chapter 21

# Biomass Resources, Energy Access and Poverty Reduction

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# Highlights

- Energy poverty and lack of access to modern energy is still a problem in developing countries, mainly in rural areas and particularly in Sub-Saharan Africa and Asia;
- Bioenergy can be harnessed to support sustainable development and should be included in the Sustainable Development Goals;
- Energy poverty reduction may contribute in reducing inequality in terms of the livelihoods and number of people living in extreme poverty;
- Modern technologies for bionergy will contribute to poverty reduction, health and development in poor areas.

# Summary

Energy has been recognized in recent decades as a key driving force for sustainable development. Access to reliable and affordable energy supports income-generating activity, increases productivity and promotes sustainable livelihoods. Poor people around the world, particularly subsistence farmers living in rural areas in developing countries, often lack adequate access to basic infrastructure, electricity and modern fuels. They depend heavily on traditional biomass to meet their energy needs, causing serious health impacts, contributing to degradation of forest resources and lowering household productivity. Improved energy access and more effective delivery of energy services - including through the use of modern bioenergy - offers opportunities to contribute to poverty reduction and rural development. This chapter provides an overview of the relationships between energy and its role in poverty reduction, focusing especially on the role of modern bioenergy and on rural areas.

# 21.1 Introduction

Energy has been recognized in the last decades as an important promoter of development through achievement of social and economic goals and as a basic input for sustaining people's livelihoods. Although not included in the Development Millennium Goals, energy access has been considered essential and is included in the Post-2015 Development Agenda, within the Sustainable Development Goals. According to the

World Bank (2014), over 1.2 billion people (nearly 17% of global population) lack access to electricity, while another 2.8 billion people depend on traditional bioenergy for their cooking and heating needs. Most are poor people living in rural areas of the developing world, and their dependence on bioenergy for cooking makes them vulnerable to a range of illnesses as a result of indoor pollution.

Around three-quarters of the world's population depend directly on agriculture and so the sector has a significant role to play in poverty reduction (UNDP 2007), particularly for the 2.7 billion poor people worldwide who currently live under USD$2.00 per day (Diaz-Chavez 2010). The poor lack adequate access to infrastructure and services, including modern, clean energy sources, and are thus heavily reliant on traditional biomass to meet their energy needs. Most are dwellers in rural areas in developing countries who depend on traditional fuels, such as biomass, to meet their heating and lighting needs. As Goldemberg (2000) notes, lack of access to adequate energy services in rural areas in developing countries has a number of social, environmental and health implications. Furthermore, improving delivery of affordable and reliable energy services especially to rural communities, will contribute to the development of human and economic capacity to adapt to impacts resulting from climate change (Casillas and Kammen 2010).

Clancy (2013) and Diaz-Chavez (2010) have highlighted the relationships between agriculture and bioenergy production. Bioenergy, especially that produced through the so-called 'first generation crops', requires intensive use of labor, land and other resources, leading to the creation of jobs, the extension of supply chains and infrastructural development. Diaz-Chavez (2010) noted empirical evidence demonstrating these positive relationships for small scales of production (see for instance COMPETE 2009; PISCES 2009; Global-Bio-Pact 2013). This chapter presents an overview of the links between energy and poverty and highlights the ways through which bioenergy can contribute to development, particularly in rural areas.

## 21.2 Poverty, Inequality and Poverty Reduction

There is no widely accepted definition of poverty. Definitions vary, for instance, according to country, the international organizations that report on poverty, and the method used to measure it. Common methods to measure poverty refer to levels of income or expenditure. This is translated into what is called the "poverty line", which specifies the income (or level of spending) required to purchase essential goods, such as food, clothing, shelter, water, electricity, schooling, and healthcare.

The poverty line enables decision makers to gauge the number and geographical distribution of the poor. It allows them to channel resources towards the poor as well as monitor progress towards a clear target (Morduch 2006).

Currently the poverty line ranges from $1 to $2 USD per day per person. Figure 21.1 shows the estimated total population worldwide and the number of people living under the poverty line at $1.25 (Povcal 2014). These are estimates from the World Bank Poverty calculator.

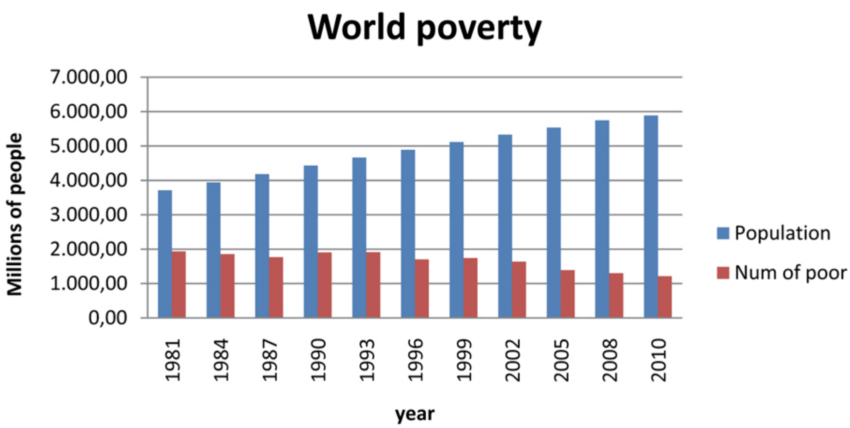


**Figure 21.1.** Estimated Total World Population and Estimated number of people living under $1.25 USD (Data from Povcal 2014).

However, it has been widely recognized that poverty is multi-dimensional – it may have to do with lack of voice as much as with lack of income. Informal markets and transactions are important, particularly for the rural poor, who may have access to assets and resources that are not measured in monetary terms. Also, income levels constitute an imperfect proxy for measuring wellbeing: higher incomes may not necessarily translate into improvements in health or education, for example. Some indices have been developed to capture these other dimensions of poverty – such as the Human Poverty Index (HPI), the Human Development Index (HDI) and the Multidimensional Poverty Index (MPI) (UNDP 2010). Definitions of all these indices are provided in Box 21.1.

Following the Rio+20 declaration on "making sustainable energy for all a reality and, through this, help to eradicate poverty and lead to sustainable development and global prosperity", the discussion on the new Sustainable Development Goals has included the consideration of a goal on energy: "Securing Sustainable Energy For All By 2030". This goal includes three targets and indicators for 2030: 1) Ensuring universal access to modern energy services; 2) Doubling the global rate of improvement in energy efficiency; and 3) Doubling the share of renewable energy in the global energy mix. It is suggested to measure the second target with an indicator that links poverty reduction with the capacity to afford power through rate improvement in primary energy intensity of GDP measured in purchasing power parity (UNenergy 2014).

## **Box 21.1.** Indices used for measuring poverty

**HPI** Rather than measure poverty by income, the HPI uses indicators of the most basic dimensions of deprivation: a short life, lack of basic education and lack of access to public and private resources. The HPI concentrates on the deprivation in the three essential elements of human life already reflected in the HDI: longevity, knowledge and a decent standard of living. The HPI is derived separately for developing countries (HPI-1) and a group of select high-income OECD countries (HPI-2) to better reflect socio-economic differences and also the widely different measures of deprivation in the two groups (UNDP 2010).

**HDI** The Human Development Index (HDI) is a summary composite index that measures a country's average achievements in three basic aspects of human development: health, knowledge, and income. It was introduced as an alternative to conventional measures of national development, such as level of income and the rate of economic growth (UNDP 2010).

**MPI** The Multidimensional Poverty Index (MPI) is a new measure designed to capture the severe deprivations that people face at the same time. The MPI reflects both the incidence of multidimensional deprivation, and its intensity – how many deprivations people experience at the same time. It can be used to create a comprehensive picture of people living in poverty, and permits comparisons both across countries, regions and the world and within countries by ethnic group, urban/rural location, as well as other key household and community characteristics. The Index includes three dimensions (health, education and standard of living). The health dimension includes an indicator on nutrition which is also a proxy to measure hunger (UNDP 2010).

Income levels are commonly measured through per capita GDP, or GDP divided by total population (UNstat 2012). However, average data on poverty or income may mask major inequalities. Two countries with similar average incomes may have very different poverty profiles, depending on how income is distributed. For this reason, it is useful to complement average data with the Gini Index or coefficient (World Bank 2013) which measures inequality. Definitions of GDP and the Gini index are provided in Box 21.2. Figure 21.2 shows a diagram of the links between the access to energy and the Gini and GDP indicators. The distribution of energy resources may result in significant social, environmental and economic inequalities. This relationship, especially in the context of access to electricity, was reviewed by Wu et al. (2012) who suggest that concerns related to inequality of energy consumption must be integrated into development strategies for all countries, irrespective of their human development level.

## **Box 21.2.** Definitions of Indicators related to poverty and inequality

**Gini** Coefficient of inequality is the most commonly used measure of inequality. The coefficient varies between 0, which reflects complete equality and 1, which indicates complete inequality (one person has all the income or consumption, all others have none). It is sometimes argued that one of the disadvantages of the Gini coefficient is that it is not additive across groups (i.e. the total Gini of a society is not equal to the sum of the Ginis for its sub-groups) (World Bank 2013).

**GDP** Gross domestic product is an aggregate measure of production equal to the sum of the gross values added of all resident institutional units engaged in production (plus any taxes, and minus any subsidies, on products not included in the value of their outputs). The sum of the final uses of goods and services (all uses except intermediate consumption) measured in purchasers' prices, less the value of imports of goods and services, or the sum of primary incomes distributed by resident producer units (World Bank 2013).

Another important source of information on poverty is the Millennium Development Goals report. In September 2000, the Millennium Summit adopted the UN Millennium Declaration. Member nations committed to a new global partnership to reduce extreme

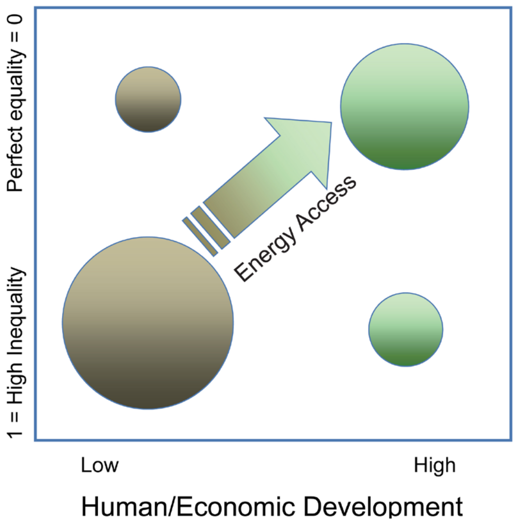


**Figure 21.2.** Representation of equality and energy access.

poverty and set out targets with a 2015 deadline, These are known as the Millennium Development Goals (MDGs) (UN 2000). They are the world's time-bound and quantified targets for addressing extreme poverty in its many dimensions including income poverty, hunger, disease, lack of adequate shelter, and exclusion, while promoting gender equality, education, and environmental sustainability (UN 2013). The 2013 UN report on MDGs shows that the target of halving the number of poor people living in extreme poverty (Goal 1.a "Halve, between 1990 and 2015, the proportion of people whose income is less than $1 a day") has been achieved: the proportion of population in developing regions living under less than $1.25 a day fell from 47% in 1990, to 22% in 2010. This is about 700 million fewer people living in conditions of extreme poverty in 2010 than in 1990. Thus, the goal was reached five years sooner than the deadline. Nevertheless, there are still 1.2 billion people who live under extreme poverty, mainly in Sub-Saharan Africa and Asia. The MDGs will be superseded by the Sustainable Development Goals still under discussion. The Sustainable Development Goals initiative was decided at the UN Rio + 20 Conference (UN 2014).

Energy is considered to be an essential input for people's livelihoods. It is used for basic activities from cooking and boiling water to heating (Clancy 2013). Biomass is the most basic energy source especially in poor households and in rural areas. Energy poverty is a wide and contextual term but is generally considered to be related to access and affordability problems in the developing world (Day and Walker 2013). It has been defined as the lack of choices for accessing energy services that are adequate, affordable and reliable (Clancy, 2013). This has led to other terms including fuel poverty, energy insecurity, energy injustice among others (Bickerstaff et al. 2013). People live in energy poverty either because there is no availability of quality energy carriers where they live or because they cannot afford them (Clancy 2013). Nwanyek (2010) pointed out two requirements for reducing poverty: to have sufficiently high and sustained economic growth and equality in income distribution or reduction of the inequality index. Additionally, diversification of income-generating activities is seen as another mean to move away from poverty as energy access is also related to household income. According to Clancy (2013) in order to end energy poverty, it is necessary to have access to modern and cleaner energy carriers (e.g. biogas, electricity) or better conversion technologies and equipment. Bioenergy crops provide an opportunity for diversifying rural activities and creating jobs and infrastructure (Clancy 2013). Although there is yet little evidence that biofuels production can reduce poverty directly, it has been demonstrated that it plays an important role in creating jobs and local markets (Diaz-Chavez 2010).

In urban, rural and peri-urban areas, vulnerable groups are more affected by poverty. These include women headed households, young people, indigenous groups, disabled and elderly people. As shown in Chapter 15, this volume, different business models may contribute to job creation and development. Nevertheless, ending energy poverty will require enabling access to modern and clean energy sources (e.g. electricity, biogas) as well as more efficient equipment for using biomass (e.g. cooking stoves).

# 21.3 Bioenergy and Poverty Reduction. International Programs

The International Energy Agency (IEA 2014) defines energy poverty as the lack of access to modern energy services, whilst access to modern energy services implies household access to electricity and clean cooking facilities (e.g. cooking stoves and fuels that do not cause indoor pollution) (OECD/IEA 2010). The IEA also acknowledges that access to energy services contributes both to human welfare and to national economic development. The larger part of the human population that lacks access to modern energy services is located in Sub-Saharan African and Asia. Table 21.1 illustrates selected indicators related to energy production and consumption of electricity regarding the GDP of main regions in the world.

**Table 21.1.** Selected energy indicators.

| Region/Country/ Economy | Population (millions) | GDP (billions 2005 USD) | Energy prod (Mtoe) | Electricity consumption (TWh) |
|---|---|---|---|---|
| World | 6958 | 52486 | 13202 | 20407 |
| OECD | 1241 | 38239 | 3854 | 10205 |
| Middle East | 209 | 1271 | 1788 | 737 |
| Non-OECD Europe and Eurasia | 340 | 1597 | 1822 | 1525 |
| China | 1351 | 4426 | 2433 | 4475 |
| Asia | 2313 | 3386 | 1405 | 1904 |
| Non-OECD Americas | 460 | 2298 | 797 | 942 |
| Africa | 1045 | 1267 | 1104 | 619 |

Source: IEA 2013

As Table 21.1 shows, Africa (mainly Sub-Saharan) poses the greatest challenge. According to the SE4ALL Global Tracking Framework (SE4ALL 2013), Sub-Saharan Africa is the only region where the rate of progress on energy access (1990–2010) fell behind population growth, both for electricity and for non-solid fuels. Access to modern energy is essential for development. It helps to provide clean water, sanitation, healthcare and other services including lighting, cooking, transport, and mechanical power. Sustainable development requires considering the double causality links, whereby income enables access to energy, and access to energy contributes to economic growth (OECD/IEA 2010).

Energy access therefore plays an important role in development. Recognizing this role, different programs have been implemented over the last few decades focusing on a wide range of objectives, from aiding access through to the tradeoffs between energy and poverty (Table 21.2).

**Table 21.2.** Selected energy programs.

| Name of initiative | Acronym | Year created | Initiative funder/ organizer | Goals | Geographical scale |
|---|---|---|---|---|---|
| Global Network on Energy and Sustainable Development | GNESD[1] | | UNEP | to increase the capacity of developing country centers of excellence for effective knowledge management of energy for sustainable development issues | Global/ National |
| Global Bioenergy Partnership | GBEP[2] | 2005 | initially organized by G8+5 | promote global high-level dialogue on bioenergy policy-related issues and facilitate international cooperation<br>• support national and regional bioenergy policy discussions and market development;<br>• favor the transformation of biomass use towards more efficient and sustainable practices;<br>• foster exchange of information and skills through bilateral and multilateral collaboration; and<br>• facilitate bioenergy integration into energy markets by tackling barriers in the supply chain | National |
| Integrated food-energy systems | IFES[3] | 2010 | FAO | To demonstrate the function at various scales and configurations, from small-scale operations managed at the village or household level primarily to meet domestic needs and sustain local livelihoods to large-scale operations designed for commercial activities | project |

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| Name of initiative | Acronym | Year created | Initiative funder/ organizer | Goals | Geographical scale |
|---|---|---|---|---|---|
| Sustainable Energy for All | SEFA[4] | 2012 | United Nations | to achieve by 2030:<br>• universal access to electricity and safe household fuels,<br>• a doubled rate of improvement of energy efficiency<br>• a doubled share of renewable energy in the global energy mix | Global/ National |
| Energy-smart Food for People and Climate Program | ESF[5] | 2012 | FAO/ UNEP/ IRENA | • Better energy efficiency<br>• Increased energy diversification, with a gradual but steady emphasis on renewable energy; and Improved access to modern energy services through better integration of food and energy production | National |

[1]http://www.gnesd.org/ABOUT/Energy-Access

[2]http://www.fao.org/energy/81319/en/

[3]http://www.fao.org/energy/78517/en/

[4]http://www.se4all.org/

[5]http://www.fao.org/energy/81350/en/

The list of programs in table 21.2 is not exhaustive as many other initiatives have been undertaken by the World Bank, the United Nations, international and local Non Governmental Organizations (e.g. Global Alliance for Cooking Stoves), as well as other research centers and non-profit organizations (e.g. Practical Action).

# 21.4 Technologies: Biogas, Cooking Stoves, Minigrids

Biomass has traditionally been a main source of energy in many parts of the developing world. However, in recent decades the sustainability of biomass production and consumption has been compromised, leading to increased concerns about accessibility, environmental impacts and human health. In some regions, biomass resources have been exploited beyond their ability to regenerate, resulting in scarcity and contributing to the degradation of soil and water, as well as loss of biodiversity (Sovacool 2012; Global-Bio-Pact 2013).

The widespread use of stoves for cooking and heating that require large quantities of biomass have played a role in reducing the availability of this resource. In addition, these inefficient devices produce large amounts of smoke that impinge on indoor air quality and affect mostly the health of women and children. In Africa and India, for instance, over 10% of children under the age of 5 suffer from acute respiratory illness associated with smoke from biomass burning (Mishra 2003; Mishra et al. 2005; Kilabuko and Nakai 2007). However, new technologies now exist that address both the issue of high biomass consumption and negative health effects.

One emerging system is that of biogas, which is obtained from millions of small-scale anaerobic digesters that animal waste to a clean fuel (family-size biogas plants, f-BGP). Conversion to gas allows 24% of the energy content in dung and crop residues to reach the cooking vessel, while over 90% of the nutrients and more than 80% of the humus are returned to cropland.

The biogas system has several advantages. It helps reduce both pathogens and greenhouse gas emissions from manure. It also increases soil fertility as manure is recycled to cropland. In addition, it helps improve health and safety in cooking and lighting, as well as contributing to better sanitation (Tricase and Lombardi 2012). Biogas digesters have helped do away with the need to gather fuelwood, thus improving school attendance, and eliminated smoke from kitchens and contributing to cleaner air and improved health.

Today this biogas system reaches 5 million homes in India, and 15 million homes in China. Families have used manure from their livestock (typically a few heads of cattle or pigs) to feed small-scale biogas digesters which help both meet their domestic energy needs and reduce expenditure on fertilizer by effectively recycling nutrients to the soil. In the case of India, the take up of this system has been 40% over the last 30 years. But insufficient local maintenance and high installation costs remain important deterrents to increased use of f-BGPs. A higher adoption rate will require the biogas system to widen the feedstock base to include crop residues that are currently underutilized or are non-marketable. Social and cultural factors also place limitations on the type of residue to be used which will need addressing. Many common crop residues and weeds are highly efficient in energy conversion and can help meet energy security targets and livelihood security in sub-tropical climates, providing an effective alternative to environmentally sensitive woody biomass combustion.

Although biogas digesters have attracted investments from countries and NGOs interested in rural energy security and sustainability, other technologies have become increasingly attractive. In recent years, efficient woodstove designs have improved significantly. For instance, there are hybrid systems that mix metal components with local clay or bricks with improved ventilation. There are also systems based on conversion of waste heat into electricity that can be used to charge cell phones and other devices.

More efficient systems that take biogas and solid and liquid biomass have been increasingly available to households in the developing world, and particularly in India and China. Governments in these countries have promoted initiatives that help set up small-scale bioenergy systems to meet the domestic demand for cooking and lighting of communities unable to access national grids. Villages have been building micro-grids using biomass or biogas to generate steam. These approaches hold considerable promise for increasing energy access in rural communities. See examples in Chapter 14, this volume.

# 21.5 Energy Access and Rural Development: the Role of Modern Bioenergy

Given the low rate of electrification and high dependence on traditional biomass in rural areas of Least Developed Countries, a potential role for modern bioenergy is of particular interest. Whereas developed countries phased out biomass many decades ago in favor of fossil fuels and then started developing modern bioenergy, the developing countries can take advantage of technological development that has already occurred. Although there are many different options and pathways, three aspects have particular significance for the connections between energy access, biomass resources and poverty reduction: (1) the use of wastes and residues; (2) the role of bioenergy in agricultural value chains and productivity; and (3) bioenergy in agro-industries. Each of these aspects is discussed briefly below.

Unlike dedicated bioenergy systems, the initial set-up costs for using residues and wastes are lower. If supplied and/or sourced sustainably, biomass wastes and residues offer the most widely available and least-cost biomass resource options. Table 21.3 provides a classification and some examples of biomass residues and wastes. More details on the different uses and applications of residues can be found in Chapter 12, this volume. The principal challenge is to develop reliable, cost-effective handling methods to reduce the costs of gathering and processing (FAO 2011). Competition for residues in such uses as animal feeds and soil protection should also be considered, as it can also impact feasibility and/or cost-effectiveness.

Countries and regions that lack energy access are almost always dominated by subsistence agriculture where farmers struggle to maintain a surplus so they can gain additional cash income. At the same time, they face difficulties in agricultural supply chains, due to the lack of refrigeration, storage and fuel for transport. Consequently, improvements in energy access and in agricultural supply chains can go hand-in-hand,

**Table 21.3.** Classification and examples of biomass residues and wastes.

| Biomass type/ source | Woody biomass | Herbaceous biomass | Biomass from fruits and seeds | Others (including mixtures) |
|---|---|---|---|---|
| Direct (by-products) | Logging by-products<br>Thinning by-products | Straw<br>Bagasse<br>husks | shells and husks<br>fruit bunches | Animal dung<br>Landscape management by-products |
| Indirect | Sawmill wastes<br>Black liquor (from pulp/ paper production) | Fiber crop processing wastes<br>Recycled fiber products | Food processing by-products<br>Waste oils | Bio-sludge<br>Slaughterhouse by-products<br>Municipal solid waste |

Source: Adapted from FAO, 2004

thus revealing the linkages between energy access for households and enterprises. It does not necessarily matter what the energy source is, but the question of value chains suggests some synergies when bioenergy and food markets can be developed together, since the sources and processing of biomass may be the same.

As agriculture becomes modernized, it assumes a smaller role in relation to industrial development. Yet a chicken and egg problem arises: companies and entrepreneurs will not invest without infrastructure and reliable energy, but at the same time such investment and the economic linkages it brings are needed in order to develop the infrastructure and reliable energy systems. Investments in agro-industries and agro-forestry, including liquid biofuels, can directly address this chicken-and-egg problem. Essentially, their comparative advantage is that they bring their energy with them! Such investments can spur further economic development since they are strongly linked to agricultural, energy and industrial development all at the same time. A recent example is the investment by Addax Bioenergy in Sierra Leone, near the town of Makeni; the investment includes a sugarcane estate, production of ethanol and production of co-generated electricity from bagasse (ABSL 2013; see Box 21.3). The surplus electricity after supplying the factory will be sent to the grid, and its availability will complement the hydro capacity.

**Box 21.3.** Addax Bioenergy Sierra Leone (ABSL)

The Addax Bioenergy Sierra Leone (ABSL) project is located near the town of Makeni in the Bombali district of Sierra Leone, approximately 160 kilometers from the capital, Freetown. The region around the town of Makeni is a fast-growing area due to its strategic location and its ability to attract investment in agriculture and mining. The ABSL project includes greenfield development of sugarcane cultivation, establishment of an ethanol distillery and export of sugarcane bagasse-based electricity to the national grid. The capital investment of some 267 million EUROs is the largest agricultural project ever undertaken in Sierra Leone and has been financed with the support of eight European and African development finance institutions. Commercial production commenced in mid-2014. The electricity exported from the factory to the grid will increase by 20% the current national power production, and thus improve energy access considerably in the region and in the country as a whole. The project will have significant effects on surrounding communities' livelihoods and access to resources, thus requiring careful monitoring in order to insure improvements in food security and local development opportunities. Furthermore, the project has international significance not only due to its unique agricultural and energy characteristics but also because it will be the first case where biofuels are exported to the EU from Africa on a large scale. In later years when the government is mature enough to implement fuel blending, the domestic market for ethanol could be developed. The cogeneration plant is the first Clean Development Mechanism (CDM) project in Sierra Leone while the ethanol plant was the first biofuels project in all of Africa to receive international sustainability certification (required for the EU market), which was given by the Roundtable on Sustainable Biomaterials (RSB).

# 21.6 Case Studies: Improved Cookstoves for Energy Access, the EnDev Program in Kenya

The Energizing Development (EnDev) initiative[1] aims to provide economically sustainable energy access and distribution schemes in rural areas and now operates

[1] Energising Development (EnDev) is an impact-oriented global sector-wide initiative between the German Federal Ministry for Economic Cooperation and Development (BMZ) and the Directorate-General for International Cooperation of the Dutch Ministry of Foreign Affairs (DGIS). EnDev cooperates with several partner countries in Africa, Latin America and Asia, and is currently carrying out activities in 20 countries. The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH is acting as the principal agency for implementing the partnership.

in twenty different countries. The Kenyan program focuses especially on improved cookstoves (ICS) and, since 2006, has disseminated over 1.4 million household stoves, benefiting 7 million people (EnDev 2012). See Bailis et al. (2005) for an assessment of the potential health and climate impacts of programs across sub-Saharan Africa. Key reasons for the program's success include:

- *Targeting fuel scarce regions:* Densely populated and/or biomass-scarce regions were initially targeted. Successful stove programs tend to be in areas where people pay for fuelwood or have to walk long distances to obtain it (Barnes et al. 1994).
- *Balancing efficiency, cost and acceptability:* EnDev prioritizes reliability, affordability and social acceptance. Stoves use locally available construction material, but follow established engineering principles. The price of €2.45-€6.50 is affordable for rural Kenyans and thus no subsidies are needed. Local construction allows users to help design non-critical parts such as pot rests, leading to higher acceptability.
- *Aiming for market transformation:* While the objective is access to energy, the program also strived to build a sustainable market for modern cooking options, through supporting production and marketing in a way that responds to user demands.
- *Alignment with national goals and policies:* The Kenyan program is implemented in partnership with the Ministry of Agriculture and in line with the Ministry of Energy strategy to increase ICS use to 30% by 2020 (KIPPRA 2006).
- *Facilitation role:* The introduction of the stoves follows a commercial approach, with the implementers' role limited to technical and management training, public awareness and marketing and evaluation of stove performance.

The 1.4 million stoves equate to annual savings of 1.3 million metric tons of firewood, 74,964 ha of forest cover and 897,120 tCO2 emissions (EnDev 2012). Some of these outcomes have been verified in scientific studies, focusing on indoor air pollution, fuel efficiency and acceptability (Ochieng 2013). Other achievements identified in previous evaluations included the following (GIZ-PSDA 2008):

- A majority of households without ICS used the three-stone-fire every day (81%), but only 21% of ICS households used the three-stone-fire daily. In other words, ICS households generally abandoned use of traditional fireplaces.
- Establishment of a 'Stove Dealers Association' to allow skills transfer and capacity-building, so as to take over once the project was phased out. The association was linked to the Kenyan Bureau of Standards to address technical standards for stoves.
- The project created synergies with agro-industries, especially tea factories, so as to include stove promotion within their environmental and livelihood initiatives.
- New businesses associated with stove production, marketing and installation created local employment for women and men and hence increased household incomes.

- In addition to households, many social institutions (schools, hotels and small businesses) also adopted the stoves to reduce firewood consumption.
- Profits accruing to producers, installers and marketers changed the perception of the sector to that of a sustainable business, rather than a 'women's promotional activity'.

It is important to recognize the need for a balance between efficiency and acceptability. While cookstove technologies that are up to 90% efficient now exist (in laboratories), they have a narrow tolerance to fuel size and moisture and thus generally require special care or pre-processing. In addition to the high cost, these factors may hinder wide scale adoption. On the other hand widely acceptable improved wood stoves with medium level efficiency can have substantial impact on efficiency based on the scale of adoption. The early success case with the EnDev program in Kenya shows that energy efficiency can be achieved on wide scale in developing countries, and the efforts can reach commercial level where program subsidies are no longer required. More effort should be geared towards learning from these successes, and replicating the programs in other regions.

# 21.7 Cross Sector-Synergies: Including Investment and Institutions

Current technology transfer rates are an important factor in deterring widespread adoption of biogas systems. They have been low, reaching only a fraction of the population in India and China (between 0.06%-0.2%) through implementation of a subsidized spread model that maximizes demonstration effects. One major shortcoming is that current on-site installation times are two to three weeks, although conventional plastic water tanks may be modified into biogas plants within one day with very low maintenance costs. The use of recycled plastics could reduce the f-BGP costs further, encouraging widespread bio-methane production and use. Overall costs could be reduced by adopting a less decentralized system based on ready-to- install designs available through new financing schemes that encourages local entrepreneurship whilst providing technological backup. A f-BGP program that converts animal waste and crop residues has the potential to offset 180mt of fuel wood or coal in India and China annually at the same time as contributing significantly to less methane emissions from animal waste (see Chapter 14, this volume).

# 21.8 Conclusions and Recommendations

The links between energy and poverty reduction are manifold. Although many of these links are indirect, the benefits that access to energy can create in poor regions are undeniable, as demonstrated by the examples discussed in this chapter. Enabling the 1.2 bn of people who lack access to electricity, along with the 2.8 bn people who are dependent on biomass mainly in poor regions in Africa and Asia to access modern sources of energy as a means of escaping poverty will require ambitious and concerted action, as envisioned in the UN initiative *Sustainable Energy for All*.

In spite of these ambitious targets, biomass is likely to continue to be the primary renewable energy resource for the world's least advantaged populations and one of the forms to reduce carbon emissions in the developed world. For this reason, rapid implementation of new bioenergy technologies is needed to avoid debilitating health and environmental outcomes.

General recommendations:

1. There is a need to better integrate the efforts of international programs working on reducing energy poverty and facilitating energy access to meet their ambitious goals by 2050.
2. There is still a need to facilitate incentives at local and regional level for the provision of energy, particularly in developing countries and rural and peri-urban areas.
3. Research and development require focus on the synergies between the social, environmental and economic dimensions of the access to energy.
4. More research and capacity building to reduce subsidies and promote new technologies and their acceptability at community level are necessary to deploy the benefits of modern energy.

# 21.9 The Much Needed Science

There is a clear link between energy access and poverty. Although energy poverty is also related to two main factors, either the lack of access to energy or the inability to pay for the service. There is ongoing research on this topic but there still is a need to improve datasets regarding positive cases where projects have clearly demonstrated the link between reduction of energy poverty and access to energy through the improvement of livelihoods, particularly in the use of bioenergy.

These links have not been incorporated in the reports of the United Nations regarding the Millennium Development Goals on poverty reduction. It mainly focuses on job creation but there is need of more primary data regarding the use of bioenergy and also the reduction of health problems.

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