262	699
Uganda	217	204	266	687
Equatorial Guinea	244	258	124	626
Zambia	179	254	169	602
Liberia	41	15	498	554
Djibouti	164	92	287	543
Mali	203	85	177	466
Guinea	98	72	275	444
Seychelles	120	89	98	307
Madagascar	130	39	138	307
Burkina Faso	18	243	41	303
Cape Verde	83	85	104	272

Source: COMTRADE, using WITS

Non-Electrical Lamps

As explained in greater detail in Annex 1 (Methodology for Trade Analysis), solar lamps may be imported by countries either under the HS six-digit subcategory HS 940550 (non-electrical lamps and lighting fittings) or under HS 940540 (other electrical lamps and lighting fittings).

In terms of non-electrical lamps and lighting fittings (HS 940550), China has an overwhelming participation in exports, but is a rather small importer. The European Union (EU) and the US are key importers. African imports are relatively small, but there is a problem of missing observations, in particular for 2012. Therefore, in Table 4-1, trade figures for 2011 and 2012 are shown separately. Table 4-2 shows African: imports of HS 940550, based on export data reported by trading partners.

Table 4-3 Other Electrical Lamps and Lighting Fittings (HS 940540): Top Traders (2012)

IMPORTS		EXPORTS	
Reporter	USD Thousands	Reporter	USD Thousands
All Reporters (excluding intra-EU)	9251995	All Reporters (excluding intra-EU)	9962497
USA	3010040		
EU27	2518760	China	5971647
Canada	521511	EU27	1310194
Japan	331037	USA	571351
HongKong,China	306826	Korea	549964
Russia	258636	Mexico	359034
Australia	246817	Chinese Taipei	285718
Switzerland	198420	Malaysia	264075
Singapore	180329	Canada	119499
China	178503	Singapore	103129
Mexico	154466	Japan	79774
Korea	143031	Turkey	69214
Turkey	134546	Developing Countries	7720994
India	95680	Africa	27128
Developing Countries	1932484	South Africa	21121
Africa	222643	Morocco	2603
South Africa	101948	Egypt	2315
Morocco	33420		
Nigeria	24628		
Egypt	23538		
Algeria	18875		
Ghana	15838		
Botswana	10164		

Source: COMTRADE, using WITS

Other Electrical Lamps

The tables for other electrical lamps and lighting fittings show a broadly similar profile of countries in terms of main global traders as well as trade values. Africa is clearly a net importer for both electrical as well as non-electrical lamps and lighting fittings. Exports of electrical lamps from Africa are concentrated mainly in one country, namely South Africa. Developing country imports in general comprise about 10 per cent of global imports (excluding intra-EU trade) of non-electrical lamps and lighting fittings while they make up about 21 per cent of global imports of other electrical lamps. The corresponding shares of global exports are 93 per cent for non-electrical lamps and 77.5 per cent for electrical lamps and lighting fittings. Of course, the majority of exports share in both categories is accounted for by China.

Table 4-4 Exports of PV Cells and Modules (HS 854140)[37] (In descending order of accumulated 2010-2012 values)

Reporters	Exports (USD millions)				Change 2012/2011 (%)
	2010	2011	2012	2010-2012	
All reporters	54005	57793	42409	154207	-27
China	25179	27946	17483	70608	-37
Chinese Taipei	7425	6951	5277	19653	-24
Japan	6397	6604	5835	18836	-12
Korea, Rep	3807	3884	3879	11570	0
Malaysia	2599	2726	2491	7816	-9
USA	2706	2427	1804	6937	-26
EU27	1835	2203	1940	5977	-12
Singapore	1253	2081	1585	4919	-24
Mexico	711	932	751	2394	-19
Philippines	362	840	790	1992	-6
India	586	328	112	1025	-66
Thailand	257	236	141	634	-40
Developing cntrs	42418	46156	32571	121145	-29
Africa	173	135	19	327	-86
-- South Africa	166	131	15	312	-89

Source: COMTRADE, using WITS

Table 4-5 Imports of PV Cells and Modules (HS 854140), USD Millions, 2004-2012 (In descending order of accumulated 2010-2012 values)

	Import values (USD millions)					
	2004	**2005**	**2006**	**2007**	**2008**	**2009**
All reporters	11359	13567	16644	21217	33182	30877
EU27	2949	4093	5514	8411	17102	15160
China	1931	2362	2681	3289	3744	3607
United States	1251	1391	1848	2156	2760	2592
Hong Kong	1205	1335	1715	1818	1984	2109
Korea	858	865	979	1277	2144	1996
Japan	1002	1136	1207	1131	1412	1212
Chinese Taipei	473	462	525	544	660	697
Australia	55	52	59	84	171	400
Mexico	283	357	414	443	488	541
India	50	54	105	169	420	405
Singapore	339	328	432	504	559	478
Canada	165	216	215	202	267	269
Malaysia	251	256	225	306	354	299
Thailand	154	180	159	163	169	115
Developing cntrs	5762	6485	7611	8989	11080	10784
South-South	2341	2904	3775	4737	6082	6256
Africa	82	115	158	200	237	241
South Africa	58	86	119	141	161	118
Developing country imports as a portion of world imports (excl. Intra-EU trade) %						
Dvlpng cntrs	50.7	47.8	45.7	42.4	33.4	34.9
South-South trade as a portion of developing country imports and of world imports (excluding intra-EU trade), %						
Dvlpng cntrs	40.6	44.8	49.6	52.7	54.9	58.0
World	20.6	21.4	22.7	22.3	18.3	20.3

Table 4-5 Imports of PV Cells and Modules (HS 854140), USD Millions, 2004-2012 (In descending order of accumulated 2010-2012 values), continued

	Import values (USD millions)				Change 2012/11 (%)
	2010	2011	2012	2010-2012	
All reporters	56765	60157	44458	161380	-26
EU27	30646	27416	12433	70495	-55
China	6145	6720	6433	19298	-4
United States	4412	7193	7260	18865	1
Hong Kong	3205	3637	3525	10367	-3
Korea	2794	2823	3031	8648	7
Japan	2189	2306	3100	7595	34
Chinese Taipei	1286	1153	1153	3592	0
Australia	1047	1510	1010	3567	-33
Mexico	876	1107	1208	3191	9
India	299	1333	872	2504	-35
Singapore	814	905	729	2448	-19
Canada	701	987	510	2198	-48
Malaysia	498	685	389	1572	-43
Thailand	229	644	673	1546	5
Developing cntrs	17155	19964	18651	55770	-7
South-South	11161	13075	12111	36347	-7
Africa	472	295	165	932	-44
South Africa	157	125	54	336	-57
Developing country imports as a portion of world imports (excl. Intra-EU trade) %					
Dvlpng cntrs	30.2	33.2	42.0	34.6	
South-South trade as a portion of developing country imports and of world imports (excluding intra-EU trade), %					
Dvlpng cntrs	65.1	65.5	64.9	65.2	
World	19.7	21.7	27.2	22.5	

Source: COMTRADE, using WITS (11 July 2013)

Solar PV Modules

Table 4-4 shows the top global exporters of solar panels. The table shows that with the exception of Japan, the top five exporters of solar panels are emerging economies, namely China, Chinese Taipei, Korea, and Malaysia. Among the top 12 countries, a number of other developing countries also figure, for instance, Mexico, Philippines, India, and Thailand. Among African countries, South Africa appears to be the only significant exporter with cumulative exports of about USD 312 million. All countries show a significant fall in the value of their exports of solar panels from 2011 to 2012. This may be attributed to the general sharp fall in solar PV prices, particularly as a consequence of oversupply mainly in China.

Table 4-5 shows the top global importers of solar panels. In the case of the accumulated value of solar PV imports from 2010-12, the EU is by far the largest importer followed by China and the US. The rise of China as a big importer could also reflect the increasing domestic deployment of solar panels as opposed to producing primarily for the export market. Given that HS 854140 includes both finished products and intermediate products. Chinese imports may have grown primarily because a huge increase of production of PV panels required a certain portion of imported cells.

India, which faces a major problem with regard to energy access, is the tenth biggest importer (if the EU is taken as 'one' reporter) from 2010-12. While a number of these could be for off-grid applications, it could also be meant for grid-connected solar PV projects, which have received an impetus with government incentive schemes like the Nehru Solar Mission. There was a huge surge in imports in 2011, mainly from China, turning India into a net importer under the provisions of HS 854140 in 2011-2012. This was also the result of a decrease of exports as the domestic market became more dynamic.

It is likely that India also has increased imports of LEDs, which are classified along with solar panels under the same HS code. An interesting observation is also the share of South-South imports as a proportion of developing country imports in solar PV modules, which has grown significantly from 40.6 per cent in 2004 to about 65 per cent in 2012 in part owing to China's increased participation in world production of solar PV modules. As a proportion of total world imports the share of South-South imports have also grown albeit less rapidly from 20.6 per cent in 2004 to 27.2 per cent in 2012.

Table 4-6 Africa, PV Cells and Modules Imports by Country (Data Reported by Importer), 2010-2012 (USD thousands)

	2010	2011	2012	Total cumulative imports: (2010-2012)
Africa	471576	284669	141259	897504
South Africa	156603	124622	53994	335219
Nigeria	195728	42915		238643
Ghana	6066	35337	28558	69961
Uganda	8465	11925	29178	49568
Algeria	9517	17293	5289	32098
Tunisia	9005	12176		21181
Cape Verde	15586	444	546	16575
Botswana	12120	2874	795	15789
Mauritius	781	2332	11839	14951
Tanzania	6410	8066		14476
Kenya	13199			13199
Egypt, Arab Rep.	5511	1766	3371	10648
Senegal	1177	3300	4077	8554
Morocco	7248			7248
Niger	1533	5633		7166
Mali	6596			6596
Madagascar	3818	2657		6476
Burkina Faso	1283	4008		5291
Cameroon	3066	1329		4395
Zimbabwe	2650	1647		4298
Rwanda		766	3390	4156
Ethiopia	1321	561		1882
Togo	605	1017	221	1843
Mauritania	210	1213		1423
Mozambique	454	752		1206
Malawi	396	704		1099
Libya	1065	0		1065
Cote d'Ivoire	396	584		980

Table 4-6 Africa, PV Cells and Modules Imports by Country (Data Reported by Importer), 2010-2012 (USD thousands), continued

	2010	2011	2012	Total cumulative imports: (2010-2012)
Burundi	306	208		514
Zambia	163	312		475
CAR	173	196		369
Gambia, The	86	34		121
Congo, Rep.	23			23
Benin	15			15

Table 4-7 Africa PV Cells and Modules Imports by Country (Based On Export Data Reported By Trading Partners), 2010-2012. In descending order of 3-year trade values (USD thousands)

Reporter	Period			
	2010	2011	2012	2010-2012
Africa	334978	297121	233390	865489
South Africa	148328	108785	60660	317773
Nigeria	22130	39331	12398	73859
Morocco	13080	14401	14271	41752
Kenya	11539	12787	15024	39350
Tunisia	12153	16102	10220	38475
Mali	5592	21406	5685	32684
Senegal	6053	11016	8299	25368
Tanzania	6495	8050	9931	24476
Cape Verde	18332	254	824	19410
Mauritania	876	3015	14738	18630
Egypt, Arab Rep.	7492	5953	3913	17358
Uganda	6244	4500	6549	17293
Angola	7191	2505	6685	16381
Algeria	9569	4237	1511	15317
Ghana	1233	3040	7648	11922
Botswana	525	7014	4048	11587
Mauritius	4346	1035	5373	10753
Madagascar	3598	2674	2520	8792
Djibouti	5397	1879	657	7932
Zimbabwe	3217	2088	2434	7738
Mozambique	2355	2788	2469	7612
Burkina Faso	699	2311	3942	6952
Sierra Leone	697	328	5786	6811
Togo	3108	1723	1437	6269
Cameroon	1440	1349	2779	5568
Zambia	1659	1672	2117	5448
Equatorial Guinea	1055	421	3372	4848

Table 4-7 Africa PV Cells and Modules Imports by Country (Based On Export Data Reported By Trading Partners), 2010-2012. In descending order of 3-year trade values (USD thousands), continued

Reporter	Period			
	2010	2011	2012	2010-2012
Rwanda	793	1875	2171	4839
Guinea	2590	997	940	4527
Niger	1164	3187	153	4505
Congo, Dem. Rep.	1605	1538	1032	4174
Congo, Rep.	1643	846	766	3255
Ethiopia	643	1276	870	2788
Libya	1832	51	527	2410
Burundi	209	511	1677	2397
Malawi	562	608	1133	2303
Benin	714	635	814	2163
Cote d'Ivoire	260	800	914	1974
Swaziland	1348	445	101	1894
Chad	407	531	914	1852
Guinea-Bissau	559	640	415	1614
Liberia	416	421	434	1272
Gabon	184	635	140	959
Gambia, The	233	232	493	957
Eritrea	316	182	408	906
Lesotho	126	349	163	637
Seychelles	96	139	151	387
CAR	84	166	121	370
Somalia	97	141	106	343
Comoros	153	21	56	229
STP	27	44	18	89

Source: COMTRADE, using WITS

Table 4-6 shows the import figures for solar panels and LEDs (HS 854140) based on import data for 2010-12 reported by African countries while Table 4-7 shows import figures based on export data reported by their trading partners. As far as Africa is concerned, South Africa accounts for the greatest import figures for solar panels in Africa. The tables reveal that other countries in sub-Saharan Africa, such as Kenya and Nigeria as well as north African states, such as Algeria, Morocco, and Tunisia are also relatively important importers. A number of LDCs for instance, Mali, Senegal, and Tanzania, have relatively high import values. This may very well reflect the importance of solar panels in providing off-grid energy access.

Table 4-8 shows that only 15 per cent of the population in Mali and 18 per cent of the population in Tanzania have access to electricity. At the same time, other countries with similarly low levels of access, such as Benin and Malawi, import much less. In addition to import tariffs, a number of other factors, such as regulation, levels of per-capita income, and other factors conducive to market growth and establishment could be driving demand for solar panels in these countries.

Table 4-8 also shows that applied tariffs on solar panels are usually zero for most sub-Saharan African countries; exceptions include Mozambique (7.5 per cent); Cameroon

(10 per cent); Democratic Republic of Congo (10 per cent); and Gabon (10 per cent), Low to very low tariffs are applied by Ghana (5 per cent); Madagascar (5 per cent); Morocco (2.5 per cent); and Angola (2 per cent). Djibouti is somewhat of an anomaly to the general trend, applying much higher tariffs of 26 per cent. Thus, overall, import tariffs are not a major barrier for solar panel imports in most African countries, although import-related costs could be further reduced for those that do apply higher tariffs.

Table 4-8 Electricity Access by Countries and MFN Applied Tariffs on Solar Clean-Energy Products

Reporter	People without access to electricity (million)	Share of population with access
Angola	13.7	26.2%
Bangladesh	88.0	46.0%
Benin	6.7	24.8%
Burkina Faso	12.6	14.6%
Cambodia	11.3	24.0%
Cameroon	10.0	48.7%
Côte d'Ivoire	10	47.3%
DR Congo	58	15.0%
Ghana	9.4	70.0%
Haiti	6.2	34.0%
India	293	75.0%
Indonesia	63	73.0%
Kenya	33	18.0%
Madagascar	15.9	19.0%
Malawi	12.7	<9%
Mali	13	18.0%
Mozambique	20.2	12.0%
Myanmar	43.5	13.0%
Nepal	16.5	10.0%
Niger	14	8.0%
Nigeria	79	50.0%
Pakistan	56	67.0%
Philippines	16	83.0%
Senegal	7.3	42.0%
South Africa	12.3	75.0%
Tanzania	38.0	15.0%
Togo	5.3	22.0%
Uganda	29.0	8.0%
Zambia	10.5	20.3%
Zimbabwe	7.3	41.5%

Table 4-8 Electricity Access by Countries and MFN Applied Tariffs on Solar Clean-Energy Products, continued

Reporter	Key clean-energy products (HS codes), import duties (%) Most recent tariff information					
	854140	940540	940550	850440	850780	853710
Angola	2	10	10	2	5	2
Bangladesh	2.5	5-25	25	3-12	25	3
Benin	0	20	20	5	20	5
Burkina Faso	0	20	20	5	20	5
Cambodia	7	0-15	15	7	35	15
Cameroon	10	30	10-30	10	20	10
Côte d'Ivoire	0	20	20	5	20	5
DR Congo	10	20	10	5	10	10
Ghana	5	20	10	3.3	10	10
Haiti	0	5	5	8.3	5	0
India	0	10	5-10	7.5-10	10	7.5
Indonesia	0	5-10	5-12.5	5-10	10	5
Kenya	0	25	25	0	25	10
Madagascar	5	20	20	5	0-10	5
Malawi	0	0-25	25	0-5	25	5
Mali	0.0	20	20	5	20	5
Mozambique	7.5	20	20	5	25	7.5
Myanmar	7.5	1	7.5	1	20	1
Nepal	0	15	5	15	7.5	10
Niger	0	20	20	5	15	5
Nigeria	0	20	20	5	20	20
Pakistan	5	5-30	30	10-20	20	25-35
Philippines	0	1-7	3-7	4.7	10	5
Senegal	0	20	20	5	20	5
South Africa	0	0-20	0	0	0	5-15
Tanzania	0	25	25	0	25	10
Togo	0	20	20	5	20	5
Uganda	0	25	25	5	25	10
Zambia	0	25	25	0	25	15
Zimbabwe	0	5-40	10-40	0	20	20

Source: on population without access to energy: REN21, Renewables 2013 Global Status Report, Table R.17 (excluding Afghanistan and Ethiopia because no tariff data available). On tariffs: WTO Tariff Download Facility

Table 4-8 provides an interesting insight into the policy landscape governing trade in some of the major products relevant to clean energy access. The countries selected are those with a population of at least 5 million people without access to electricity. It should be noted that solar panels enjoy zero or low applied tariffs in most of these countries. Other products that are important inputs into solar mini-grid systems, such as electric accumulators (relevant for electricity storage) and charge controllers in general, attract higher rates of duty (in the range of 10-25 per cent for most countries) followed by static convertors (5-15 per cent for most countries). Solar lamps (possibly imported under HS 940550 and HS 940540) attract tariffs of 10-25 per cent in many countries where access to electricity is an issue. It may be worth exploring further the reason for higher tariffs for these goods in these countries — for instance, to find whether they are part of generally high tariffs in place in these countries for domestic tariff revenue generation purposes or whether they are intended to protect domestic manufacturing units. While higher tariffs applied for HS 940550 could make imports of solar lamps (if imported under this HS code) costlier, they would also discourage cheaper imports of more polluting and fossil-fuel burning kerosene lamps which also fall in the category of non-electric.

4.3.2 Issues related to taxation and imports

Lack of clarity

Both India and African countries are plagued with this issue. Varying degrees of taxes and duties are imposed on the items imported, depending on whether they are fully assembled imports or sub-component imports. This coupled with improper understanding of the regulations by the authorities in charge of imposing the taxes and duties leads to inconsistent taxation across various imports. In many cases, the tax/duty policies were quite nuanced—for example, imposing different rates on products with integrated vs. external solar panels—and leading people from the same geography to report dramatically different effective tax rates.

An issue specific to India is that the taxes and duties imposed are regulated both at the federal level (central government) as well as by the respective state governments. The diversity of taxes on solar products and components from state to state creates significant confusion and has proven to be cumbersome. That being said, state-specific policy adoption can prove beneficial, as it creates a space for regulatory autonomy, which can serve to further the growth of the sector provided the states exploit it properly. For instance, the Indian states of Rajasthan and Gujarat have been able to make significant inroads into the solar space specifically because of their respective state policies.

Ambiguity in HS codes

The HS codes adopted also add to the confusion in the taxation process. As explained in the methodology (Annex 1), solar lamps may be imported either under HS 940540 or HS 940550. For example, India has a specific national tariff line for solar lamps—94055040 under the broader HS 940550 sub-category. But, is it likely many or most countries may not have such a specific tariff line for solar lamps under HS 940540 or HS 940550 resulting in a lack of clarity.

Similar confusion arises in ambiguous product descriptions that fail to state explicitly what the HS code stands for. For instance, HS 76151012 and HS 76151930 represents “solar collectors” and “solar collectors and parts,” respectively. So, while importing a solar collector, there is little clarity on which HS code applies. Luckily, however, the taxation/duty structure is identical between the two HS codes.

Counterintuitive taxation

A good example of this is evident in some countries in Africa where the sub-components used in the assembly of solar products are taxed at a higher rate compared with imports of fully assembled products. The scenario results in substantial increases in the cost of product assembly, as each subcomponent is taxed separately compounding the final cost that is then transferred to the consumer.

This greatly discourages the setting up of local assembly units for these types of equipment, thereby impeding the development of a domestic ecosystem for these products. It also has the adverse effect of limiting employment-generation opportunities. Most foreign companies feel that this is one of the major stumbling blocks to setting up an assembly facility in the country. In Kenya, for example, importers need to apply for the duty exemption for each individual shipment, and products are often denied preferential duty status owing to unclear regulations. Another example of how counterintuitive taxation regimes can be detrimental is the case of a solar systems assembly company in Senegal that went out of business in 2011 because of the excessive taxation on the sub-components used in the system.[38]

Delays

While it is heartening to note that various countries have adopted taxation exemption measures for solar products, these exemptions are marred by bureaucracy and red tape and poor operational implementation in real life. For instance, many manufacturers in countries where this exemption is provided, such as Ethiopia and Tanzania, complained of the delays associated with lengthy procedures at the port of entry that stem from customs agents' lack of understanding of solar products, corruption, and/or inconsistent tax treatment of goods at the airport.

This issue also holds true in the case of India, where the exemption on taxes is given only after approval from MNRE. For instance, an inverter to be used in solar installations is typically exempt from taxation, but is still charged a 5.3 per cent education CESS, and if the clearance from MNRE is not received on time, the importer has to pay taxes and duties to the tune of about 30 per cent or risk delaying their installation activities. This greatly discourages manufacturers looking to setup production and assembly facilities, as they may not always be willing to deal with the associated hassles, which result in lost revenue owing to the opportunity cost associated with these delays.

Chapter 5

Conclusion: Lessons and Identifying Needs and Priorities for Developing Countries

5.1 Introduction

The chapters prior to this have dealt with various issues that greatly affect the uptake of renewable energy based systems in developing countries with a specific emphasis on South Asia and Africa. This chapter provides an overview of the issues as well as some of the steps that may be taken to combat some of the barriers to adoption of these systems.

5.2 Key Barriers

Some of the key barriers to adoption of solar products include:

- Low purchasing power of a significant percentage of the off-grid population most in need of better energy access. The fact that solar products have high upfront costs makes this worse, as the cost of the products take up a large percentage of monthly/annual household revenue.
- Lack of access to finance both from a consumer perspective and from a manufacturer/distributor perspective.
- Inability of companies to make capital investment in stock and limited access to supplier finance.
- Limited understanding of the solar industry by the local banks and MFIs has an adverse effect on their willingness to finance solar products, as most lending institutions adopt an overly cautious approach.
- Market spoilage through proliferation of low-cost products characterized by their substantially lower quality.
- Lack of consumer awareness about the inherent benefits, be it health or monetary, of using modern solar equipment in place of their traditional counterparts. In addition, consumers are in most cases not aware of the various available solutions and are unable to make informed decisions that best suit their requirements.
- Subsidizing traditional fuel sources, such as kerosene as opposed to solar products, reduces the cost competitiveness of solar products.
- Lack of business capacity for distribution, marketing, and sales of off-grid products by retailers.
- Inability to service and support solar products by retailers owing to lack of expertise as well as a lack of appetite to aggressively push solar products as a solution as opposed to traditional alternatives.
- Slow rate of policy implementation and lack of focus of policies to foster the growth of a domestic ecosystem with subsidies focused solely on products.
- Lack of awareness among consumers about the prevalent policy regime and applicable subsidies for renewable energy based products.
- High component cost for manufacture/assembly of renewable energy based products locally, which significantly increases the cost of the end product, thereby reducing affordability, especially in Africa.
- High import duties levied on renewable energy based products and components associated with their manufacture/assembly. This issue is especially adverse in the case of certain countries in Africa where taxes and duties can at times be two times more than those seen in India for corresponding products.
- Counterintuitive taxation regimes that favour imports of prefabricated products

as opposed to domestic manufacturing and assembly.

- Imposition of domestic/local content requirements on products limits innovation and stifles sourcing of cheap components for product manufacture, thereby adversely impacting both cost and quality.
- Improper implementation of standardization practices reduces ability to customize products to consumer requirements.
- Policy regimes that link subsidy disbursal to both local content requirements and frail standardization norms that reduce choices available to consumers.
- Absence of well-established supply chains that extend up to the end consumer.
- Lack of grassroots organizations that help both in product advertisement (awareness creation) as well as final product sales and service.

5.3 Recommendations

- **Awareness creation (end user)** — Widespread awareness-creation measures should be adopted so the end consumer is aware of all the solutions available, i.e. what traditional sources of energy can be replaced by alternate renewable energy based products, so that consumers can not only make a choice to shift to the new energy sources, but also make an informed decision. Increased outreach would help speed up the uptake of these products by opening up the market. It has been demonstrated that door-to-door marketing is the most effective strategy for product sales in rural areas. However, this is associated with high costs, which further lower the already low margins on these products. Thus, part of the funds used for capital subsidy could be diverted to awareness-creation activities through NGOs and other agencies to help reduce distribution costs (thereby reducing product costs) while speeding uptake. This is beneficial to both the distributor as well as the consumer.
- **Awareness creation (others)** — Awareness creation activities should also be undertaken so that financing institutions are aware of the products and associated services, as loan grants are usually declined owing to this lack of awareness, which makes financing institutions wary of disbursing loans to the end user. Another area where awareness creation is required is the case of import ports where customs duties and taxes are levied on renewable energy based products even though they are exempt from such duties. This issue is particularly prevalent in various regions across Africa where the officers in charge are unaware of such subsidies. Thus, reforms are required not only in the policy/regulatory level, but also at the operational level.
- **Product quality assurance** — In various countries in Africa, quality-assurance programmes through the employment of testing and certification mechanisms does not exist, but these exist in India. Thus, it becomes vitally important for testing centres to be setup across the continent to evaluate the products being marketed within the various countries, and appropriate certifications should be given to these products so that consumer confidence is fostered.
- **Standardization** — While standardization measures have been implemented in countries, such as India, with the intention of ensuring quality, they are often cited as being a constraint by product manufacturers. These standardization measures dictate parameters, such as number of LEDs, the type and battery capacity to be used, the nature of housing to be employed for solar lanterns, and the sizing of SHS system etc. Companies, such as Sundaya in Indonesia, have opted for modular construction of a system that can be customized based on the end consumer's requirements by reducing/adding components as required, thereby aiding in cost optimization and affordability. Such a strategy, for instance, would assist a low-income consumer to purchase a basic one-light system and then add more lights or other components to the system as and when she is able to afford

it, thereby spreading the cost of the system over a longer period. If currently prevalent standardization mechanisms are imposed strictly such systems would not be available. Thus, standardization procedures should not be seen as 'the be all and end all' of product approval for sale. Product approval for sale in a territory should be decided on a product-to-product basis rather than according to a blanket criterion.

- **Improving access to finance** — Policy and regulation should be formulated in a way that encourages financing through MFIs for two important reasons. First, renewable energy based products are usually associated with costs that are of a lower scale, which makes them ineligible for traditional loans. Second, MFIs usually focus on areas with lower economic development and as such have an established line of access to the target consumer segment, which also serves to overcome the bottleneck of supply chain constraints, as MFIs themselves would be able to take the product to the end consumer. With MFIs viewing these products as associated with higher risk, owing to lack of awareness or perceived risks associated with lack of repayment etc., the policy should be formulated so that guarantees can be given by the government to mitigate these perceived risks.

- **Priority sector lending** — Access to finance is a limiting factor not just for the end consumer, but also for large enterprises undertaking development in this sector. Large projects, such as the provision of energy access in remote areas through the construction of micro-grids for instance, are usually undertaken by the private sector. Capital costs associated with these projects are usually high; therefore, loans available for these projects come with a high interest component, which dictates that in order to secure profits, a large portion of the costs have to be transferred to the end consumer. This, in turn, could reduce affordability. Treating such projects as a priority sector would help reduce the financing costs (due to lower interest rates more than anything else) which then would encourage more private players to undertake them. For instance, priority sector lending is already employed in India and regulated by the Reserve Bank of India (RBI) for various sectors, including agriculture, education etc., but it has not been extended to the energy sector in general and the renewable energy sector in particular.

- **Promotion of innovative business models** — Subsidy mechanisms in various countries in Africa as well as in India are limited to the provision of a capital subsidy (as a percentage of total capital cost) on various products. Innovative business models, such as 'pay as you go' would not benefit from an upfront subsidy, since the payments under this model are spread over time (the payments are made per unit of electricity consumed until the cost of the system is recovered; after that, ownership is transferred to the consumer). Thus, the subsidy in this case would have to be provided on a per unit of electricity consumed basis either directly to the consumer or to the service provider and then transferred to the consumer. Regulations would have to be revised to accommodate such innovative business models as they decrease the burden on the end consumer.

- **Adequacy of subsidy** — The amount of subsidy disbursed is based on a benchmark capital cost, which is determined by the government. But, this benchmark cost is not a true representation of actual cost, as the cost of components varies monthly while the subsidy is revised on an annual basis or sometimes once every two years. For instance, in recent months module prices have been increasing, thus it should be expected that the benchmark costs for SHS will increase in tandem. However, this is not the case, resulting in a situation where the initial proposed capital subsidy would prove to be inadequate, especially for SHS systems.

- **Local content requirements** — Availability of subsidies (particularly capital subsidies) as seen in the case of India is subject to the condition that the product and certain components used in it (such as solar PV modules) are manufactured locally within the country. This is counterintuitive, as the customer is not always assured of the best quality or the best price. Thus, a policy measure where subsidy disbursal is dependent on the performance and quality of the product rather than the source of the sub-components or region of manufacture would ensure higher uptake.

- **Dissociating subsidies from LCR and standardization practices** — As mentioned previously, subsidy entitlement is entirely dependent on whether the products fulfil the LCR and standardization criteria. Capital subsidies are one of the key factors that coax new consumers into adopting renewable energy technologies, as their high capital costs in most cases is prohibitive. Linking capital subsidies with LCRs and standardization measures greatly limits consumer choice. Thus, the regulations should be reframed in a way that gives these subsidies on a product-to-product basis after sufficient evaluation of the product.

- **Evolving a domestic ecosystem** — Current regulations focus more on product penetration than on the development of an ecosystem with the front-loaded capital subsidy. It has been demonstrated that merely a capital subsidy on the end product could have adverse consequences, as there could be fly-by-night sellers that peddle the products while lacking after-sales support capabilities. With this in mind, the subsidy disbursal would have to be designed in way that incentivizes the entire value chain. Such a scenario would encourage the players in all parts of the value chain to perform at their best potential, thereby creating a self-sustaining market. For example, the government could provide marketing and product promotion support for the distributors/retailers and aid the manufacturers with quality-control support. Furthermore, after the market has achieved critical mass, the need for the subsidy in itself would become redundant and can be slowly withdrawn. Encouraging domestic manufacture and assembly of products would also help inculcate the workforce with the skillset required to provide after-sales support and service, which is an important influencer in the decision-making process for the end consumer.

- **Elimination of competing subsidies** — Currently, it can be widely seen that fossil fuels, such as kerosene, are heavily subsidized; therefore, renewable energy systems are unable to compete in terms of cost. Thus, devising a plan to channel the subsidy offered for fossil fuel systems toward renewable energy systems either in part or in full would ensure that sufficient funds are available for disbursal as well as provide an opportunity to create a surplus of funds in the budget, which could be used to increase the quantum of subsidy offered for renewable energy based products. This, in turn, could serve to entice more end users into adopting these products.

- **Taxes and duties** — This problem is more rampant in Africa than in India. The taxation levels in African countries are prohibitively large and tend to inflate product prices by a significant proportion. In light of this, countries in Africa should adopt a taxation/duty regime that makes renewable energy technology based products exempt from such levies as seen in the case of India. Also, to promote domestic manufacture/assembly of products, counterintuitive taxation (as described in section 4.4.2) should be avoided to prove more incentive for manufacturers seeking to manufacture/assemble the product locally and import sub-components. This would secure the best/cheapest possible price for each component. It should be noted that these cost savings would then be passed on to the consumer in a highly competitive market. For example, “the elimination of VAT and tariffs for solar panels in Tanzania led to the reduction of PV costs by half and, according to a number of distributors, served as a major stimulus for increased sales.”[39]

Chapter 6

Facilitating Access to Energy in a Sustainable Energy Trade Agreement

Trade policy has the potential to play a constructive role in facilitating access to energy for poor populations across the world. While the role of a potential SETA would be to address market access barriers for SEGS and clarify ambiguity in existing trade rules that affect sustainable energy scale-up, provisions could be crafted to help prioritize issues and barriers that are critically important for sustainable energy access.

This paper has identified a number of trade-related aspects that play an important role in facilitating or constraining access to sustainable energy access (SEA) goods. Provided below are a list of the main gaps and challenges identified as well as options on how SETA concluded either within or outside of the WTO framework could address them.

(i) **Clearer Classification of Products:** It may be desirable for countries that are important traders of SEA products to identify and clearly define these products, including within national tariff lines, as well as agree to arrive at a common description for these products so as to minimize confusion and ensure consistent tax treatment upon importation. If there is a need to reclassify some of these products at the HS six-digit level (for instance there exists no clear classification for solar lamps) SETA parties in coordination with other WTO members (if necessary) could set up a working group on the matter and subsequently pursue this at the World Customs Organization. This would also help members distinguish between various types of products—particularly for products like cleaner cook-stoves—based on their environmental impact, nature of the fuel used etc., and apply differentiated policies and trade-related charges and other requirements reducing or minimizing the risk of violation of GATT Article III provisions based on non-discrimination of 'like' products or 'substitutes.'

(ii) **High import duties and taxes:** The taxes and duties levied on renewable energy products and particularly parts and components associated with the manufacture and assembly of sustainable energy goods is particularly problematic for African countries. While most African countries may not be willing or ready to join a SETA immediately, they could consider voluntarily addressing high duties that hold back imports of these goods and components as well as simplifying the duty structure for such products. Appropriate provisions for special and differentiated treatment for African countries could be part of the deal as well as enhanced provision of non-trade related technical assistance.

(iii) **Local content requirements and contingent incentives**: LCRs for sustainable energy goods important for energy access are sometimes a condition for government subsidies. Such requirements hold back dissemination of important equipment and restrict consumer choice. WTO rules usually do not discipline end-use consumer subsidies, and rules are silent or ambiguous on LCRs that are conditional upon consumer subsidies. This is possibly an area where a potential SETA could contribute to clarity.

(iv) **Standardization policies and related capital subsidies and incentives:** Standardization policies and capital subsidies that affect access for sustainable energy equipment, such as solar lamps, can constrain the sale of innovative or the most efficient and effective models. As highlighted in this paper, subsidies for off-grid equipment could be made conditional on standards (such as wattage for solar panels, or battery sizes and fixtures) that could limit the choice of components used. It may be better to have such subsidies conditional upon performance rather than design. It may be desirable for a SETA to incorporate a monitoring mechanism or a working group on SEA standards that tracks such problematic standards and accredited related requirements. SETA members could then take it up with relevant authorities in the importing country. If new approaches to standardization are necessary within standardizing bodies for such equipment vital to energy access, SETA members could pursue it as a priority within relevant standardization bodies, such as the International Electrotechnical Commission (IEC). Subsidies provided to local firms for manufacture of SEA products could be reviewed and benefit from a waiver or an extended phase-out under a SETA, depending on the balance struck between the need to develop a local manufacturing and distribution ecosystem vis-à-vis immediate access to imports. In these instances, coherent policies, such as a more open trade policy for raw-materials and components used in the manufacture of cook-stoves or solar lanterns, need to be in place.

(v) **Trade facilitation related measures:** Trade facilitation measures that speed up clearance of sustainable energy equipment at customs and ports could be considered by a SETA. For instance, all SEA-related goods could be subject to customs inspection and clearance in a certain number of hours/days unless there is serious reason to extend that period. These are also related to developing a classification of sustainable energy products based on clearly identifiable characteristics and HS codes and are easily identifiable and understood by customs authorities. Raising awareness among customs officials on duty exemptions for which sustainable energy products may be eligible would also minimize delays and facilitate trade.

(vi) **Establishment of an SEGS trade policies monitoring mechanism:** A SETA could contain a provision for regular monitoring and periodic review of members (and possibly non-members) trade-related polices on SEGS. This would be complementary for instance to the WTO's trade policy reviews and could happen on a more frequent basis, for instance, once a year. A process of notification of non-tariff sustainable energy related measures (such as various sustainable energy related incentive schemes provided and the conditions associated with these subsidies and incentive schemes) could also be introduced for SETA members. Such a notification process could also include relevant notifications made to other WTO bodies, such as the Committee on Technical Barriers to Trade (TBT). The review process could be done for all members simultaneously and could include monitoring the phase-out of any existing SETA non-compliant measures and discuss an extension of any waivers granted. Any policies that affect easier access to SEA goods could also come under the purview of these measures.

(vii) **Geographical scope of a SETA:** The importance of countries, such as China, the EU, India, and the US in manufacturing, exporting, and importing products such as solar lighting equipment underscores the need and relevance for these countries to form part of a SETA. It may also be worthwhile, given the importance of energy access to countries in African, to have a number of these countries either as observers or involved in agreeing on those provisions of a SETA that directly or indirectly affect their manufacture, exportation, or importation of SEA equipment.

(viii) **Technical cooperation related measures:** Any technical cooperation or assistance mechanism that is set up by a SETA should take into account measures that could help facilitate the dissemination of SEA products. For instance, this paper identifies a lack of awareness among customs officials regarding various tax and duty incentives eligible for SEA products as well as on relevant HS codes under which the products are imported. This could be one of the areas where a SETA could create a fund for the training of customs authorities in countries where it may be necessary. Such ‘awareness-creation’ exercises could also include updated information on any changes to HS codes or reclassifications that countries may agree upon for SEA products.

Figure 6.1 The Role of a SETA in Facilitating Access to SEA Products

SEA goods trade-related issues and challenges	Nature of Solution	Options Within a SETA
Unclear HS classification of certain SEA products such as solar lamps	Establish a clear and coherent classification system for SEA products agreed upon by all WTO Members or at least initially by SETA Members	SETA Working Group on Product Classification to address SEA products (among others) and if required forward these recommendations to World Customs Organisation.
High import duties and taxes in some countries including components and complicated duty structure.	Lower import duties and taxes as appropriate particularly on components and inputs and simplify duty structure.	Could be addressed as part of discussions/negotiations within a SETA with voluntary commitments being undertaken initially by African countries even if not part of a SETA with appropriate S&DT.
Local Content and related incentives.	Removing or gradual phase-out of local content and related incentives if they do not lead to the establishment of a competitive domestic industry within a certain period of time.	Could be addressed as part of discussions/negotiations within a SETA and included as an explicit SETA provision.
Subsidies contingent upon unreasonable standards criteria that stifle innovation.	Addressing standards related issues and incentives in a manner that facilitates innovation and introduction of products that are effective and efficient in the local context.	Establishment of a monitoring mechanism or a working group on SEA (sustainable energy access) standards that tracks such problematic standards and accreditation related requirements and takes it up with relevant national authorities.
Delays at customs including due to confusion regarding product classification and erroneous imposition of higher taxes due to lack of awareness on tax exemptions the products may be eligible for.	Expedited customs procedures for SEA products and raising awareness among customs officials	SETA can include trade-facilitation related provisions that prioritize SEA products. Related technical assistance and co-operation provisions could aim at raising awareness among customs authorities.
Monitoring SEA trade policies and obstacles	Supporting solutions through technical assistance and co-operation	Monitoring compliance with SETA provisions and supporting effective implementation of SETA provisions

• SETA Technical Assistance and Co-operation Measures
• SETA Monitoring Mechanism

Endnotes

1. Barack H. Obama "Remarks by President Obama at the University of Cape Town" The White House (30 June, 2013), http://www.whitehouse.gov/the-press-office/2013/06/30/remarks-president-obama-university-cape-town (10 December, 2013).

2. Btu stands for British Thermal Unit. It is a traditional unit of energy equal to about 1055 joules. One Btu is the amount of energy needed to heat one pound of water by one degree Fahrenheit.

3. *Access to Energy and Human Development,* Amie Gaye, UNDP, 2007/08

4. *Global Energy Futures and Human Development: A Framework for Analysis*, Alan D. Pasternak, October 2000

5. IFC. *Lighting Asia: Solar Off-grid Lighting* (2012).

6. Off-grid population indicates the number of people without access to electricity

7. S.R. Khandekar et al – World Bank, 2010

8. *Access to Energy and Human Development,* Amie Gaye, UNDP, 2007/08

9. Source: Modi et al, MDG, 2005

10. Source: Lighting Asia: Solar Off-grid Lighting, IFC, February 2012

11. Information and Resources on Gender Equality and Empowerment of Women, UN

12. FAO. *The State of Food and Agriculture 2010-11* (2011).

13. Practical Action (2005).

14. Modi et al- MDG (2005).

15. Brüderle(2011).

16. K-factor - This number, the molar ratio of products of incomplete combustion (PIC) emittedt ototalcarbonemitted,isdefinedbyresearchers as the k-factor of a fuel, and it varies based on the technology used with the fuel. Renewable energy technology based fuels usually have lower k-factors than traditional fuel sources.

17. Practical Action (2005)

18. IEA (2012)

19. Hydraulic head refers to the difference in height between the highest point from where the water falls to the lowest point where the turbines that it turns are kept. The energy/electricity generated is proportional to this difference in height or head.

20. These are based on solar PV system prices in the US. National Renewable Energy Laboratory (US), Lawrence Berkeley National Laboratory (US), July 2013

21. Feed-in-tariff (FiT) is a policy mechanism adopted to encourage investment in the renewable energy sector. Under this mechanism, a power producer is offered long term contracts for power procurement. The price specified in the contract is usually in terms of a unit of electricity generated.

The price offered is determined based on the cost of electricity generation of each technology. For instance, since wind energy based systems have lower capital costs, they are offered a lower FiT when compared to solar energy based systems which have a relatively higher capital cost. In some cases (as seen in the case of Germany), the prices are usually determined by fixing a certain return on investment for the developers and then calculating the tariff backwards.

22. Feed-in-Tariffs as a Policy Instrument for Promoting Renewable Energies and Green Economies in Developing Countries, UNEP, 2012

23. IFC. *Lighting Asia: Solar Off-grid Lighting* (2012).

24. Ibidf.

25. IFC, *Lighting Asia: Solar Off-grid Lighting* (2012).

26. Ministry of New and Renewable Energy, India, 2012

27. IFC. *Lighting Africa* (2010).

28. SELCO Solar Pvt. Ltd. (2012).

29. Brüderle (2011).

30. US demands WTO examines India's anti-dumping investigation, PV-Tech with inputs from RESolve Energy Consultants (February 2013) http://www.pv-tech.org/news/us_demands_wto_examines_indias_anti_dumping_investigation (30 March 2013).

31. IFC. *Lighting Africa* (2010).

32. IFC. *Lighting Asia: Solar Off-grid Lighting* (2012).

33. Data from Ministry of Commerce and Industry – India and RESolve Analysis

34. IFC. *Lighting Asia: Solar Off-grid Lighting* (2012).

35. IFC (2010) *Solar Lighting for the Base of the Pyramid - Overview of an Emerging Market.*

36. Unless otherwise indicated as some countries have only reported data for 2011 at the time of writing

37. Except for Korea, the value of solar PV exports of all major reporters fell sharply in 2012, compared with 2011. This is largely owing to falling prices. The sharp decline in Chinese exports can also be attributed to (the threat of) unfair trade disputes.Figures for country groupings (all reporters, EU, developing countries, Africa) are also affected by some missing observations

38. Sustainable Power Electric Company (SPEC)

39. IFC (2010) *Solar Lighting for the Base of the Pyramid - Overview of an Emerging Market.*

40. *Economist. "Solar Lighting: Lighting the Way,"* 1 September 2012, http://www.economist.com/node/21560983 (12 December 2013).

41. Other electric lamps and light fittings" are electric lamps and light fittings other than chandeliers and other electric ceiling or wall lighting fittings (HS 940510); electric table, desk, bedside or floor-standing lamps (HS 940520) or lighting sets of a kind used for Christmas trees (HS 940510).

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Annex I

Methodology Used for Trade Analysis in Chapter 4

Scope

Recalling the discussion in previous sections of this paper, the focus is on the following CEG technologies, all being off-grid applications:

- Solar off-grid home electric systems
- Solar mini-grids serving a community, cluster of households, or a village
- Individual solar lighting appliances

A solar home system (SHS) uses a photovoltaic (PV) module to provide power for lights and small appliances. The system also needs a rechargeable battery and a charge controller. An energy converter (from DC to AC) may be required so that standard mains-voltage equipment can be run from the SHS. The same equipment may be required for solar mini-grids. In addition, solar lighting appliances require solar lamps and appropriate lighting fittings.

In order to generate trade flow and tariff information, key products associated with these technologies have to be identified in terms of internationally used nomenclatures, in particular the Harmonized System (HS). Information is generated using the United Nations Commodity Trade Statistics Database (COMTRADE) for trade flows and the WTO Integrated Database notifications for information on most-favoured nation (MFN) applied tariffs.

Several issues arise. First, HS product descriptions are, in most cases, too general to exclusively or predominantly capture CEGs. Consequently, other goods also are included. Second, the analysis includes some multiple-purpose components (e.g. batteries) that may or may not be used in solar-energy technologies. Third, even where a solar CEG (e.g. a PV panel) can be clearly identified, there is no way to know whether the technology will be applied off-grid (in most cases it will not). Certain CEG, e.g. a solar lantern with an incorporated PV cell, may be specific for off-grid applications, but most CEGs are fungible and may either be connected to the grid or applied off-grid. This affects in particular the trade-flow analysis.

The above does not really affect the tariff analysis. Information on tariff rates for any CEG can (and must) always be found as any product can be imported only under the provisions of a particular item in the tariff schedule of the importing country (among other reasons because an import duty may be levied). In the vast majority of cases, customs authorities will use technical criteria (unrelated to CE) to determine the provisions under which TL a product should be imported.

Classification issues

The HS is a multi-purpose classification system for traded products that is internationally harmonized up to the six-digit level. The World Customs Council (WCO) seeks to keep the HS up to date in terms of changes in technology or patterns of international trade, through amendments that are introduced every five years, most recently in 2012.

Some recent amendments in the HS are particularly relevant for CEGs. According to the *Economist*, the biggest technical problem for the further deployment of solar lighting (in Africa) is the batteries. "Nickel-metal-hydride batteries are more expensive and less polluting than nickel-cadmium cells, and have a longer life. Lithium-ion batteries, the sort found in laptops and mobile phones, are better still, but are too expensive."[40] In the 2012 Revision of the HS, new subheadings have been created in HS 2012 to provide separately for these accumulators, facilitating analysis and tariff negotiations.

Further to the harmonized six-digit codes, a national tariff schedule includes national tariff lines (TLs) for tariff purposes. A TL may have 8, 10 or more digits. Some national tariff schedules include TLs that capture a CEG more narrowly. Amendments in national tariff schedules can be implemented more easily. National TLs, however, are not internationally harmonized.

Trade and tariff information

The trade-flow and tariff analysis is based on data reported by countries to COMTRADE (trade) and the WTO (tariffs). At the time of writing, some countries have not yet reported 2012 trade statistics. Some African countries, in particular certain LDCs, have not reported trade data or have done so for only some years. Therefore, some statistics on African imports are based on exports to Africa reported by trading partners. The trade-flow analysis is based on COMTRADE, using WITS.

The tariff analysis focuses on the most recent MFN-applied tariffs reported by WTO members to the WTO. Source: the WTO Integrated Database notifications, using the WTO Tariff Download Facility (http://tariffdata.wto.org/). In addition, the WTO Tariff Analysis Online facility has been used to access tariff-line level information.

Relevant HS codes

The following six-digit HS is used to generate trade-flow and tariff information

Table A1-1 Relevant HS Codes Used for Trade Analysis

Clean Energy Good	HS Sub-heading	HS Description	Remarks.
PV panel	Ex HS 854140	Photosensitive semiconductor devices, including photovoltaic cells whether or not assembled in modules or made up into panels; light emitting diodes	In key importing countries, trade in PV cells and modules seem to make up a large (and growing) portion of trade in all goods traded under this HS subheading. The subheading also includes LEDs.
Rechargeable battery	HS 850750 HS 850760	Electric accumulators, nickel-metal hydride (850750) and Lithium-ion (850760)	New subheadings have been created in HS 2012 to provide separately for these accumulators (previously they were part of 850780 (Other accumulators).
Energy converter	HS 850440	Static converters	
Charge controller	HS 853710	Boards, panels, consoles, desks, cabinets and other bases, for electric control or the distribution of electricity. For a voltage not exceeding 1000V	
Solar lighting	Solar lighting	Non-electrical lamps and lighting fittings	HS-6 does not explicitly mention solar lamps. Some national tariff schedules break the HS down into “petroleum-burning lamps” (such as kerosene lamps) and “other”.
	Ex HS 940540	Other electric lamps and lighting fittings	HS-6 does not explicitly mention solar lamps.

Table A1-2 Selected Clean Energy Goods (CEG), World Trade (Excluding Intra-EU Trade) in 2011 and 2012

	Imports (USD millions)		Exports (USD millions)	
	2011	2012	2011	2012
HS 854140	60144	44261	57791	42406
HS 850440	41297	37951	33370	32809
HS 853710	28785	30535	26789	28209
HS 940540	8302	9206	8366	9959
HS 940550	1081	970	1136	1110
HS 850750		1383		1462
HS 850760		8525		9499

Source: COMTRADE, using WITS (June 2013).

HS **854140** (Solar PV cells and modules) is by far the most important from a market and trade perspective, representing USD 60 billion of world imports (excluding intra-EU trade) in 2011 (even considering that part of this value corresponds to LEDs). World exports grew by an average rate of 28 per cent per year between 2004 and 2011 to USD 58 billion, with Chinese exports growing by 71 per cent per year. During this period, global annual capacity additions grew by 60 per cent per year on average.

Trade in solar PV cells and modules, in particular developed country imports, is overwhelmingly driven by new grid-connected capacity installations. Trade data do not reveal much about trade in PV cells and modules that will eventually be applied off-grid. In many developing countries, in particular those with large populations without access to electricity, however, PV imports may be driven to a considerable extent by off-grid projects. Therefore, this note provides detailed information on imports into African countries and other developing countries with large populations without access to electricity, because these imports may be a hint that countries are installing off-grid capacity. In the African context, for example, relatively high imports into countries such as Ghana, Mali, Mozambique, Senegal, and Tanzania may be linked with solar projects documented in various publications, such as the REN21 Renewables 2013 Global Status Report and other recent publications available on the Internet. For example: Mali's rural electrification programme has brought electricity to 740,000 people in the last six years, primarily (98 per cent) with off-grid systems, thereby increasing the share of people with electricity access in rural areas from 1 per cent to nearly 17 per cent. Mozambique also has increased access through off-grid solar PV; the 0.5 MW of capacity added between 2010 and the end of 2012 brought the national total to 1.3 MW. (REN21, page 89).

HS 850440 (static converters) and **HS 853710** (electricity control or distribution appliances) include multiple-use products that collectively represent high volumes of trade, but only a small portion of the value of a reporter's imports under the provisions of these sub-headings may be associated with the deployment of CE technologies.

Since **HS 850750** (nickel-metal hydride) and **HS 850760** (lithium-ion batteries) were introduced only with the HS 2012 revision, no specific trade data are available for earlier periods. The trade values shown may increase significantly as more countries report HS 2012 trade data to COMTRADE.

With regard to solar lamps and lighting fittings, the HS codes identified also include other lamps; therefore, it is not possible to know how much trade corresponds to solar lamps. On a global scale, most trade in solar lamps and lighting fittings may be reported under the provisions of HS 940540 (Other electric lamps and lighting fittings), which accounts for more than USD 8 billion (for all items of the six-digit HS code) in average annual trade in the period 2010-2012. World trade under the provisions of HS 940550 (non-electrical lamps and lighting fittings) is small—just over USD 1 billion. China accounts for a very high portion of world exports of the non-electric lamps and lighting fittings under the provisions of HS 940550 and most likely also dominates exports of any solar lamps traded under this sub-heading. India is also said to be an important exporter of solar lamps. Not included in the analysis presented here are portable lamps provided for by HS 851310. Trade data indicate that average annual world trade in portable lamps of HS 851310 in the period 2010-2012 was worth USD 1.9 billion and USD 2.8 billion, using import and export data respectively.

Import tariffs

Import tariffs are applied at the national tariff line level.

In the case of **HS 854140**, MFN-applied tariffs are, in general quite low. There are some exceptions. For example, Cameroon, the Democratic Republic of Congo, Djibouti, and Gabon have relatively high tariffs. These countries are very small importers of PV devices.

MFN-applied tariffs affecting products falling under HS code **HS 940550** (non-electrical lamps and lighting fittings) are rather high in many developing countries (Table A2-4). A problem is that the same HS code also includes petroleum-burning lamps, such as kerosene lamps, which may result in serious health issues and have adverse environmental impacts. Developing countries may seek to reduce import duties for only solar lamps, but this may be somewhat complicated where there is no designated tariff line for solar lamps. India has a designated TL for solar lamps. Effective 2011, India has introduced a lower MFN tariff duty of 5 per cent for solar lamps, leaving the rates for all other lamps at 10 per cent. This represents an incentive in favour of solar lamps. Similarly, Malaysia has a higher rate for petroleum-based lamps than for '"other" lamps.

In practice, solar lamps may be traded under **HS 940540** (other electric lamps and lighting fittings).[41] MFN-applied tariffs applied to tariff lines of this HS code are, in general, similarly high (Table A2.3).

Tariffs far **HS 850750** (nickel-metal hydride batteries) and **HS 850760** (lithium-ion batteries), introduced with the HS 2012 revision, are the same. For reporters that have not yet reported tariffs in HS 2012, the relevant HS code is **HS 850780** (other accumulators), which includes a wider range of batteries.

The creation of separate HS codes at the internationally harmonized six-digit level may facilitate tariff negotiations on nickel-metal hydride and lithium-ion batteries.

Tariffs for **HS 850440** (Static converters) are high in countries, such as India, Indonesia and Pakistan. Most countries apply tariffs of 5 per cent or less. Tariffs for HS 853710 are somewhat higher

Annex II

MFN Applied Tariffs For Selected Energy Access Products

Table A2-1 MFN-Applied Tariffs By Selected Reporters: HS 854140 - PV Cells and Modules

Reporter	Year	MFN Applied Tariff				
		HS version	Number of TL	Average of AV Duties	Minimum AV Duty	Maximum AV Duty
Argentina	2012	HS07	27	5,9	0	12
Australia	2013	HS12	1	0	0	0
Bangladesh	2011	HS07	2	2,5	0	5
Brazil	2012	HS12	18	1,2	0	12
Cameroon	2011	HS07	1	10	10	10
Canada	2012	HS12	1	0	0	0
Chile	2012	HS12	1	6	6	6
China	2010	HS07	3	0	0	0
Congo	2011	HS07	1	10	10	10
Côte d'Ivoire	2012	HS07	1	0	0	0
Dem Rep of Congo	2010	HS07	2	10	10	10
Djibouti	2012	HS07	2	26	26	26
Egypt	2012	HS07	1	0	0	0
European Union	2013	HS12	2	0	0	0
Gabon	2011	HS07	1	10	10	10
Ghana	2010	HS07	2	5	0	10
Hong Kong, China	2013	HS12	2	0	0	0
India	2012	HS12	4	0	0	0
Indonesia	2012	HS07	3	0	0	0
Japan	2012	HS12	3	0	0	0
Kenya	2012	HS12	1	0	0	0
Korea, Republic of	2012	HS12	7	0	0	0
Malaysia	2012	HS07	1	0	0	0
Morocco	2011	HS02	2	2,5	2,5	2,5
Nigeria	2011	HS07	1	0	0	0
Pakistan	2012	HS12	1	5	5	5
Philippines	2012	HS07	3	0	0	0
Senegal	2012	HS07	1	0	0	0
Singapore	2012	HS12	5	0	0	0
South Africa	2013	HS12	3	0	0	0
Sri Lanka	2012	HS07	1	0	0	0
Taipei, Chinese	2013	HS07	7	0	0	0
Tanzania	2012	HS12	1	0	0	0
Thailand	2011	HS07	3	0	0	0
Tunisia	2012	HS12	2	0	0	0
Turkey	2011	HS07	2	0	0	0

Table A2-1 MFN-Applied Tariffs By Selected Reporters: HS 854140 - PV Cells and Modules, continued

Reporter	Year	MFN Applied Tariff				
		HS version	Number of TL	Average of AV Duties	Minimum AV Duty	Maximum AV Duty
Uganda	2012	HS12	1	0	0	0
United Arab Emirates	2013	HS12	1	0	0	0
USA	2012	HS12	5	0	0	0
Viet Nam	2012	HS12	5	0	0	0
Zambia	2012	HS12	1	0	0	0

Source: Integrated Database (IDB) notifications.

Table A2-2 MFN-Applied Tariffs by Selected Reporters: HS 940540 - Other Electric Lamps

Reporter	Year	MFN Applied Tariff				
		HS version	Number of TL	Average of AV Duties	Minimum AV Duty	Maximum AV Duty
Algeria	2010	HS07	1	30,0	30	30
Angola	2011	HS02	1	10,0	10	10
Argentina	2012	HS07	2	18,0	18	18
Australia	2013	HS12	1	5,0	5	5
Bangladesh	2011	HS07	4	16,8	5	25
Benin	2012	HS07	1	20,0	20	20
Botswana	2013	HS12	8	7,5	0	20
Brazil	2012	HS12	2	18,0	18	18
Brunei Darussalam	2011	HS07	8	5,0	5	5
Burkina Faso	2012	HS07	1	20,0	20	20
Burundi	2012	HS12	1	25,0	25	25
Cambodia	2012	HS07	8	13,1	0	15
Cameroon	2011	HS07	2	30,0	30	30
Canada	2012	HS12	3	4,3	0	7
Cape Verde	2013	HS07	1	30,0	30	30
CAR	2011	HS07	2	30,0	30	30
Chad	2011	HS07	2	30,0	30	30
Chile	2012	HS12	3	6,0	6	6
China	2010	HS07	3	15,0	10	17,5
Colombia	2012	HS12	3	15,0	15	15
Congo	2011	HS07	2	30,0	30	30
Costa Rica	2012	HS12	2	7,0	0	14
Côte d'Ivoire	2012	HS07	1	20,0	20	20
DR of the Congo	2010	HS07	1	20,0	20	20
Djibouti	2012	HS07	8	26,0	26	26
Egypt	2012	HS07	4	17,5	5	30
European Union	2013	HS12	7	3,7	2,7	4,7

Table A2-2 MFN-Applied Tariffs by Selected Reporters: HS 940540 - Other Electric Lamps

Reporter	Year	MFN Applied Tariff				
		HS version	Number of TL	Average of AV Duties	Minimum AV Duty	Maximum AV Duty
Gabon	2011	HS07	2	30,0	30	30
Ghana	2010	HS07	1	20,0	20	20
Guinea	2012	HS02	1	20,0	20	20
Guinea-Bissau	2012	HS07	1	20,0	20	20
Indonesia	2012	HS07	9	7,8	5	10
Israel	2012	HS12	6	21,7	0	100
Japan	2012	HS12	2	0,0	0	0
Kenya	2012	HS12	1	25,0	25	25
Korea, Republic of	2012	HS12	4	8,0	8	8
Lesotho	2013	HS12	8	7,5	0	20
Liberia	2011	HS96	1	15,0	15	15
Madagascar	2012	HS12	2	20,0	20	20
Malawi	2012	HS07	4	8,8	0	25
Malaysia	2012	HS07	5	11,0	0	25
Maldives	2011	HS07	9	25,0	25	25
Mali	2012	HS07	1	20,0	20	20
Malta	2002	HS02	7	6,4	5	8
Mauritania	2010	HS96	1	20,0	20	20
Mauritius	2012	HS12	5	3,0	0	15
Mexico	2012	HS07	1	15,0	15	15
Morocco	2011	HS02	20	24,3	2,5	30
Mozambique	2012	HS07	1	20,0	20	20
Myanmar	2012	HS12	8	1,0	1	1
Namibia	2013	HS12	8	7,5	0	20
Nepal	2012	HS07	1	15,0	15	15
Niger	2012	HS07	1	20,0	20	20
Nigeria	2011	HS07	1	20,0	20	20
Pakistan	2012	HS12	2	17,5	5	30
Panama	2012	HS12	7	12,9	10	15
Philippines	2012	HS07	8	4,0	1	7
Rwanda	2012	HS12	1	25,0	25	25
Senegal	2012	HS07	1	20,0	20	20
Sierra Leone	2012	HS07	1	20,0	20	20
Singapore	2012	HS12	8	0,0	0	0
South Africa	2013	HS12	8	7,5	0	20
Sri Lanka	2012	HS07	5	12,0	0	30
Swaziland	2013	HS12	8	7,5	0	20
Taipei, Chinese	2013	HS07	10	5,4	1,7	10
Tanzania	2012	HS12	1	25,0	25	25
Thailand	2011	HS07	8	20,0	20	20
The Gambia	2012	HS07	1	20,0	20	20

Table A2-2 MFN-Applied Tariffs by Selected Reporters: HS 940540 - Other Electric Lamps, continued

Reporter	Year	MFN Applied Tariff				
		HS version	Number of TL	Average of AV Duties	Minimum AV Duty	Maximum AV Duty
Togo	2012	HS07	1	20,0	20	20
Tunisia	2012	HS12	22	30,0	30	30
Turkey	2011	HS07	31	2,9	2,7	4,7
Uganda	2012	HS12	1	25,0	25	25
USA	2012	HS12	3	4,9	3,9	6
Zambia	2012	HS12	1	25,0	25	25
Zimbabwe	2012	HS07	2	22,5	5	40

Source: Integrated Database (IDB) notifications.

Table A2-3 MFN-Applied Tariffs by Selected Reporters: HS 940550 - Non-electric Lamps

Reporter	Year	MFN Applied Tariff				
		HS version	Number of TL	Average of AV Duties	Minimum AV Duty	Maximum AV Duty
Cameroon	2011	HS07	3	20	10	30
Canada	2012	HS12	2	6	5	7
Chile	2012	HS12	1	6	6	6
China	2010	HS07	1	20	20	20
Colombia	2012	HS12	2	15	15	15
Congo	2011	HS07	3	20	10	30
Côte d'Ivoire	2012	HS07	1	20	20	20
Dem Rep of Congo	2010	HS07	1	10	10	10
Djibouti	2012	HS07	2	26	26	26
Egypt	2012	HS07	4	2	2	2
European Union	2013	HS12	1	2,7	2,7	2,7
Gabon	2011	HS07	3	20	10	30
Ghana	2010	HS07	3	10	10	10
India	2012	HS12	7	9,3	5	10
Indonesia	2012	HS07	10	6,8	5	12,5
Japan	2012	HS12	2	0	0	0
Kenya	2012	HS12	1	25	25	25
Korea, Republic of	2012	HS12	1	8	8	8
Malaysia	2012	HS07	4	8,8	0	15
Nigeria	2011	HS07	1	20	20	20
Pakistan	2012	HS12	1	30	30	30
Philippines	2012	HS07	5	5,4	3	7
South Africa	2013	HS12	1	0	0	0
Sri Lanka	2012	HS07	2	17,5	5	30
Taipei, Chinese	2013	HS07	2	7,5	7,5	7,5

Table A2-3 MFN-Applied Tariffs by Selected Reporters: HS 940550 - Non-electric Lamps, continued

Reporter	Year	MFN Applied Tariff				
		HS version	Number of TL	Average of AV Duties	Minimum AV Duty	Maximum AV Duty
Tanzania	2012	HS12	1	25	25	25
Thailand	2011	HS07	4	20	20	20
Tunisia	2012	HS12	2	27	27	27
Uganda	2012	HS12	1	25	25	25
USA	2012	HS12	3	4,9	2,9	6
Viet Nam	2012	HS12	4	20	5	25
Zambia	2012	HS12	1	25	25	25
Zimbabwe	2012	HS07	2	25	10	40

Source: Integrated Database (IDB) notifications.