

Progress Report 2012

on

Energising Development – Phase 2

Partnership between

The Netherlands Ministry for Foreign Affairs

The Norwegian Ministry of Foreign Affairs

The Australian Agency for International Development

The UK Department for International Development

The Swiss Agency for Development and Cooperation and

**The Bundesministerium für wirtschaftliche Zusammenarbeit und
Entwicklung (BMZ)**

Executed by:

**The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)
GmbH**

In cooperation with:

Agentschap NL

With co-financing from IrishAid and the EU

SUMMARY VERSION

Published by:

Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH
Postfach 5180
65726 Eschborn

T +49 61 96 79-0
F +49 61 96 79-11 15
E info@giz.de

Internet:
www.giz.de

Name of sector project:
Energising Development

Responsible
Dr. Carsten Hellpap

Eschborn, Germany, May 2013

Contents

- A Executive Summary 2
- B Introduction – Energising Development Partnership – Phase 2 3
 - B.1 Overall Objective of the Partnership 3
 - B.2 Relevance of EnDev for International Energy Initiatives and the Partner Country’s Development Strategy 3
- C Achievements of EnDev 2..... 4
 - C.1 Number of projects and regional distribution 4
 - C.2 Achieved number of persons..... 5
 - C.3 Impacts 8
 - C.4 Some lessons learnt from failures and challenges 13

Key achievements

1.96 million household members with electricity



24,300 small and medium enterprises with a modern form of energy



11,600 social institutions with a modern form of energy



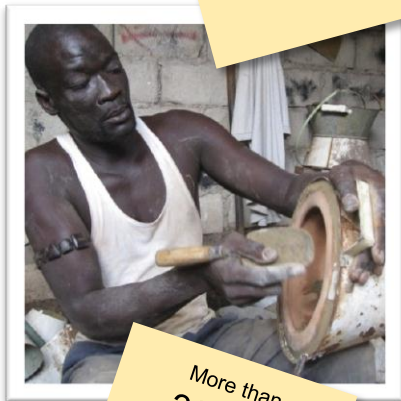
8.37 million household members with improved cookstoves



1.03 million t of CO₂ saved per year



More than 30,000 technicians, stove producers, sales men etc. trained



A Executive Summary

In 2012, the EnDev Partnership comprised 20 projects in 19 different countries. The focus of the programme is on Africa. 59 % of the EnDev 2 funds are allocated for activities in African countries.

By December 2012, EnDev 2 had facilitated sustainable¹ access to modern energy services² to 5.3 million people. Households were connected to the central grid or a minigrad or could use electricity through photovoltaic systems. Others benefited from improved and clean cooking technologies, such as improved firewood and charcoal stoves or biogas plants (Table 1).

In addition, more than 4,100 social institutions got access to improved cooking energy or electricity, or other modern energy carriers, and 12,300 small and medium enterprises were provided with a modern form of energy for productive use.

These figures take into account:

- a “sustainability adjustment factor,” which takes into consideration that the access provided to modern energy technologies is not sustainable in all cases
- a “windfall gain factor” considering that some households supported by EnDev would have gained access to modern energy services anyway even without support
- a “double energy factor”, which accounts for households and welfare institutions, which received an improved cookstove or other modern cooking energy technologies but already had access to electricity

Lighting / Household application	Cooking	HH Total
1.14	4.18	5.3
Table 1: Adjusted number of people with access to modern energy (EnDev 2; in millions)		

The number of people, which got sustainable access to modern energy services on household level through the EnDev programme (phase 1 and 2), amounts to 10.3 million.

EnDev has studied the impacts of the different country activities to verify the assumptions regarding the impact of energy development measures, the links between energy for development and the Millennium Development Goals (MDGs) and to check the sustainability of the EnDev results and impacts. Since 2009 EnDev has carried out more than 80 baseline, impact and sustainability studies. Results of the studies till 2011 were presented in previous reports. In the present report key findings of studies in 2012 are summarized.

The expenditures for EnDev 2 activities in 2012 amounted to EUR 21.7 million.

¹ Sustainable means here long-lasting access

² The term modern energy service refers to electricity as well as to natural gas, LPG, and biogas as cooking fuels and to advanced cooking stoves for solid fuels, that have higher combustion efficiency (at least 40% in comparison to traditionally used stoves)

B Introduction – Energising Development Partnership – Phase 2

B.1 Overall Objective of the Partnership

In December 2004 the then Netherlands Minister for Development Cooperation (MFA / DGIS) and the German Federal Minister for Economic Cooperation and Development (BMZ) launched a partnership on Energy Access whose centre stage is the programme “Energising Development (EnDev)”. As a result of the first phase of EnDev 5.02 million people got access to electricity or clean cooking technologies by end of 2009.

The Norwegian Ministry of Foreign Affairs joined the partnership in 2011, the Australian Agency for International Development, the UK Department for International Development and the Swiss Federal Department of Foreign Affairs followed in 2012. The objective of EnDev is now to provide at least a total of 14,3 million people with sustainable access to modern energy services by end of 2018 (5 million in the 1st phase, another 9 million in the 2nd phase).

The defined outcomes are considered a measurable and significant contribution for achieving the MDGs, as energy is a key requirement to reduce poverty and to improve the standard of living and an input for economic activities and growth. Consequently, the success of the programme does not only depend on the number of people reached but also on the impact of the modern energy service provided on income, health, education and well-being.

B.2 Relevance of EnDev for International Energy Initiatives and the Partner Country’s Development Strategy

The overall objective of EnDev to facilitate access to modern energy services is shared by a growing number of international initiatives. This highlights the relevance of energy access for the international agenda. On the other side, it poses a challenge to all initiatives to coordinate activities in a way that approaches don’t conflict with each other but are complementary or even synergistic.

EnDev has established working partnerships with several international programmes and organisations working in the field of energy access.

EnDev played a major role in the methodological consultations for the **SE4ALL Global Tracking Framework**. EnDev sent a whole set of comments to the Steering Group and individual members that prepared the draft framework. The access indicators in the last version of the tracking document are consistent to a large extent with the EnDev indicators.

In the European context EnDev cooperated closely with the **EU Energy Initiative Partnership Dialogue Facility (EUEI PDF)** in the preparation of the SE4ALL scoping mission to Uganda and in general policy dialogue issues concerning energy access.

EnDev contributed to the International Workshop Agreement of the **Global Alliance for Clean Cookstoves** and is supporting several test centres as part of the Alliance initiative.

Lighting Africa and EnDev together with the Fraunhofer Institute developed quality and tests norms for Photovoltaic Individual Electrification Systems (solar lanterns) that were approved by the International Electrotechnical Commission (IEC). The norm is based on a set of laboratory and field tests that were carried out by Lighting Africa, Fraunhofer and EnDev. In addition, EnDev and Lighting Africa updated each other regularly about country activities, approaches and plans including during the International Lighting Conference in Dakar 2012.

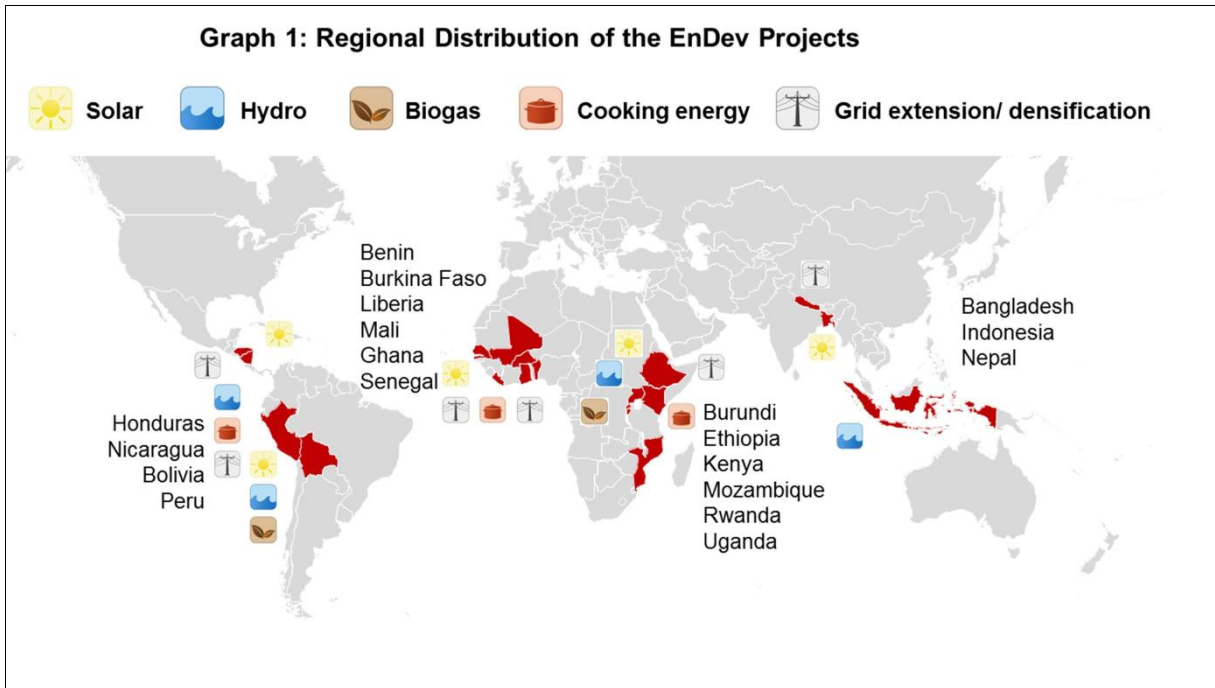
EnDev has been discussing with **ESMAP** the development of indicators for access to energy and results-based approaches. EnDev staff participated also in discussions on renewable energy resource mapping.

EnDev had several meetings with **ADB** about a closer cooperation in Asia. It was decided to coordinate and develop new activities in Bangladesh and Indonesia. First discussions between the country representatives took place but still did not materialize in concrete joint plans.

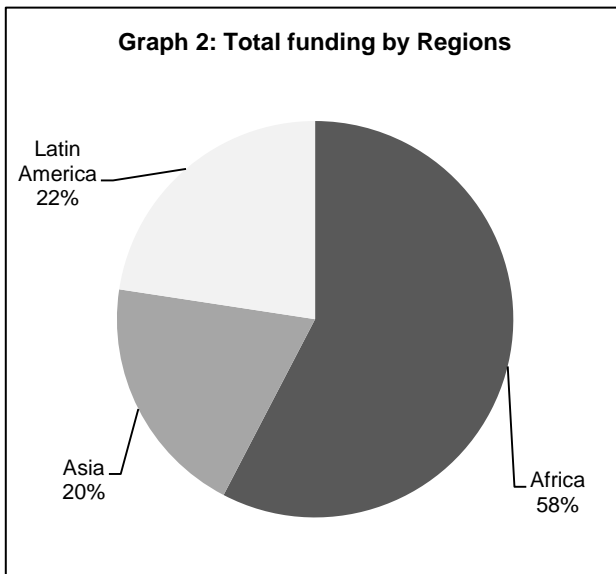
C Achievements of EnDev 2

C.1 Number of projects and regional distribution

In 2012 EnDev Partnership projects have been carried out in 19 countries (Graph 1).



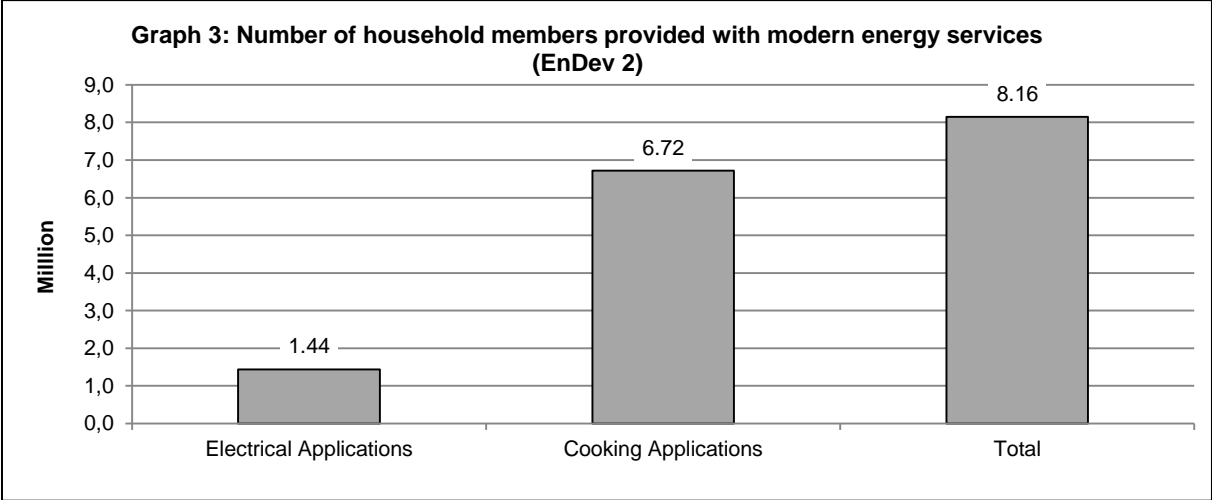
Twelve out of the 19 countries where EnDev has been active in 2012 belong to Africa, followed by four countries in Latin America and three countries in Asia. After approval of the Annual Planning 2013 EnDev will extend its activities to 23 countries (15 in Africa, 4 in Asia and 4 in Latin America). The focus on Africa is also reflected in the allocation of financial resources to the different regions. Out of the EUR 130 million allocated to country projects 58 % will be spent in Africa followed by 20 % in Asia and 22 % in Latin America (Graph 2).



Three EnDev Projects in Africa (Senegal, Benin, and Burkina Faso) received additional funds from the ACP-EU Energy Facility II to upscale their activities. Irish Aid allocated EUR 725,000 to EnDev-Ethiopia for the electrification of health centres with PV systems.

C.2 Achieved number of persons

By Dec 2012, 8.16 million household members were provided either with electricity or improved cooking technologies under EnDev 2. Out of this figure, 1.44 million people were connected to a grid / minigrid or are benefiting from the installation of a Solar Home System or lantern. The remaining 6.72 million people were provided with access to improved cooking energy, when households acquired an energy efficient improved cookstove (see Graph 3). In addition, 4,100 social institutions got access to improved cooking energy or electricity, or other modern energy carriers and 12,300 small and medium enterprises were provided with a modern form of energy for productive use.



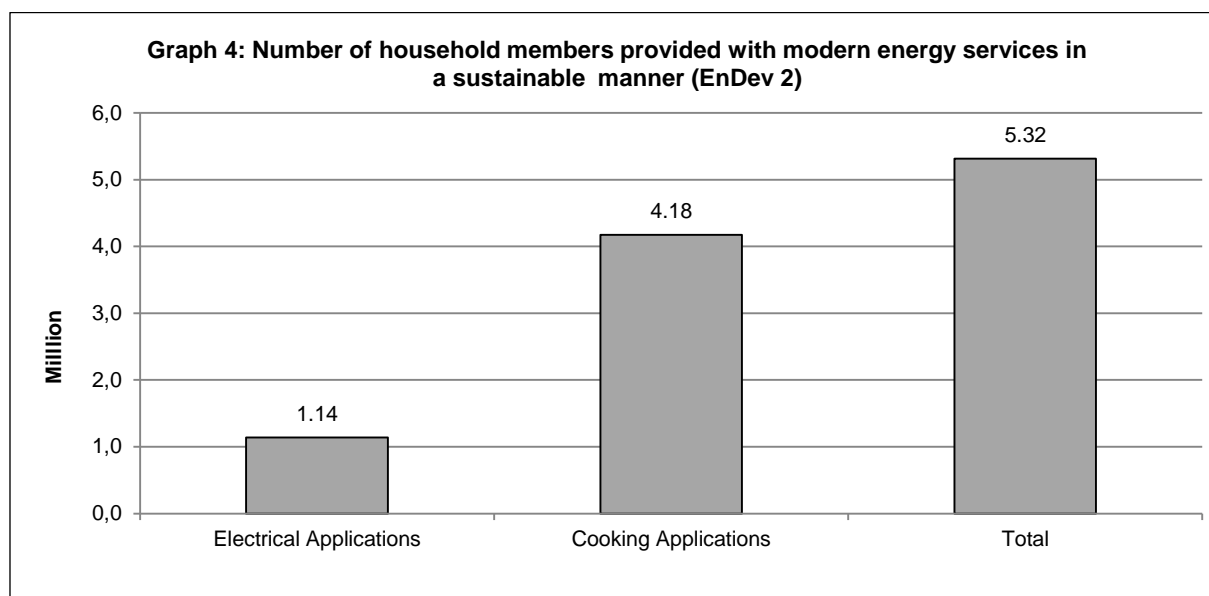
When assessing the outcomes it is important to consider the sustainability of the achieved access as well as windfall gain effects and a so called double energy effect.

EnDev interventions are aimed at establishing or enhancing sustainable markets for affordable energy technologies, fuels and services adapted to needs of the target population. Thus, one of the key activities of EnDev projects is to train and support local manufacturers in technical and business skills. However, not all of the manufacturers trained stay in business. Especially in the case of stoves where profit margins are low up to 50 % of trained stove producers stop this business after the project support ended, portraying the commercially extremely weak market structures at the bottom of the pyramid. In case of solar systems and hydropower plants households and communities may not be able or willing to maintain the service or technology for a longer period of time due to shortage of money or risk factors (e.g. disasters) which are hardly addressable by development actors. These losses of access are not easily compensated through the market forces. Consequently, the number of people having durable access to modern energy services is generally lower than the number of people who were initially provided with modern energy services. This is, in particular, the case for devices that have a short lifespan and require frequent maintenance. Depending on the technology or provided services, the attractiveness and lifespan of the devices and services a sustainability adjustment factor is applied ranging from -5 % to -40 %. In some cases as for grid extension and hydropower the decrease of the number of people with access to modern energy is exceeded by an increase because many people move into villages with grid electricity as they also want to benefit from the new infrastructure. Therefore, a small growth adjustment factor is applied for these specific cases.

The windfall gain factor takes into account that some households benefit from support and subsidy measures of the EnDev programme, although they would have gained access to modern energy services anyway. For instance, a significant percentage of households in Bangladesh would acquire a Solar Home System even without any support from the project but of course they take advantage of the subsidy schemes provided by EnDev.

The third adjustment factor (double energy factor) which was originally related to the fact that some households and welfare institutions which benefit from improved cookstove activities may already have access to electricity or to liquefied petroleum gas (LPG), is now modified. The factor is applied only in those cases where households, social institutions and enterprises have already access to modern energy in the same category (electricity or clean cooking technology). Quite often households use in parallel different types of technologies, such as LPG and three stone fire or kerosene lamp and electric lanterns. In those cases households will only be counted if the traditional, unhealthy technology is the primary, dominating one.

When applying these three different adjustment factors the total number of people provided with modern energy services in a sustainable way under EnDev 2 is 5.3 million (4.18 million with stoves and 1.14 million with electricity and other modern energy carriers) (graph 4).



The total number of people who got sustainable access to modern energy services on household level in the EnDev programme (phase 1 and 2) is 10.3 million. In addition 11,600 social institutions and 24,300 small and medium size enterprises got access to electricity or modern cooking technologies.

EnDev aims at achieving a ratio of 1/3 to 2/3 between electrification and stove outcomes. Currently the share of electrified households is 21 % of all benefitting households. Main reasons, why electrification is advancing relatively slow, are among others:

- Change of government policy and commitments such as reduction of public spending for micro hydro plants
- Unattractive tariff settings minigrids
- Bureaucratic administrative processes for procurement of goods and licencing procedures
- Lack of investors in renewable energy technologies
- Poor quality of products (solar systems) spoiling the market
- High import taxes for renewable energy technologies
- High costs of electrification technologies and services in comparison to improved cookstoves

Electrification outcomes according to different access levels

As already presented in the last Annual Planning Document EnDev had developed a tier system for defining different levels of access consisting of five levels. In this system access is

defined in terms of services, for which both “energy” and a device turning the energy into a useful service are required. As it is often difficult to directly monitor a service, access can be claimed by demonstrating access to the respective device and the required energy. Alternatively again, and assuming there is a more or less logical sequence in which services are used as based on needs, access can be claimed on the grounds of a certain electricity consumption.

The EnDev tier level system was slightly modified in the last six months as a result of intensive discussions with the World Bank about access criteria and the tier system which is going to be implemented in the SE4All initiative and which will be published in May 2013.

The current EnDev tier system is summarised in the table below, where for each of the five tiers the service package is indicated as well as the corresponding electricity consumption, the typical delivery system and the number of people that can be counted per household. Thereby a first attempt is also made to incorporate efficiency, particularly of lamps, in the scheme by differentiating the amount of electricity required per tier, considering that for ‘enough light’ far less electricity is required if e.g. LEDs are used instead of incandescent bulbs.

The corresponding tier system for improved cookstoves is still in process.

tier	terminology	people counted	description of services	proxy indicator >= kWh/pppa	typical supply system
5	Full	1 household	tier 4 services + use of devices typically requiring several kilowatts, such as air conditioners	1000	grid
4	Advanced	1 household	tier 3 services + use of devices typically requiring a kilowatt, such as water heaters, irons, vacuum cleaners,	400	grid with hickups
3	Moderate	1 household	tier 2 services + use of devices typically requiring a few hundred watt, such as rice cookers, refrigerators, freezers	100	minigrid
2	Basic	1 person depending on lighting amount (>= 300 lumen hours) + energy amount for radio and cell phones	bright light, use of radio and telephone + other devices typically requiring some tens of watts, such as TV, video, fan, computer	10 with LED/CFL, 20 with incandescent or unknown lamp	SHS etc.
1	Partial	0,25 person depending on lighting amount (>= 150 lumen hours) or energy for radio and cell phone	medium bright light + possibly limited radio/cell phone	1,50	PicoPV , battery charging stations

Based on this system the EnDev electrification outcome figures in the different tiers are as follows:

Tier	1 ³	2	3	4	5
	135,703	596,341	46,719	145,828	336,743

³ For its outcome target EnDev is counting only a fraction of the above mentioned persons within tier 1 as Battery Charging and PicoPV does usually not supply a full household (average 5 persons).

C.3 Impacts

EnDev aims at ensuring that people in developing countries get access to modern energy services. Combined with this outcome it is intended:

- to increase the efficiency of the use of cooking and lighting energy sources in benefiting households;
- to reduce indoor air pollution
- to reduce health problems related to the use of traditional energy services, especially for women and young children, who are most affected
- to reduce climate-damaging emissions
- to reduce deforestation
- to develop and strengthen pro-poor markets for improved cookstoves and off-grid solar products and
- to generally improve people's living conditions.

The monitoring and reporting system currently in place for EnDev focuses on measuring the number of people provided with modern energy services, the energy efficiency of the promoted energy technology or service, the turnover of involved companies and the reduction of greenhouse gas emissions. In an ad-hoc and limited way, projects report on the direct benefits of having access to energy services as well, such as cost savings, improvement of health situation, better educational conditions, and opportunities for income generation.

In addition to the regular reporting, impacts of EnDev are studied through baseline studies, special impact assessments, mid-term reviews and ex-post evaluations. The findings of the studies are also used to confirm or improve the adjustment factors which are applied to the reported outcome figures.

In 2012, nine studies / reports initiated in 2011 were finished. In addition, 23 new studies / reports were initiated, twelve of them are completed. eleven are still in progress. The studies cover electrification as well as stove projects in 13 countries. A full list of all reports is available in energypedia.

A comprehensive overview of the achieved impacts of the entire programme is published in the EnDev Report on Impacts (EnDev, 2010). The report is currently being updated and will be published this year.

Increase the efficiency of the use of the primary energy source

a) Stoves: In 2012 EnDev tested the efficiency of promoted stoves in six countries: Bangladesh, Benin, Bolivia, Ethiopia, Kenya, and Peru. Stoves not saving at least 40 % of energy under laboratory conditions were not included in the adjusted number of outcomes. However, they are not necessarily excluded from project activities because they often have positive impacts on indoor air pollution and work load, even if they don't reach 40 %.

Several field studies among others by the „Rheinisch-Westfälische Institut für Wirtschaftsforschung (RWI)“ have shown that households quite often do not fully realize the energy saving potential of the improved cookstoves so that fuel consumption is only reduced by 25 % to 35 %. Main reasons are that a) households tend to cook more (more or bigger meals) and b) households often do not extinguish the fire in the stove but let it smoulder for a longer period of time. As a consequence of these findings EnDev will use only an average reduction of fuelwood consumption of 30 % per improved cookstove in its calculations.

In several countries households cook on various types of stoves. Thus, an improved cookstove will not necessarily replace completely the three-stone fire. The traditional fire is often used especially for small meals, like breakfast. Therefore, we will assume that on average improved cookstoves will only be used for 80 % of the meal preparation.

b) Lighting systems: EnDev is almost exclusively promoting Compact Fluorescent and LED lamps for lighting that produce a brightness of 60 or more lumen per Watt. These lighting systems are 300 times better than a candle and a kerosene wick lamp (0.2 lm / W).

Reduction of Indoor Air pollution and health impacts

Lighting and cooking with traditional devices using solid fuels is the cause for fire accidents and indoor air pollution. Acrid smoke and deposits of soot in the lungs are responsible for more than 500,000 deaths around the world every year according to WHO. Some authors even estimate that household air pollution from cooking with solid fuels kills 4 million people annually⁴.

Stoves: Improved cookstoves promoted by EnDev directly reduced indoor air pollution through saving of firewood, the improvement of burning process leading to reduced smoke emissions and by introducing chimneys for specific stove types. As mentioned above we calculate with an average reduction of fuelwood consumption of 30 %. Open fires in three-stone stoves produce incomplete combustions leading to emissions of complex mixtures of pollutants such as particulate matter of different sizes (PM), carbon monoxide (CO), nitrogen dioxide, volatile organic compounds including benzene, and polycyclic aromatic hydrocarbons. We have calculated that the emissions of these substances will be reduced by 42 % assuming a 30 % reduction of fuelwood consumption due to improved burning processes. This is confirmed by a study from Kenya which found in the case of improved cookstoves 33 % lower levels of kitchen CO and 42 % lower levels of personal CO as compared to three-stone stoves. Chimney stoves reduce in-house emissions and emission exposure almost down to zero.

Up to now we have no clear picture whether the reduction of indoor air pollution of improved cookstoves without chimney is sufficient to decrease the incidence of certain diseases. In several studies people being interviewed reported that they had less health problems as a result of less smoke produced by the ICSs when compared to the three stone fire.

Other studies did not find any evidence that improved cookstoves without chimney have any benefiting health impact as the indoor air pollution is still too high. Significantly greater air quality benefit can be achieved by cooking in locations with sufficient air circulation and separate from the main living rooms. Also certain behaviour changes, including extinguishing fire when not in use as well as fuelwood drying reduce the exposure to smoke. These findings advise EnDev to follow a more integrated approach when promoting cookstoves.

A substantial reduction in exposure to indoor air pollution and a reduction of respiratory symptoms, headaches and eye infections have been demonstrated several times for chimney stoves.

Among fuelwood-using households, the vast majority persons responsible for cooking are women (>90 %). A study in Burkina Faso revealed in 14 % of the households, additionally a baby is carried and in 29 % of the households a child under six years often stays close to the stove while cooking takes place. Therefore, it is obvious that especially women and young children are benefitting from reduced indoor air pollution.

Electric light: Kerosene lamps emit carbon monoxide (CO), carbon dioxide (CO₂), sulfur dioxide, nitrogen dioxide, formaldehyde, various volatile organic carbons (VOCs), and particulate matter of different sizes. The exposure to the toxic gases exceeds quite often international standards for ambient air quality. Exposure to emissions of lamps affects more family members as in the case of stoves, and occurs over longer time periods (several hours per evening). Children are most vulnerable to the emissions since PM inhalation can hamper lung development. Kerosene lamps are also one of the main causes of fire accidents.

⁴ Lim S.S et al. 2012, A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010, *Lancet*, 380: 2224-60.

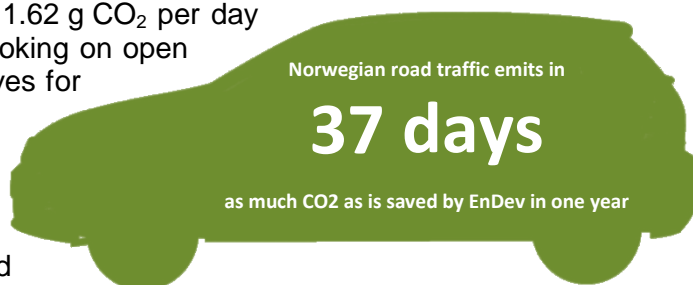
Electric light can prevent all negative health impacts. In addition, it improves people's safety while in the dark (e.g. thefts, snakes) and hygiene within homes. In several studies families noted a decrease in the dirtiness of the walls and reported that they clean their houses more often.

Electric power is important for any well-functioning health care system because it enables clinics to refrigerate vaccines, sterilise medical equipment, provide lighting in wards and operating theatres, and make use of communication equipment. According to clinics statistics from Ghana, the introduction of modern lighting in the clinics have led to an increase in the number of women delivering in the facility, and of people seeking medical service in cases of emergencies at night. Health staff reported that the quality of treatments had improved dramatically due to better lighting: Emergency operation or stitches were much safer and easier with solar lighting, and hygiene in the clinic had improved, resulting in reduced risk of infections. The report also notes that solar electrification has helped retain qualified health staff in the rural post, and has reduced cost of lighting and charging of mobile phones, which clinic staff need in order to communicate in cases of serious emergency. EnDev is going to verify these findings in a planned study in Ethiopia.

Electrification through grid extension, mini hydropower plants or photovoltaic installations helps to reduce waste problems by decreasing the demand for small throw-away batteries. Used batteries are usually discarded in the local environment as toxic waste without further treatment. However, special attention must be paid to the proper disposal of the solar batteries, a process which is still in its infancy in many project regions.

Climate-related impacts

An improved fuelwood cookstove, which is saving 30 % of firewood in practice and used to prepare 80 % of the meals saves up to 1.62 g CO₂ per day or 0.592 t CO₂ per year compared to cooking on open fires. The total savings of all EnDev stoves for one year amount to approx. 997,000 t of CO₂⁵. Air pollutants as a result of incomplete combustion are not included in this calculation.



Electric lamps of SHS, mini-grid and grid connections are replacing at minimum two kerosene lamps, thus saving at least 0,15 t CO₂ per year. Solar lanterns replace 90 % of a kerosene lamp, saving 0,069 t CO₂ per year.

The total CO₂ saving of 1.85 million stoves and access to electricity for 219,000 households supported by EnDev are: 1,029,000 t of CO₂. This is as much as the Norwegian road traffic emits in 37 days.⁶

Impact on Deforestation and soil degradation

Woodfuel originates from a wide range of land-use systems. These include primary or secondary forests, trees outside forests, agricultural plantations, agroforestry areas, and tree plantations. EnDev has currently no overview how much fuelwood is taken from the different types of land plots by the target households. The degree of damage caused by fuelwood collection in the project region is also not known.

⁵ For the time being the CO₂ savings per year are only calculated for Solar Home Systems, offgrid hydropower, PicoPV and improved cookstoves of EnDev 1 and EnDev 2, which were present in December 2012. The calculation is according to UN-FCCC based on default values and were necessary own assumptions.

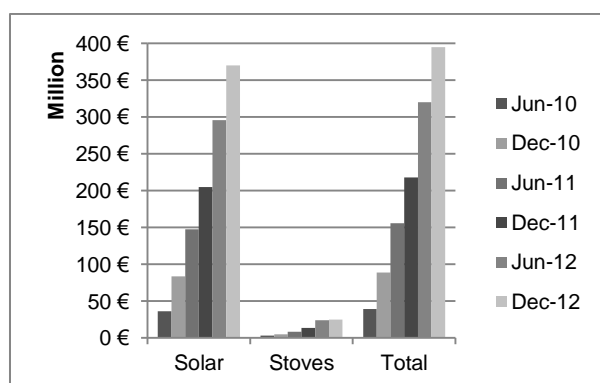
Within EnDev the adjusted outcome figures are used to calculate the CO₂ savings. However, only the Replacement Factor (sustainable used systems) and the Windfall Gain Factor (systems would have been sold even without EnDev) are applied. The Double Energy Factor will not be applied, as both "electrical systems" as well as improved cookstoves contribute to CO₂ reduction.

⁶ CO₂ emissions of road traffic in 2011 amounts to 10.1 million CO₂ equivalents: <http://www.ssb.no/en/klimagassn>

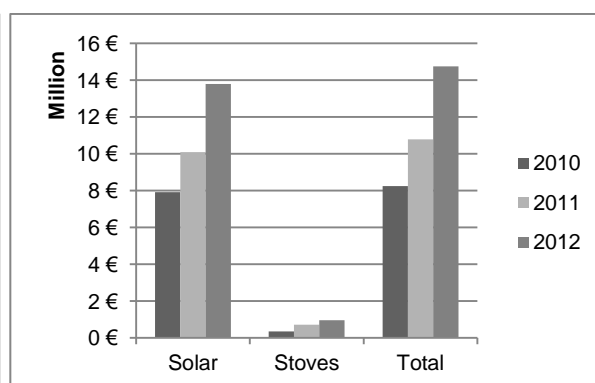
Several international studies have demonstrated that fuelwood consumption can have significant consequences for forest areas. For example, the South African Institute of Physics (IOP) studied recently the forest area with an aircraft based imaging system and a light detection and ranging system to calculate tree height by firing millions of laser pulses down to the ground and measuring the time it takes for the light to return to the aircraft. They found out that under current consumption rates, the fuelwood in the communal areas of Lowveld, South Africa, would be totally exhausted within 13 years. They also showed that households using fuelwood would need to be reduced by 15 % a year for eight years, before biomass stabilises to a sustainable level. Studies with similar results for other areas in Africa have been published by World Bank and FAO. Thus, there is no doubt that modern and clean energy services, with improved energy efficiency contribute to the reduction of deforestation, but the magnitude has still to be investigated more in detail in the EnDev projects.

Development of pro-poor markets

For the development of self-sustaining markets it is essential that sales figures of energy products and services reach a critical mass of customers and sufficient turnover, allowing enterprises to stay in business on medium and long term. Based on this concept calculations were carried out about the total number of sold / installed energy technologies / services and the corresponding turnover of the involved enterprises (see graph 5). According to these data, turnover of local solar companies active in markets which EnDev supports has been EUR 369 million and the turnover for stove producers EUR 24 million. The total turnover is estimated to be around EUR 393 million. The average monthly turnover of solar companies increased from EUR 7.9 million in 2010 to EUR 13.7 million in 2012, that of stove producers from EUR 340,000 to EUR 954,000. It is planned to analyse the sales and turnover data more in detail in the upcoming reporting periods and to continuously assess the market development for different products and services.



Graph 5: Accumulative turnover



Graph 6: Average monthly turnover

General improvement of people's living conditions

Impacts on Income and Employment: Households with an efficient improved cookstove spend less on firewood than those without, so that these households can save part of their income. Households connected to the grid or benefiting from a photovoltaic system drastically reduce their expenditures for kerosene, candles and single-use batteries. However, the overall impact on the family outlay depends on the amount of the electricity consumed.

For small businesses, electrification makes a significant contribution to economic growth and poverty reduction. A bright illumination of markets and workshops helps to attract new customers. With access to electricity, businesses can diversify the service they offer and extend their working hours into the evening. However, it is very rare for new income generating activities to arise as a consequence of a new electricity supply alone.

Thus, an immediate economic development as a result of energy access is limited to affected entrepreneurship either in producing energy services or using energy for (most already existing) productive means.

On the other hand the economic development of the rural population is highly influenced by the level of education, the state of health and the general living conditions of households which are positively affected by improved cooking technologies and access to electricity.

A study about biogas in Rwanda found that the main impact of the programme helped households to reduce energy expenditure and move away from a reliance on firewood and charcoal. Digester owning households spend about 30 % less on energy as compared to the control group, or at most an annual reduction in expenditure of about 58,000 RwF. The reduction in expenditure comes mainly from reduced use of firewood (5 kilograms less per day as compared to control households) and charcoal.

Impacts on Education: Children in rural areas, especially girls, often spend a great deal of time on basic subsistence activities, such as collecting firewood. Less wood need due to an improved cookstove reduces time for collection and increases school attendance. Although access to electricity does not have an immediate impact on educational levels, it influences learning performances by providing adequate lighting for children to spend more time studying and reading later into the evening. Thus, in a baseline study in Bangladesh households being electrified stated that they spent 2.26 hours on reading while no- electrified households 2.00 hours. Electricity brings with it the possibility of gathering information through radio or television.

Households at EnDev hydropower sites in Indonesia operate primarily lighting devices, but also TV sets and other information and entertainment devices like CD or VCD player or charge mobile phones. Ownership and use of mobile phones is significantly higher in electrified households, compared to non-electrified households selected as control group. 81 % of households name TV as their major source of information.

The electrification of schools means that teachers can use computers, televisions, and tape recorders, a significant contribution to the quality of the education system (sometimes critical to get / keep teachers in rural areas). In addition, adult education in the evening hours becomes possible.

Workload: Women have often a high workload as they have to shoulder the double burden of field work and the bulk of household responsibilities. Therefore, women can often spend less time than men in education. Their workload also reduces women's options for participating in productive activities, which condemns them to economic dependence. The improved cookstove activities helps to address these issues. Almost all respondents of an interview of the Improved cookstoves Project in Kenya claim to have saved time on wood collection and cooking. Half of the respondents who saved time use this additional time to carry on their productive activities. About a third of the respondents saving time were doing leisure instead (going to the church, visiting family members, etc.).

In some countries women have become stove entrepreneurs, thus improving their social position, and enhancing their roles within families and villages.

Electric light gives women the freedom to do some of their housework after dark, so they have more time to relax, to study or to do other work during the day.

C.4 Some lessons learnt from failures and challenges

Some technologies proved to be too expensive under local conditions to be widely accepted: RWI and the International Institute of Social Studies from the Erasmus University Rotterdam assessed Rwanda's National Domestic Biogas Programme (NDBP), which had been supported by EnDev for several years. Despite a favourable policy environment, the programme has fallen short of its targets, achieving only about 15 % of its originally intended target. The main reason for this shortfall appears to be the large gap between the actual prices for a digester versus the price that was used in the feasibility studies. For instance, for the most popular digester (6m³) the ex-ante price was pegged at 260,000 RwF but the actual price turned out to be 800,000 or almost three times the anticipated price. Based on the cost savings that are associated with the use of a digester the payback period, without discounting future benefits, for the most popular digester may be expected to be about nine years with the current subsidy of 300,000 RwF and 14 years without the subsidy.

It should be avoided to facilitate energy access only to a fraction of the community: In several communities EnDev faced the problem that the new energy service or technology benefitted only part of the population. Thus, the extension of a minigrid is limited and will often not provide electricity to all households in a community. This will automatically create conflicts if an adequate solution is not found for the unserved households.

It is not enough to create new jobs but also adequate production conditions: For example, working conditions in small workshops producing metallic stoves are generally poor. Workers are sitting on the ground or on cushions, with the work done in the dirt. The ergonomics of such arrangements are poor; the work is very demanding, and only young, able-bodied men have the endurance to do such stove building. In addition, most shops have very few tools and minimal infrastructure. Consequently, the productivity is low.

An insufficient number of households maintains their stoves properly and replaces them in due time: In several studies it was found that households continue to use their stoves even if the stoves are seriously damaged and malfunction. Thus, household use stoves much longer than the anticipated average lifespan. In addition, there is a broad variation among households in the intensity of the maintenance of stoves. Some households clean the stoves every day and repair them whenever needed. Others don't maintain them at all. Both phenomenon affect the sustainability of the stove activities and complicate the monitoring of sustainable outcomes.