CLIMATE SOLIDARITY

18 EXEMPLARY APPROACHES IN THE COUNTRIES OF THE SOUTH

> Climate
> Energy
> Development

Best Practices

Guidebook

geres

FOREWORDS

It has become clear now: Earth's atmosphere is quickly warming up. This rise in temperature will have major impacts on the whole planet, with very different signs according to the area concerned.

After the 1992 Rio Earth Summit, an international dialogue was initiated, which aims at reconciling climate protection with international solidarity. It is the Framework Convention on Climate Change whose ratification was followed in 1997 by the Kyoto Protocol signature. The latter came into force in 2005 and international negotiations have already been launched on the implementation conditions for a second commitment period, after 2012.

Solidarity has been reflected in many different ways. Firstly, industrialised countries acknowledge having particular responsibility in greenhouse gas emissions whose concentration is now worrying. Almost all of them committed in reducing their emissions following established targets. Thus, many research-action works are underway to produce and consume, build infrastructures, carry on agricultural policies, organise transports, while limiting greenhouse gas emissions or absorbing them.

Secondly, industrialised countries commit in guiding the least developed countries' populations and governments on the way to a clean development; anticipating these countries' needs, they also commit in helping their populations adapt to climate change. It's the question of the poorest countries' right to development; in general, they emit low levels of greenhouse gases, but are the first global warming' victims.

Regarding this last point, development and international solidarity stakeholders are invited to integrate the fight against climate change in their development actions, and to promote the transfer of techniques used toward the least developed countries. They'll need to enhance their experience with new skills, for instance to apply project mechanisms established in the Kyoto Protocol which are one of the means they have at their disposal. Thus, they'll encourage the birth of sustainable solutions while acknowledging the developing countries' future role.

In this context, GERES took the initiative of this best practices guidebook on "Climate-Energy-Development". This association, created in 1976, after the first oil crisis, is now counting with a hundred collaborators to carry on innovative sustainable development projects in France and in Southern countries.

This guide shares out field experiences, illustrated by role-model operations, in order to prepare development stakeholders – NGOs, civil society, donors, administration and decision-makers – to answer to the century's challenges regarding solidarity and climate change.

Brice LALONDE

France's ambassador for climate change negotiations

CONTENT

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This best practices guidebook was conceived and coordinated by GERES (Groupe Énergies Renouvelables, Environnement et Solidarités) under the responsibility of Swan Fauveaud.

Many GERES' experts have contributed to technical fact sheets

David Béritault, Simon Biney, Eric Buchet, Arnaud Guidal, Alexia Hebraud, Aurélien Hérail, Leo Heiniger, Antoine Lasgorceix, Benjamin Pallière and Vincent Stauffer.

Proofreading committee was made up of: Dominique Frey, Alain Guinebault, Alexia Hebraud, Sophie Ibos, Julien Jacquot, Thomas Mansouri and Fabrice Thuillier.

The translation has been made by David Rorke and Isabelle Guinebault.

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INTRODUCTION

Climate changes are upsetting environmental, economic, and social balances. Developing countries, and among them those categorised as least developed, are the first affected by these upsets that are aggravating existing vulnerabilities.

In developing countries, agricultural activity is the lynchpin of the economy. From 50 to 80 % of the energy used by households is biomass—sourced from the forest. The most prominent manifestations of climate variability (droughts, flooding, etc.) predicted by the experts will hit agriculture and forestry the hardest. The result will be a decline in food security and depletion of energy resources. These harmful effects will be compounded by the spiralling cost of energy—the mainstay of domestic life, economic development, and access to education and health services.

For human communities to adapt to climate changes they need to have new energy sources available, make better use of existing sources, and change agricultural and field husbandry practices. There is a strong interaction between climate, energy, and development.

At the present time, information is often inadequate or sadly lacking in the following areas:

- Link between access to energy and adaptation to climate changes.

- A tiered list of action priorities to reduce emissions in developing countries.

- Issues involving energy technologies and energy supply chains, in terms of impact on the climate.

- Financing mechanisms provided for under the Kyoto Protocol (CDMs, Adaptation Fund) and carbon finance in general.

In the face of this situation, it is necessary to supply the persons directly concerned, notably NGOs, with information to assist them in making decisions, as well as technical data to support them in their projects for development and climate change mitigation.

Put together by GERES (Groupe Énergies Renouvelables, Environnement et Solidarités), this best practices guidebook presents an overview of technologies and exemplary approaches that combine development and climate change mitigation. Development stakeholders are called upon to refresh practices implemented in order to adapt to current and future climate conditions, in such areas as energy efficiency, managing the energy demand, renewable energies, getting value from waste, resilient agriculture practices, and deforestation control.

This book is intended for all development stakeholders—institutions in developing countries, donor agencies, international solidarity organisations, decentralised cooperation operators, technical cooperation agencies—to name just a few.

We trust you will enjoy reading about all of these things.

All on the GERES team

RATIONALE I

CLIMATE CHANGE:
A MAJOR AND GLOBAL CHALLENGE

Virtually all scientists now agree on the unprecedented global warming phenomenon that is taking place at an accelerated pace. The current warming pattern started in the mid-19th century with the Industrial Revolution and became more apparent in the post-war decades during which an economic boom was experienced in countries belonging to the Organisation for Economic Co-operation and Development (OECD). It is acknowledged today that this warming trend will have a major global impact, with manifestations that will vary considerably from one affected zone to the next.

The purpose of this section is to review the cause of this phenomenon and its manifestations. It will then go on to discuss its impact on developing countries of the South and the challenges it is putting before them. The conclusion will outline the international mechanism set up under the United Nations Framework Convention on Climate Change and the Kyoto Protocol.

UNDERSTANDING WHAT IS BEHIND CLIMATE CHANGE

A recent many-facetted phenomenon

The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 under the impetus and guidance of the United Nations and given the mandate of assessing the current body of scientific, technical, and economic knowledge on climate change, its ecological and socio-economic impacts as well as strategies touted to control it. The panel regularly publishes reports that are considered to be the baseline reference for scientists and policymakers. In February 2007, the Fourth Assessment Report of the Intergovernmental Panel on Climate Change concluded that most **of the observed increase in average temperature of the planet since the mid-20th century is "very likely" due to the observed increase in greenhouse gases produced by man**. The rate of certainty is over 90 % compared to just 66 % in 2001, as appeared in the Third Assessment Report.

These studies reveal that recent changes are evidence of planet-scale warming:

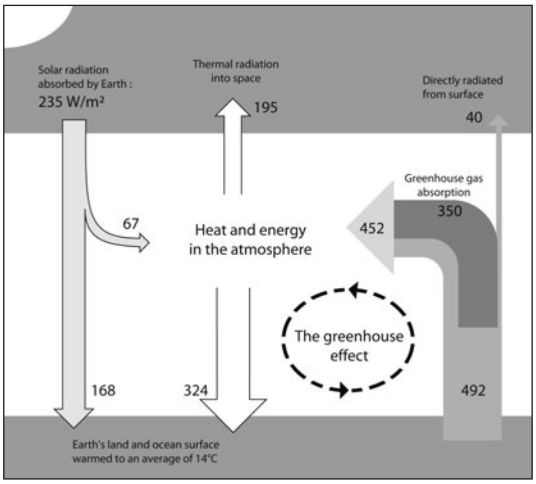
- **The average temperature of the earth's surface reportedly increased** by 0.6°C during the 20th century. Since the second half of the 19th century, the 1990s was the hottest decade, with a peak in 1998. Warming recorded in the northern hemisphere during the 20th century was the highest in the past one thousand years.
- **Snow cover and glacier expansion have decreased**. Satellite data show a probable 10-% shrinking of snow cover since the late 1960s.
- **The average sea level rose** between 10 and 20 centimetres during the 20th century.
- **An increase in precipitation** was observed in zones of average and high latitude in the northern hemisphere, accompanied by a rise in the frequency of extreme patterns of precipitation in these regions.
- **Hot spells caused by the El Niño effect have been more frequent**, longer lasting and more intense since the mid-1970s. In some regions, including parts of Asia and Africa, an increase in the frequency and intensity of droughts has been observed in recent decades.

The link between climate and the greenhouse effect

Climate change results from the internal variability of the climate system combined with a number of external factors.

The atmosphere plays the key role in climate regulation. It allows about half of the radiation from the sun to reach the surface of the earth. In turn, the earth reflects infrared rays back into space, part of which escapes through the atmosphere and part of which is returned to the earth due to a greenhouse effect. Rays are sent back down to earth naturally by "greenhouse" gases (GHGs) present in the atmosphere in the form of water vapour, CO_2, methane and nitrous oxide.

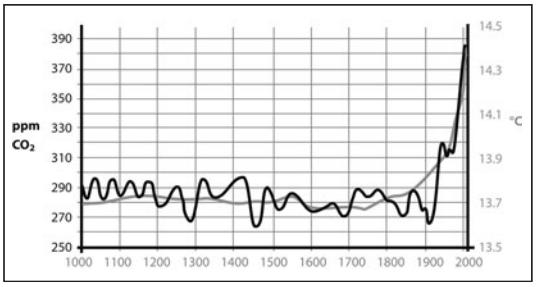
This greenhouse effect determines the temperature and therefore the climate on earth. If these gases and clouds were not present, the average temperature on earth would be -18°C rather than 15°C as currently recorded. The increasing volume of GHGs is causing more energy to be returned to the earth. The greater concentration of GHGs is therefore a major factor behind the climate change now being experienced. Other factors such as changes in solar radiation and volcanic explosions can also have a significant impact on the climate.



Greenhouse effect on earth

A recent increase in GHG concentration

A sharp rise in the concentration of GHGs in the atmosphere has been observed during the 20th century. The current concentration of CO_2 is the highest it has ever been over the last 420,000 years. The current escalation rate has been unprecedented in at least the last 20,000 years. The concentration of methane in the atmosphere has increased by 151 % since 1750 and is continuing to go up. New gases of industrial origin have also come on the scene, including chlorofluorocarbons (CFCs) and HCFC-22 such as freon, perfluorocarbon (CF_4), and sulphur hexafluoride (SF_6).



Changes in the CO_2 concentration in the atmosphere and temperature on earth over the last 1,000 years (source: IPCC)

Human activities driving increased GHG emissions

More thorough analyses than in the past confirm that most of the observed warming is anthropogenic, i.e. caused by humans. A case in point is CO_2 concentrations, which have jumped by 30 % since the beginning of the Industrial Revolution and the resultant intensification of economic activity. It has become more pronounced during the 20th century. Approximately three quarters of man-induced CO_2 emissions in the last 20 years are due to burning fossil fuels such as oil, coal, and natural gas. The remainder is basically due to change in the use of land, notably forest destruction. Methane (CH_4) and nitrous oxide (N_2O) are agriculture discharges, also resulting from changes in land use. Tropospheric ozone (O_3), fluoride gases (CFC, HFC, PFC, and SF_6), and exhaust fumes are causes of ozone layer depletion.

STRONG, UNPREDICTABLE IMPACT IN COUNTRIES OF THE SOUTH

Manifold manifestations

Despite progress made in modelling climate change, **considerable uncertainty prevails with regard to its causes and indicators as well as their scope**. However, it can be stated today with certainty that climatic warming will continue and that it will have a major overall impact on the planet, with its manifestations varying considerably according to the area involved.

Future risks firstly involve the continued **rising of the earth's temperature and of the sea level**. According to various interpretations, there is considerable variance in the conclusions of the IPCC. In the scenario of an overall effort to reduce CO_2 emissions, the increase in the average temperature of the earth between 1990 and 2100 would be between +1.4°C and +2.6°C. If nothing is done to limit them, global warming would run between +3.2°C and +5.8°C, while the sea level is predicted to rise between 9 and 88 cm by 2100 due to thermal expansion of the upper levels of the ocean and glacier melt.

The rise in temperature and changes in precipitation patterns will have a heavy impact on ecosystems. **Biological diversity will be threatened. Climate zones could move vertically towards the poles, disrupting forests, deserts, prairies, and other ecosystems**. Deserts and other arid regions could be subject to even more extreme climatic conditions; some mountainous zones would be affected (displacement of species to higher altitudes because of the warming). Alterations are anticipated to affect the ice cover of Greenland and Antarctica, shorelines and coral formations. The frequency and intensity of weather extremes will increase (thunderstorms, flooding, cyclones, etc.).

Impact on countries of the South

Least Developed Countries (LDCs) are particularly vulnerable to climate change and climate variability. **Vulnerability is defined as the sensitivity of a system (territory, country, or continent) to the unfavourable effects of climate changes or the incapacity of the system to deal with such changes, including climate variability and extremes**. Vulnerability is a function of the nature, extent, and speed of the climate variation that the system is considered to be exposed to, the sensitivity and adaptivity of the system. As far as countries of the South are concerned, their vulnerability is due among other things to the fact that their economies are closely dependent on climate-related activities, such as agriculture, which is furthermore based on the development of natural resources. Agriculture forms based on climate-dependent practices, for instance rain-fed farming, will suffer decreased yields.

Climate change may cause a deterioration of natural environments already suffering from tremendous pressure, with a dwindling of the vegetation cover in arid zones or deforestation and loss of biodiversity in wet areas. Such pressure on natural environments may cause a reduction or abandonment of regenerative practices such as fallowing land and pasture animal migration, with marginal land being put into crops or livestock herds concentrated on limited spaces.

Reduced forest cover also means **a dwindling of the energy biomass, which is the prevalent energy source in many LDCs**.

This vulnerability will also become greater in relation to access to water. With the intensification of the water cycle, the wettest regions will experience higher precipitation levels and a consequent rise in the risks of flooding. Conversely, arid and semi-arid regions such as the Maghreb and Sahel, where drinking water is already in short supply, will suffer droughts of greater severity, with an impact on agricultural productivity and food security. The intensity and duration of droughts will increase and areas affected by drought will likely be extended.

Climate changes will also have a health impact due to an increase in malnutrition and its effects, a greater incidence of diseases and accidents due to heat waves, flooding, storms, fires, and droughts. Similarly, diarrheal diseases are bound to increase due to poor water quality and alteration of the spatial distribution of certain vectors of infectious and parasitic diseases (malaria, meningitis, etc.).

In conclusion, climate change is anticipated to become an obstacle to development in countries of the South, and their low level of development accentuates their vulnerability.

INSTITUTIONAL FRAMEWORK TO COMBAT CLIMATE CHANGE

A consultative process

There is shared responsibility for the factors causing climate change. The first attempt led by the UN to get a better grasp of climate change and ways of dealing with it is the **United Nations Framework Convention on Climate Change (UNFCCC)**. It was opened to signature in 1992, and entered into force on 21 March 1994; 189 counties have ratified it, including the United States and Australia. It constitutes a form of international governance on climate.

The Kyoto Protocol that sprung from this convention was opened for ratification in 1998 and entered into force in February 2005. It proposes a time frame for the reduction of six greenhouse gas emissions, with **commitments from 38 industrialised countries, accounting for an overall 5.2-% drop in carbon dioxide emissions by 2012** compared to the 1990 level. Some 175 countries have ratified it to date with the notable exception of the United States. **The European Union has agreed to a blanket target of an 8-% reduction**. Countries referred to as developing, including emerging countries such as India, Brazil, Indonesia, China, Mexico, and South Korea, have not made any quantified commitment regarding their emissions reduction under the Kyoto Protocol. They are nevertheless closely associated in discussions regarding the post-2012 targets to the extent that their economic growth will have a strong impact on future global GHG emissions.

Measures to counter climate change

Under various international agreements, mechanisms have been put in place to control climate change. **These measures have been classified into two major action initiatives—mitigation and adaptation.**

Mitigation measures include human interventions to reduce sources of greenhouse gases or to consolidate greenhouse gas sinks. Adaptation implies adjusting natural or human systems in response to present or future climatic stimuli, or the effects thereof, in order to alleviate their harmful effects or to take advantage of beneficial opportunities. **Mitigation measures are necessary to harness or reduce the impacts of climate warming, but are not sufficient**.

Due to physical inertia (carbon cycle) and social inertia (many negotiation sessions needed to reach an agreement, policy enactment, etc.), **the present and future atmospheric concentrations of GHGs will produce negative effects that need to be anticipated through adaptation measures**.

Flexibility mechanisms for mitigation

In order to facilitate reaching the emissions reduction targets of industrialised nations, the Kyoto Protocol provides for the possibility of using three major "flexibility" mechanisms in complement to polices and measures that these countries are expected to implement at the national level.

Negotiable emissions permits

Trading in GHGs has come on the scene, with the establishment of a "greenhouse gas market." This market puts a commercial value on GHGs expressed in a single reduction unit: the tonne of equivalent CO2. Based on the targets they set, countries that ratified the protocol can convert the unused portion of their emission rights into "negotiable emissions permits" and sell them to countries that have exceeded their emission levels. Such an exchange can also take place between companies with reduction targets in a country. Trade markets for emissions licences have thus developed such as the stringent European Union Emission Trading Scheme (EU ETS) (see Rationale 2). Credits generated by the two other mechanisms outlined hereinafter (CDM and JI) share in these markets.

Joint Implementation (JI)

This mechanism makes it possible for governments in industrialised lands to fund carbon storage and greenhouse gas emissions reduction projects. It involves industrial or forestry projects, particularly those undertaken in countries working towards a market economy (Russia, countries of Central and Eastern Europe, etc.). Such projects make it possible to generate emission credits usable by investors.

Clean Development Mechanism (CDM)

This is the only mechanism that applies to countries of the South. Under it, industrialised countries with quantified emissions reduction targets are authorised to invest in greenhouse gas reduction projects in developing countries. Initiated by public or private investors, such mechanisms generate emissions reduction credits referred to as Certified Emission Reduction Units (CER) in relation to a baseline situation. The credits can be stocked or traded and must be shared between the foreign investor and the host country or partner. The project can also be implemented unilaterally, in which case the credits will accrue entirely to the operator in the country of the South.

NB: The following section will develop the principle of Negotiable Emissions Permits and the CDM.

Adaptation measures

A set of international mechanisms has been implemented to facilitate adaptation to climate change related phenomena.

National Adaptation Programmes of Action (NAPAs)

NAPAs are designed to analyse action priorities with regard to adaptation in least developed countries (LDCs). NAPAs list the urgent needs of LDCs to adapt to current climate change risks. As they respond to these needs, countries will position themselves to enhance their resilience and capacity to adapt to climate variability, current climate extremes and future climate changes. Beyond the ongoing modelling processes for potential climate change phenomena, NAPAs take into consideration adaptation strategies already implemented locally, thus giving added value to local knowledge and skills.

Adaptation support funds

- The Least Developed Countries Fund (LDCF) is provided to help LDCs prepare and implement their NAPAs. Funding for the LCDF is voluntary, with the majority of funds donated by Canada, Denmark, and Germany. Australia and the United States are not contributing to this fund. The existing resources of this fund amount to 160 million dollars (including contribution pledges). It has enabled 46 countries to prepare a NAPA

1. IPCC definition

(June 2008, source GEF). However, the LDCF is proving to be inadequate to care for implementation of all the adaptation strategies and actions inventoried under the NAPAs.

- The Special Climate Change Fund (SCCF) provides funding for activities in regard to adaptation, technology transfer, energy, transportation, industry, agriculture-forestry, waste management, and economic diversification. As of June 2008, it was worth 65 million dollars. The SCCF is funded by voluntary contributions from various industrialised countries. The United Kingdom, Canada, Germany, the Netherlands, and Denmark are its leading donors.

Management of these two funding tools has been put under the Global Environment Facility (GEF).

- The Adaptation Fund (AF) is filled by a 2-% tax levied on the sale of CDMs. Adopted at the Conference of the Parties in Bali in 2007, this fund is the most recent adaptation fund. The Bali agreement stipulates that the Adaptation Fund will be managed within the GEF by a 16-member board of directors including: one representative from the Alliance of Small Island States, one representative from Least Developed Countries (LCDs) and two from Developing Countries (DCs). With a current balance of 80 million dollars, the AF could grow to 500 million by 2012 with the said taxation of CDMs.

These funds are frequently criticized because the total amount of means mobilised remains too low in comparison with the estimated costs of adaptation (from 10 to 40 billion dollars).

UNITS OF MEASURING CLIMATE CHANGE

Global warming potential (GWP)

Not all GHGs have the same effect on climatic warming. The GWP is the unit of measure of the effect of a given mass of GHG on climatic warming in relation to CO_2 (GWP of CO_2 = 1) over a period of 100 years. The following table shows the GWP value of Kyoto Protocol GHGs:

Greenhouse gas (GHG)	GWP
Water vapour: H_2Ov	8
Carbon dioxide: CO_2	1
Methane: CH_4	23
Nitrous oxide: N_2O	296
Perfluorocarbons (PFCs): CF_4, $C2F_6$	5,700; 11,900
Sulphur hexafluoride: SF_6	22,200
Hydrofluorocarbons (HFCs): CHF_3, CH_3CHF_2, etc.	120 to 12,000

Tonne of CO_2 equivalent (t CO_2 equivalent)

To carry on trade in GHG emissions reduction credits, it was necessary to establish a unit common to all GHGs: the tonne of CO_2 equivalent.
The GWP of a GHG is multiplied by the quantity of the GHG emitted in order to determine its emission in tonnes of CO_2 equivalent:
CO_2 equivalent tonne of a gas = tonne of the gas x GWP of the gas
For example, methane has a GWP value of 23, which means that it has a warming potential 23 times greater than CO_2. So when a company emits 1 tonne of methane, this is reckoned as an emission of 23 tonnes of CO_2.

Tonne of equivalent carbon

GHG emissions may also be counted as tonnes of equivalent carbon.
Given that one kilogramme of CO_2 contains 0.2727 kg of carbon, the emission of one kilogramme of CO_2 is therefore the same as 0.2727 kg of equivalent carbon.
equivalent carbon = equivalent CO_2 x 0.2727

RATIONALE 2

CARBON FINANCE AND CLIMATE SOLIDARITY

The clean development mechanism (CDM) is the main measure of emission reductions under the Kyoto Protocol that allows value to accrue from initiatives taken in developing countries. Procedures for formalisation of a CDM are complex and involve many persons and entities.

Voluntary exchange markets were developed in parallel with CDMs and cater to persons and entities that buy carbon credits basically for ethical reasons or to enhance their corporate image. The voluntary market makes it possible to obtain funding for projects that do not fit in with the CDM methodological framework. Although generally small in scale, such projects may be diverse in form and sometimes quite innovative.

This section will outline the principles governing both the CDM arrangement and the voluntary exchange market. It will review how “carbon finance” is an opportunity for development stakeholders to get funding for their initiatives and in this way play a meaningful and necessary role in promoting “social” carbon.

REDUCING GREENHOUSE GAS EMISSIONS IN DEVELOPING COUNTRIES

Overview

The CDM is a means for industrialised nations (with quantified emissions reduction objectives) **to invest in greenhouse gas (GHG) reduction projects in developing countries**. Initiated by public or private investors, these projects generate Certified Emission Reduction Units (CER).

The CDM was designed with the idea of enabling industrialised countries to lessen the cost of emissions reductions and make it possible for developing countries to attract additional private investment that would have a favourable socio-economic impact. Host countries would thereby have a basis to stimulate foreign investment and technology transfer, and contribute to sustainable development.

At the present time, private corporations are the main users of these mechanisms, although a number of institutions and NGOs are also starting to implement CDM projects.

The sectors concerned are **energy, waste handling, industry, the residential and tertiary sector, transportation, agriculture**, and **forestry**. Eligibility is open to projects for energy conservation, fuel switchover, renewable energies, or afforestation/reforestation (carbon sequestration).

Concept of CDM project additionality

The final rules for implementation of a CDM arrangement were adopted in 2001 at the 7th Conference of the Parties to the UN Framework Convention on Climate Change held in Marrakech, Morocco. One of the key conditions for project eligibility is that it must be “additional.” Additionality is established by **demonstrating that the emissions reductions achieved by means of the project would not have taken place without the creation of the said mechanism and the Kyoto Protocol**.

Concretely, **the project’s additionality is demonstrated by showing that it lifts at least one of the following barriers**:
- Investment
- Technological
Erected due to current practices (i.e. the project cuts fresh ground).

A project implementer must therefore analyse the potential barriers to putting the technology in place.

The concept of additionality will be illustrated here with a CDM project for dissemination of photovoltaic kits in Morocco. The implementers are *GERERE* and *SCET Morocco* (see Fact Sheet 1.4 - Photovoltaic battery kits).

This project is being implemented in rural communities in Morocco where there is no access to the main electricity grid. People are generally connected to local mini-grids that are powered by diesel gen-sets.

The project is striving to make photovoltaic battery kits available that run on solar energy and produce enough electricity for household use (lighting, radio, etc).

The average cost of a kit is € 880, while it costs a household in the neighbourhood of € 300 to € 450 to hook up to a mini-grid (obviously cheaper). This raises an initial financial barrier for these families to go photovoltaic.

The most likely scenario is that households will keep on using electricity from gen-sets that have GHG emission issues.

The CDM and sale of the credits linked to it can generate enough funds to lift this financial barrier by subsidising the difference in capital cost and thus help families acquire a photovoltaic battery kit. **This project is designed to reduce GHG emissions and is additional.**

The **additionality** of projects is a **pivotal point in criticism against the CDM**. Fault is found with many projects because they are not additional. It is argued that in some cases, the activities implemented by a CDM project would have taken place even without the incentive of carbon finance (such as energy efficiency or waste reprocessing).

Rules of operation

Stakeholders

Operation of CDMs is allowed by the CDM governing agencies and such projects involve the host country. **Specific entities have been established**:

CDM stakeholders	Who?	What do they do?
Governing agencies	Executive Board (EB) (commissioned by the UNFCCC)	- Supervises implementation of the CDM, registers CDM projects, issues the CERs. - Accredits the Designated Operational Entities (see below).
	Designated Operational Entities (DOE)	- Private organisations approved as DOEs by the Executive Board. - Validate and verify CDM projects. - Provide public awareness.
Host country	Designated National Authority (DNA)	- Set up by the host country that has ratified the Protocol. - Determines the sustainable development criteria of the country and controls the project approval process.

Typology

The UNFCCC has classified CDM projects and methodologies based on their areas of application and scale. **Three categories have been defined**:

- **CDM projects**
This category mainly involves large-scale projects (in contrast to the following category) and corresponds to the mechanism initially described in the Marrakech agreement process.

- **Small-scale CDM projects**
This category was established later and subsequent to criticism voiced against the complexity of the CDM. Its purpose is to simplify initial procedures that were deemed to be too unwieldy and redhibitory for small-scale projects. Less cumbersome reductions calculation and surveillance plans were implemented. Project validation followed by verification and certification is handled by a single DOE.

The "small-scale" rating is proving to be the most suitable for projects implemented by development operators (NGOs, institutions, technical cooperation agencies).

- **Afforestation/reforestation projects**
The "forestry" CDM includes afforestation and reforestation activities only. This category does not take into account projects for deforestation control. Forestry CDMs generate so-called "temporary" credits

Project cycle

Validation and registration procedures for a CDM are long and complicated, although they are relatively well marked out. The project implementer has to comply with five mandatory steps prior to being in a position to get value from the CERs:

Step 1
Write up a Project Design Document (PDD)
A standard document to be submitted for the approval of the Executive Board.
It contains key information for calculating emissions reductions.

Step 2
Approval by the Designated National Authority (DNA)
The DNA examines the project. It must be consistent with the development priorities of the host country.
The project implementer and host country reach an agreement on how the future credits will be shared.

Step 3
Validation of the project by the Designated Operational Entity (DOE)
The project implementer chooses an accredited DOE and hires its services for validation of the project. (PDD review). The DOE then makes out an application for registration with the Executive Board.

Step 4
Final registration of the project
After reviewing the validation report, the Executive Board decides whether or not to register the project as a CDM.

Step 5
Surveillance, Verification and Issuance of CERs
Verification of emissions reductions achieved by the project is handled by a DOE.
The Executive Board issues a volume of CERs equivalent to the confirmed emissions reductions.

Length of crediting period

For **"standard"** and **"small-scale" CDM** projects, the period for issuance of CERs is selected by the project implementer between two possibilities:
- **Non-renewable period of 10 years**.
- **Twice renewable period of 7 years**. In this case, the baseline scenario has to be recalculated at the conclusion of each period.

For forestry CDM projects, the length of the project may be 30 years non-renewable or 20 years twice renewable, again requiring a recalculation of the baseline after each period.

Prospects and limits of the CDM

A prospect review of CDMs was conducted by the World Bank in 2007[1] and showed that **projects were concentrated mainly in emerging countries** such as India, China, and Brazil. **They are not currently bringing significant benefits to least developed countries (LDCs)**, notably countries of Africa for whom CER sales amounted to 3 % in 2006.

This study further pointed out that projects for the destruction of industrial fluoride gases accounted for 34 % of marketed CER credits, followed by projects for the destruction of nitrous oxide (N_2O), with a 12-% share. Projects for clean energy use (hydroelectricity, solar power, biomass energy, windmills, etc.) captured

1. The World Bank State and Trends of the Carbon Market 2007.

16 %, up compared to the previous year (2005), where they held 10 %. Energy efficiency and fuel switch projects increased from 1 % to 9 % from 2005 to 2006.

Why least developed countries have such low access to clean development mechanisms is explained by the long, **complicated, and costly procedures required**. The data needed for CDM methodologies (see box p18) are difficult to come by in most of the countries. Crediting of emissions must comply with very stringent requirements. **CDM transaction costs are too high and discriminate against small-scale projects** that do not have economies of scale on their side.

The CDM arrangement is also found fault with because of its low impact in terms of sustainable development. Furthermore, technology transfer to host countries favours large industrial-level programmes. **It is therefore difficult to demonstrate the additionality of certain projects**.

FROM KYOTO FLEXIBILITY MECHANISMS TO CARBON FINANCE

Greenhouse gas exchange market under the Kyoto Protocol

To assist industrialised countries achieve their reduction objectives, a "monetarisation" of GHGs was devised, with the establishment of a "**greenhouse gas market**," and in this framework a market value is set for GHGs. A country can thereby convert the unused share of its emission rights into "negotiable emissions permits" and sell them to countries that have exceeded their emissions levels. This exchange can also take place between businesses that have reduction objectives within the same country.

Mandatory exchange markets have thus developed in a number of countries that signed the Kyoto Protocol. Thus, **the tonne of carbon derived from CDMs is one of a number of possible exchange currencies on these markets**.

The European Union put in place the European Union Emission Trading System (EU ETS) to achieve its objective of 8-% reduction (2008-2012). It has been in operation since January 1, 2005 and involves some 12,000 industrial sites in Europe that are large emitters of greenhouse gases. Businesses are given emission quotas through National Quota Allocation Plans (NQAP) and can exchange quotas. Businesses can use CERs to fill part of their emission quotas. However, there is a ceiling on this use and businesses must also make arrangements to reduce their own emissions. Any business not complying with its commitments will be penalised per tonne of CO_2 emitted above its quota.

Japan, Australia, and New Zealand are currently looking into how they can also set up such markets.

Selling prices of CERs on the official market fluctuate tremendously from one mandatory commitment market to the next. For example, on the European market (EU ETS) an excessive allocation of emissions permits to businesses in 2007 caused the CER rate to plummet. After shooting up to over 20 euros, a tonne of CO_2 could only fetch about € 0.2 euro in May 2007. With commitments under the Kyoto Protocol kicking in on January 1, 2008, distribution of the number of emissions permits was cut by 7 % for 2008. Credit exchanges within the market in early 2008 were above 20 euros.

In 2007, the total volume of CER transactions amounted to 551 million tonnes of CO_2 equivalent, with an estimated value of 7.4 billion dollars. Financial flows from carbon transactions therefore achieved a significant level. But although emissions reductions were created in emerging countries, the latter are getting too small a piece of the cake.

Emergence of a voluntary exchange market and notion of "offsetting"

While the Kyoto Protocol was being put into effect, a growing number of **businesses, private persons, and public stakeholders made a voluntary commitment to offset the greenhouse gases they are emitting**. Thus, voluntary exchange markets came on the scene.

Voluntary exchange markets are mechanisms for the exchange of carbon credits mainly outside of international regulations. On these markets, individuals or organisations purchase **verified emission reduction units (VERs)** from greenhouse gas emission reduction or carbon sequestration projects. These VERs are used to offset the emissions of the purchasers. A small share of the VERs is sold on these markets to buyers who want to offset with credits from the official market.

Different from the mandatory commitment markets, **purchasers on voluntary markets have no obligation to reduce emissions**. They purchase carbon credits essentially for ethical reasons or to enhance their corporate image. The voluntary market is designed to fund projects that are not compatible with the CDM methodological framework. They are often smaller in scale, varied in format and sometimes innovative. Emissions reductions marketed or exchanged on these markets are sourced from projects carried out in developing countries (as are CDMs) or projects set up in countries that did not sign the Kyoto Protocol (United States and Australia as of 2007).

Let us take an American industry sector business for purposes of illustration. It has decided to put in an electrical cogeneration system to produce some or all of the electricity it needs to light its buildings. This system enables it to reduce its GHG emissions because it is generating part of its electricity and thereby cutting down on its overall consumption of fossil energy. This business cannot relate to any objectives in the Kyoto Protocol because its home country did not sign it. It will get value from its emissions reduction, for instance through a voluntary approach in the framework of a CCX-type voluntary exchange market (see below). What this business has in mind is to put its own house in order in terms of emissions reduction and prepare for a possible mandatory commitment if the United States was some day to sign the protocol and at that time also come under the Kyoto reduction objectives.

A second illustration is found in the case of an international solidarity organisation conducting a project to install five micro electrical power stations in a developing country (each one outputting about 10 kW), meaning that each station would enable a saving of about hundred tonnes of carbon equivalent. This NGO would be in a position to get value from the emission reductions by following a simpler, less costly methodological framework than that of the CDM, which really doesn't fill the bill. It could market a few tonnes on the voluntary offset market (private persons, businesses that want to offset their emissions) and thereby tap some additional funding for its project. If it is not familiar with carbon finance, the NGO could turn to an intermediary agency that would look after the methodological end of things for the value capture and marketing of its emissions reductions.

A market in the process of being structured

A major activity centre for the voluntary exchange market is the Chicago Climate Exchange (CCX), with a volume of trade exceeding **11 million tonnes of emission reduction since it started operating in 2003**. The CCX is North America's largest market. It is made up of a number of states, municipal governments, and private businesses. They all voluntarily committed to reducing their GHG emissions by an average of 4 % for the 1998-2001 period for Phase 1 (2006) and by 6 % for Phase 2 scheduled to end in 2010.

Offset providers have made their appearance with the voluntary exchange market. They work as intermediaries with project implementers on the one hand and end purchasers that want to offset their emissions on the other. Offset providers can, where necessary, give methodological support to project implementers so that they get value for emissions reductions. They then provide a portfolio of offset projects to their buyers (private persons, businesses, institutions, etc).

Their activities are based on raising public awareness regarding climate change and international solidarity. Many have become specialised with private persons for offset of their air travel. Offset providers are growing in numbers in Europe (My Climate, Climate Care, Action Carbone, CO2 Solidaire,...), the United States (Carbon Fund, Terra Pass,...), Australia (Climate Friendly,...), Canada (Offsetters,...), etc.

Public authorities and members of civil society in a number of countries have wanted to see that quality is controlled in projects presented for an offset offer. Regulations are gradually being put in place. One example is France's charter for offsetters (under *ADEME*).

Voluntary markets are not subject to rules and regulations like the mandatory exchange markets; the rules of the game can be very diverse. Thus, the low quality of some supported projects, variability of carbon credit prices, and lack of transparency of the project's mechanisms behind the credits or the once-only use of carbon credits, have fired all sorts of criticism against this approach. Nowadays, there is **tremendous inconsistency in emission reductions traded on the voluntary market**.

In order to ensure greater transparency and traceability of credits, different quality labels and standards of accreditation have been developed. They are enabling a surer guarantee of product quality and the emergence of a genuine market.

Among these standards, the following can be highlighted:
- Voluntary Gold Standard, a brainchild of the *WWF* organisation and 54 mainly environmental NGOs. It also has applications for CDM projects.

- Voluntary Carbon Standard (VCS) developed by stakeholders in carbon finance: Climate Group, *IETA*, *WBCSD*, etc.
- Verified Emission Reductions (VER+), a service of TÜV SÜD, a German Designated Operational Entity.
- And the list goes on.

Selling prices of carbon credits on the voluntary market fluctuate a great deal from project to project and are closely linked to the quality of the emission reduction project. **Selling prices range from a just a few euros to as much as a hundred euros per tonne of carbon**.

Transactions on the voluntary market involve much smaller amounts than those on mandatory exchange markets. The voluntary exchanges amounted to some ten million tonnes of CO_2 equivalent or 50 million dollars in 2006. On the other hand, they tend to be multiplying, with a teeming of initiatives that reflect the awareness. A combination of the various estimations and projections reveals the emergence of this market, of which the volume, i.e. the quantity of carbon credits exchanged in it, has on the average been doubling every year since 2004.

According to ICF International, a consulting services firm, the voluntary GHG emissions reductions market is anticipated to shoot up from only 20 million tonnes CO_2 equivalent in 2006 to over 220 million tonnes in 2012.

Registering and getting value from VERs

The methodology to get value from emissions reductions for a project focusing on the voluntary exchange market is based on that of the CDM. Methodologies developed for CDMs for working out the baseline scenario, validation, and tracking, can be used as is or adapted, as the case may be.

The following are mandatory key steps:

- Writing up the project design document:	Step 1 of the CDM project cycle.
- Tracking emissions reductions:	Step 5 of the CDM project cycle.

When the project focuses on an accreditation standard for its carbon credits, this generally entails the assistance of additional stakeholders (standards agencies and certifying agencies). For example, the VCS standard makes it mandatory to have the project design document (PDD) verified and the verification report must be prepared by an outside organisation accredited as Designated Operational Entity in the CDM system.

Having the VERs recorded in a registry guarantees that they are only used once. Simple ethics dictates this step. Accreditation standards people often require this and have put their own registry in place. **That explains the establishment of the "Blue Registry" by TÜV SÜD**, which anyone can access on the Internet, thus guaranteeing transparency.

Other stakeholders have established registries, among them being the Bank of New York (BoNY), wherein registration and carbon credit transfer procedures are now being developed. In France, the Caisse des Dépôts has also opened a registry.

OPPORTUNITIES FOR DEVELOPMENT OPERATORS

Carbon finance—a potential financial lever

Programmes carried out by development and solidarity stakeholders often outline **initiatives and practices that promote climate change mitigation without always explicitly mentioning this objective**. Indeed, when these actors intervene in the fields of renewable energies, the economics of energy or carbon sequestration, change in land use (agroforestry, agriculture), the thrust of their activities is genuinely contributing to climate change mitigation and generally has a pronounced social character because of their solidarity mandate.

A number of development NGOs have followed the procedures and registered CDM projects with the UNFCCC. The size of their project and emission reduction quantities were big enough to justify this approach (a reduction that is reportedly in the neighbourhood of 3000 t CO2 equivalent per year). Other NGOs whose projects are not as big prefer working with the voluntary market because transaction costs are lower and it is more suitable for projects generating limited emissions reductions (such as 500 to 1,000 t CO_2 equivalent per year).

More "social" carbon with a high added value

In most cases, **development and solidarity projects in particular are additional** (according to the meaning of the term given by the CDM). In other words, in addition to emission reductions alone, **they are making a contribution to the economic development of the zone or are providing significant social spin-offs** (health, education).

The project for dissemination of improved cookstoves in Cambodia that GERES and its partners have been carrying out since 1997 is just one example of this approach.

A high-performance cooking appliance (allowing a 25-% saving in wood charcoal) has been offered as a switch from the traditional cookstove used by families in Cambodia. It looks exactly like a traditional stove. It costs slightly more, but the fuel savings quickly offsets the higher cost. It is relatively easy to build using local skills and materials.

This project is eligible under the CDM arrangement and the voluntary market. As far as Cambodia is concerned, the project is designed to reduce consumption of a non-renewable fuel (such as wood sourced from a forest that is not replanted). By doing this, CO_2 emissions are reduced. CO_2 emission reductions for this project in Cambodia are estimated to be 314,000 tonnes CO_2 equivalent (as of late 2006), with 151,448 families having obtained the fuel-efficient model.

Training small-scale cookstove manufacturers has been a means of ensuring skills transfer and the subsequent large-scale dissemination of these new cookstoves. This new economic industry is bringing in incomes or at least resulting in money saved for all involved, from the manufacturer to the end user, as well as for the wholesalers and retailers in between. Where less wood is used, the persons involved in making meals inhale fewer toxic fumes. Time generally spent by women and children gathering wood is also reduced.

This is an example of the great benefits that the project has brought in addition to emissions reductions. **This project is a source of economic and social benefits and has carved a permanent place for itself in Cambodia**. It is generating high added value emissions reductions, notably on the voluntary market, wherein purchasers are particularly interested in projects that have an environmental, social, and economic dimension.

The community and local development approach of the NGOs that are using simple technologies and focusing on the poorest of the poor is an approach for which a place must also be found in carbon finance. The notion of "social" carbon is particularly meaningful in this case.

Precautions

Nevertheless, it must be kept in mind that **carbon finance is one of a number of new tools to get international solidarity projects up and running**. In the case of the voluntary offsetting market, it is also a means of making private persons and businesses aware of and getting them involved in North-South solidarity initiatives.

Taking advantage of this type of financing is not, however, an end in itself for development and solidarity stakeholders who are carrying out and will continue to carry out long-term initiatives in a broader objective of poverty alleviation. **Carbon finance has the potential of bringing in meaningful amounts of additional funding; it can likewise be an additional tool in lobbying for support**. Conversely, the offsetting providers (governments, businesses, private persons, etc.) who are therefore partly behind the funding made available **must give special attention to reducing their own emissions—putting their own house in order**—before thinking about offsetting something that will be offset anyway.

Project Design Document (PDD) and CDM methodologies

The Project Design Document is a standard form to be submitted for the approval of the Executive Board. It contains key information for calculating emissions reductions:

- Emissions baseline scenario. This is the most probable scenario of future emissions if no CDM project had been set up, in other words, business as usual. It is based on methodologies for working out baseline scenarios, validation, and tracking (see methodology box below).
- A plan for tracking the project's emissions (hence reductions).
- A study of the project's impact on the environment, feedback received from consultation with the directly concerned local parties.

Methodologies for working out baseline scenarios, validation, and tracking are in essence the "user's guide" as far as the CDM project implementer is concerned. They are used to calculate emission reductions.

Upon approval of the Executive Board, they can be used for other CDM projects of a similar vein. If it is found that no CDM methodology is appropriate, the project implementer submits a new one. Methodologies that have been approved or that are at the approval stage can be searched online at the UNFCCC website: www.unfccc.org.

USER NOTICE

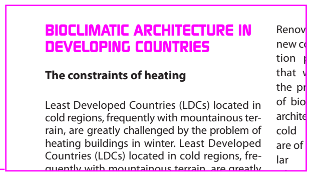
Before going on with the reading, it's necessary to quickly explain the book organisation!

18 Fact sheets

These fact sheets cover areas such as **energy efficiency as well as renewable energies, sustainable agricultural practices, reforestation or avoided deforestation**.

For each fact sheet, there are **4 different approaches** for the concerned operation or technology.

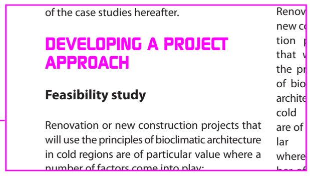
« Understanding the challenges »



What are the development challenges which justify implementing the operation presented?

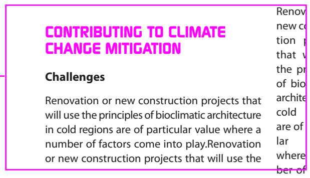
What are the functioning principles of the technologies and practices presented?

« Developping a project approach »



What are the main steps and characteristics of a project introducing this technology or practices (project's targets and duration, required skills, intervention areas, perpetuation modes, etc.)?

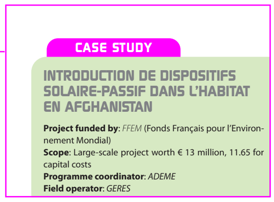
« Contributing to climate change mitigation »



In what extent does the operation participate in adapting to and mitigating climate change?

Is it eligible to the Clean Development Mechanism (CDM) and/or to the Voluntary Market? What are the emission reduction estimates?

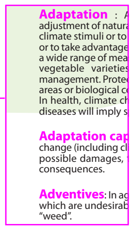
« Case study»



It's an opportunity to study a Southern country and to discover an ongoing or executed project and to get to know a development project operator and his partners.

A glossary

The vocabulary used can sometimes be complex. A glossary has then been created to make fact sheets easier to understand. You can find key words and a list of acronyms. Words in *italics* are explained in the glossary, so don't hesitate to consult it!



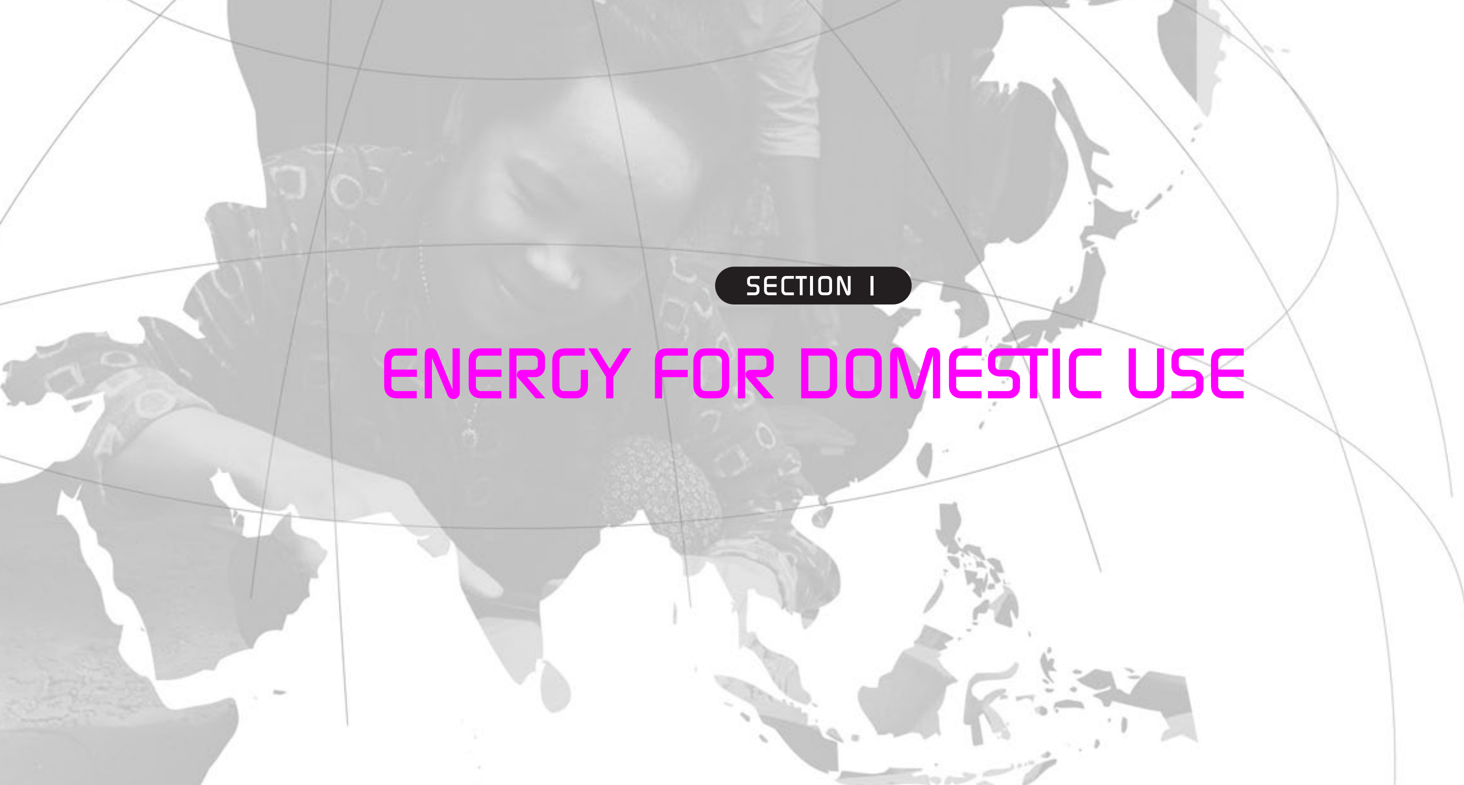
Energy measure units: REMINDER

Throughout the book, energy measure units are mentioned. It's necessary to understand the different measures used to talk about energy installations, energy efficiency, a solar panel power, etc.

The legal unit used is the **joule (J)**: amount of energy exerted when a force of 1 Newton is applied over a displacement of one meter in the direction of the force. The energy supplied to a system during a time unit to make the job is the power. Power is expressed in **Watt (W)**: power of an energy system in which 1 joule per second is dissipated.

Nevertheless, it can be quite frequent to find data expressed in **Watt-hour (Wh)** or even in kilo Watt-hour (kWh), i.e. 1,000 Wh. Watt-hour corresponds to the energy produced during one hour by a 1 Watt power system, i.e. 3,600 joules.

In the case of solar electric systems, the unit used is Watt-peak (Wp); it represents the highest electric power delivered by an installation for standard sunlight of 1,000 Watt per m^2 at 25°C.



SECTION I

ENERGY FOR DOMESTIC USE

For people living in developing countries, irregular or limited access to energy is part of their way of life. Yet energy is a crucial factor for the development of economic activities and a staple on the home front (lighting, access to water, cooking). The poorest households spend as much as 30 % of their budget on energy, not counting the time spent gathering wood for cooking or heating.
The biomass is by far the largest source of energy for such people, as it is generally accessible at no or little cost. It is tapped for basic needs such as fuel for cooking and heating. But increased use of biomass energy is having an environmental impact on ecosystems. When the source of wood fuel is not replenished, the result is forest destruction or environmental degradation, which is non-renewable biomass. This key concept has only come to the fore since 2008 in the mechanisms of the Kyoto Protocol.
The purpose of this section is to introduce examples of operations or technologies that make it possible to enjoy sustainable access to energy for domestic purposes and use this energy in a more efficient manner.

SOURCES OF ENERGY AND ASSOCIATED CONSTRAINTS

Uses and sources of energy for domestic use

Energy is omnipresent in daily life. With it, water is pumped and purified, meals are prepared, and food is preserved. Access to electricity and therefore to lighting makes it possible for people to study at home and to take night courses. Street lighting provides added safety for women and children. Electricity also promotes the development of systems necessary for communication or leisure (cell phones, radio, and television). The many uses that can be made of it are crucial for the development of countries of the South.

The biomass supplies a big part of this household energy. "Biomass" means all of the organic matter of living organisms in the various ecosystems and the products derived from it, such as lumber, straw, bagasse (the fibrous residue of processed sugar cane), and wood cull. Traditional biomass refers to fuel wood along with agriculture and forest waste that is intended for use in cooking or household heating. The term "modern biomass" refers to the use of conversion capacities superior to traditional biomass (gasification, pyrolysis, etc.), for the production of electricity or liquid bio-fuels, both of which make it possible to use resources more efficiently.

Wood is the usual form of biomass fuel and is generally sourced from forests. Some 70 to 90 % of primary energy consumed in Sub-Saharan Africa is fuel wood. Wood is often available on a "free-range" basis in rural areas. It is gathered from neighbouring ecosystems (savannas, forests, etc.) and is sometimes processed into charcoal for marketing in urban zones.

Notion of energy poverty

Despite the preponderant place of the biomass in household energy consumption and the wastage that goes along with its use due to inefficient appliances, its share is often inverted in terms of cost. It costs more to use fossil fuel, which may be more occasional, such as the use of a battery, charging the battery with a generator, or using gas for cooking and kerosene for lighting. Access to gas and kerosene is promoted when government subsidies are provided.

The following data are taken from a study conducted in two provinces of Cambodia. They describe typical energy consumption patterns of households (GERES, PNUD, 2008) and the associated budget.

Energy used for		Cooking		Lighting/audiovisual		TOTAL
Energy source		Biomass	Gas (LPG)	Electricity	Kerosene	
Energy consumed per household	kWh/month	2 248	48	46	13	2 355
	percentage	**95,5**	**2**	**2**	**0,5**	**100**

Usage de l'Energie		Cooking		Lighting/audiovisual		TOTAL
Energy source		Biomass	Gas (LPG)	Electricity	Kerosene	
Energy consumed per household	in riels[1]	33 600	14 600	75 620	4 221	128 041
	percentage	**26,2**	**11,4**	**59,1**	**33**	**100**

Use of energy per family, in rural Cambodia

This example shows that cooking accounts for 97.5 % of household energy consumption, but only 37.6 % of its energy budget. On the other hand, even though the share of electricity consumption is very small (2 %), it takes nearly 60 % of the household budget.

Energy poverty describes the situation where communities consider household fuel as an adjustment variable in household economics. For instance, the family will cut down on heating, will refrain from getting the battery recharged for lighting, etc., when the expenses entailed would mean being unable to get food.

Similarly, the further people live away from urban centres, the more they have to pay for lighting and the use of audiovisual appliances, because the generation systems are less efficient (the cost of one kWh of electricity produced from a battery may be 50 to 100 times the cost of the electricity delivered over a conventional electricity grid); yet, despite their inefficiency, such energy sources have the advantage of flexibility of use (no fixed customer charges come with them).

Problems in using fuel wood

A number of constraints and impacts are encountered in using biomass energy for daily needs (cooking, heating, etc.).

The time spent gathering wood makes this work drudgery, especially for women, and this time cannot be used for other purposes (education, income-generating activities, etc.). The increasing need for fuel wood is putting huge pressure on natural resources (forests, savannas, and other ecosystems). Where wood is gathered intensively, forest destruction, loss of green cover, or soil degradation occurs. The subsequent biomass depletion may translate into an increase in time spent gathering or a jump in the price of charcoal. Furthermore, exposure to the fumes from burning wood in a confined space can result in serious lung ailments.

Thus, the countries of the South are confronted with the need to develop ways of producing biomass energy and using it in a more sustainable way.

CHALLENGES FACING DEVELOPMENT STAKEHOLDERS

Stakeholders have many different targets before them. One such target could be working to help the affected communities cut down on their energy bill and/or the effort required to gather wood. The money and time saved by such measures can then be devoted to other needs such as education or health. Another target could be limiting the environmental impact caused by the use of fuel wood.

1. In Cambodia, the currency is the riel; as of August 2008, 1,000 riels = € 0.17.

To achieve such targets, two major initiatives can be highlighted:

- Promote the introduction of energy-efficient household appliances

  Fact Sheet 1.1 - Fuel-efficient cooking,
  Fact Sheet 1.3 - Efficient natural gas equipment)

- Vary the supply by setting up long-term energy supply channels such as:

  - Biomass or fuel production using what is referred to as the renewable biomass

    Fact Sheet 1.1 - "Biomass energy renewal" section

  - Introduction of household appliances that use renewable energy

    Fact Sheet 1.2 - Solar cooking,
    Fact Sheet 1.4 - Photovoltaic battery kits

  - Access to an electricity supply adapted to actual needs and at a reasonable cost in the form of mini-grids

    "Decentralised energy services" section.

HOUSEHOLD ENERGY AND CLIMATE CHANGE MITIGATION

On the surface, fuel wood may appear to be a renewable energy source since it comes from plants and plants are a renewable resource because they only need light and water—of which there is an unlimited supply—to grow. However, this is a widespread misconception.

If wood is gathered from natural sources such as a forest and burned at a rate faster than the source is replenished, the carbon cycle is broken[2]. Excess carbon dioxide (CO_2) goes out into the atmosphere. This makes it a "non-renewable biomass" and a contributor to greenhouse gas emission, just as fossil fuels are, and therefore also to climate change. Management of the biomass used by households is therefore a major issue to be addressed in the effort to combat climate change.

Furthermore, desertification and a declining forest cover in some regions (the Sahel is a case in point) are results of climate change. There is a consequent depletion of the biomass that is of crucial importance to families whose main energy source is fuel wood. Smart use of the biomass, optimizing it, is a valid action-adaptation strategy.

Two approaches are relevant in combating climate change and are now eligible under the *Clean Development Mechanism* (CDM) framework:

- Reducing the use of a source of fossil or non-renewable fuel by the introduction of energy-efficient appliances.

- Substitution of a source of fossil fuel or non-renewable biomass energy by a renewable source.

How this eligibility works will be shown in the various Fact Sheets to follow.

2. The decomposition of plant material under natural conditions, or due to anthropogenic burning, results in equivalent carbon dioxide (CO_2) emissions. Theoretically, this is re-absorbed by growing plants/trees through the process of photosynthesis. This is referred to as the carbon cycle.

Fuel-efficient cooking and biomass energy

> **Related fact sheets:** *Fact Sheet 1.2 - Solar cooking; Fact Sheet 4.1 - Charcoal briquettes from farming residues; Fact Sheet 5.3 - Forestry plantations; Fact Sheet 5.5 - Sustainable charcoal production*

In countries of the South, food cooking is a daily routine that requires an average of 600 kg of wood per person per year. In rural areas, this need is basically met by the use of *traditional biomass energy*, wood in particular generally available for free. For example, in rural Africa, the biomass accounts for 80 to 90 % of the energy resources used for home cooking needs. Consumption ranges from 6 to 10 kg per family a day, or 2 to 4 tonnes per family a year. Given Africa's population of 750 million inhabitants of which approximately 55 % live in rural communities, this amounts to 275 million tonnes of biomass that goes up in smoke for daily meal cooking or 360 million tonnes of CO2 equivalent emitted into the atmosphere. In urban areas, families purchase charcoal or natural gas. The utilisation efficiency of these fuels varies according to the equipment used but in any case it can be enhanced.

For development stakeholders, the focus is at the level of supply of and demand for cooking energy. The supply is the biomass in all its forms—such as agricultural waste, hewn wood, charcoal, and briquettes. The demand is manifested through the energy behaviour of households, the equipment used and levels of cooking energy consumed.

Parallel to this approach of distributing improved cookstoves, energy plantation is a means of renewing the biomass supply for rural communities and thus meeting their needs for fuel wood and at the same time limiting demands made of the forest.

This fact sheet outlines the distribution of improved cookstoves and ways of implementing silvicultural energy plantation.

DOMESTIC COOKING IN THE COUNTRIES OF THE SOUTH

A major development issue and an environmental issue

In rural areas, cooking is generally done in a rudimentary manner; for the poorest of the poor, this involves the "three stone stove" made of stones placed on the ground on which a cooking pot is put, or traditional stoves usually assembled of local materials.

Families get their fuel supply by purchasing wood and/or charcoal or gathering wood out it in the forest. If such forest scavenging exceeds the renewal capacity of the forest ecosystem, a situation of *non-renewable biomass* is referred to. That translates into destruction of the forest. Moreover, inefficient cooking equipment incurs an energy loss as high as 70 % of the energy produced.

Cooking and use of the biomass that it entails therefore beg the issue of biomass and energy source diversification, as well as that of its utilisation efficiency for cooking.

The accelerated scarcity of biomass is causing development stakeholders to become aware of the need to address these problems.

Technologies and practices that limit the impact of cooking

The "improved" cookstove

This type of cookstove is based on the general design and use of traditional cooking systems. The simplest versions are based on such principles as having a well-designed burning rack, an optimally sized combustion chamber, and limited space under the cooking pot to induce heat transfer from the flames produced. Simply working up these internal parameters to an optimum extent enables savings of wood or charcoal in the order of 15 to 30 % compared to a traditional cookstove for similar output, which eases the higher purchase cost. This type of stove has become very popular in urban centres as purchasers catch on to the savings that are realised.

Three stone stove, Benin

Depending on how they are used, cookstoves are referred to as individual or institutional units. The distribution of such cookstoves is a particularly important strategy in areas where wood fuel is scare, such as in the Sahel or where deforestation is gathering speed.

Making a home cookstove, Cambodia

Energy plantations

This is an upstream operation involving the planting of fast-growing woody trees for the purpose of providing a regular supply of fuel to communities round about on a multi-year basis.

Putting up a stock of fuel wood, Cambodia

A number of approaches are possible:

- Private family plantations (agro-forestry).
Such plantations may include tree types that can be used to produce both fuel and food. They focus on optimisation of the local agriculture system using crop association techniques (pepper on areca nut trees, betel vine on sesbania, etc.).

- Plantations in forest-based communities.
This involves community plantations of a size commensurate with the biomass needs of the group for both domestic and handicraft activities.

> Plantation on unencumbered and undeveloped public spaces (communal land, roadsides, etc.).

Hedges in Cambodia have a high "wood energy" potential

The most commonly grown species are acacia (Acacia auriculiformis), leucaena (Leucaena leucocephala), cassia (Cassia siamensis), quickstick (Gliricidia) and sesbania. Eucalyptus is meeting with strong criticism because of its dominating or even invasive tendency on ecosystems where it gains a foothold.

The plantation operation starts with tree nurseries that are usually put in prior to the rainy season and worked for a few months. It is best to select tree types that tolerate local environmental constraints (unregulated animal grazing, drought, flooding, soil type, etc.). The seedlings are then transplanted in the open field. Mulching techniques are sometimes used to increase plantation productivity. Depending on soil fertility, 5- to 10-year rotation patterns may be implemented.

Such plantations are a supply of what is called renewable biomass because it is sourced from trees grown on agricultural land in contrast to biomass scavenged from a forest area that is not subsequently replanted (and is therefore non-renewable).

Development stakeholder involvement

Stakeholders may become involved at numerous levels

Exert an upstream influence on public policy-making

This influence would be aimed at achieving improved fuel wood management by regulating such things as the right to scavenge in the forest or introducing energy plantation. The establishment of *forest-based communities* is also a forestry policy measure to be promoted. Forest-based communities are local communities that enter into a contract arrangement with the government under national statutory provisions governing the forest. Depending on the country, they receive a multi-year concession (about 15 years) on a specific area of forest land. Forest-based communities are bound by specifications detailing how the space is to be managed, and this may include the obligation to grow forest trees only. This is a forestry management decentralisation process.

Distribution of improved cookstoves

This may be something undertaken as an emergency measure in areas where there is little fuel wood gathering security and where fuel wood use is limited. It may also be an appropriate initiative for health or education agencies working with facilities offering an institutional food service such as schools and hospitals. The cookstoves help reduce the energy bill of such establishments.

Support for setting up energy farms and the use of efficient wood charcoal-making procedures

(See Fact Sheet 5.5 Sustainable charcoal production)
These are initiatives that impact the fuel supply. They limit the brunt of fuel production on the forest. This support can take the form of a component in a more general agro-forestry project designed to combat deforestation.

Ideally, the stakeholder would be involved in all of the above areas, although it is admittedly not always easy to implement an overarching approach. Stakeholders, challenges, and means differ from one area to the next.

DEVELOPING A PROJECT APPROACH

Initial diagnostic analysis

The cooking process must be looked at as a whole with diagnostic analysis focusing on the supply of cooking fuel as well as the demand. the Thus the goal is to achieve an appropriate balance between the two and assess the relevance of any initiative in this field and how it will be carried out.

Study of needs and relevance

In assessing the relevance of introducing improved cookstoves in a given territory, it is necessary to analyse the demand for cooking energy. This analysis will seek to characterise energy behaviours, the cooking equipments, and levels of consumption in the zone wherein implantation is being contemplated.
Analysis of the supply will attempt to characterise the biomass used for cooking (forest tree types, bushes, agricultural waste, dung, other residues), its yearly productivity level, how it is collected (seasonal variation, tools) and storing, and quantities produced by the identified tree types. The goal will be to identify inadequate sources and actual needs.
The supply and demand studies must be designed to highlight potential impediments to development, including those that relate to the cooking operation as well as to the biomass supply. The study will take account of the environmental impacts of current practices.

Determining the project size

This includes estimating the number of families concerned and the type of equipment that will meet the needs, considering the local skills base, materials available, and an appropriate means of distribution. Where energy plantation is involved, the study will identify the appropriate tree type to be used for planting, the number of hectares available, and potential association with other crops in the study zone

Combining efficient cooking equipment distribution with energy plantation

It is acknowledged that the energy needs of domestic household cooking (in both urban and rural communities) will continue to grow in the years to come (population increase, rising cost of fossil fuels). A 30-% reduction of this consumption may be a short-term response, but overall consumption will return to the previous level due to the increase in the number of families cooking with wood. The environmental impact will therefore remain the same as the initial situation where a non-renewable biomass is involved. On the other hand, combining the distribution of new equipment with a renewable biomass production strategy will promote a sustainable reduction of the environmental impact (maintenance of forests, reduction of GHGs).

Disseminating improved cookstoves

Targets:

Individual households, institutional cooking set-ups based on cooker size

Functionality, equipment efficiency:

The materials used to manufacture an improved cookstove and manufacturing techniques vary from one geographic location to another depending on the available components and skills level. The materials generally used are fire clay, sand, and sheet metal for dressing. Energy efficiency and service life are the same as for a traditional cookstove, whereas fuel wood savings amount to 25 to 30 % as the case may be. It is noteworthy, though, that there is always a difference between the efficiency in real-life situations and laboratory testing situations in which the performance is often better.

Technological maturity:

The development of basic improved cookstoves (upward channelled combustion on a rack, "rocket stove," etc.) is now relatively well mastered technologically and such stoves are now very popular in urban centres in countries of the South.
Getting rural families to adopt it is seemingly encountering greater barriers, as the solutions offered do not always appear to be suited to the context. The primary concern is not saving fuel (as it is not purchased in these settings), but the performance obtained in relation to the purchase cost (traditional cookstoves can generally be made by the individual at no cost). What is to be featured is a multifunction equipment that would include cooking and heating water (or even ste-

rilising water) at the least, capable of using local free-range biomass and simplifying the cooking process (ergonomics, faster cooking times). It must be added that fuel burning technology has been improved considerably in recent years in industrialised countries (norms on emission quality) for domestic heating equipments among others. A technology transfer is starting to take place.

Essential aspects of project guidance:

- Technology development component:
Examples are sought using identical equipments; laboratory tests are conducted to develop innovations and enhancements.

- Distribution component:
Distribution requires training people who presently make traditional cookstoves in the production of new models and supporting the establishment of marketing networks (dealers and distributors).

- Marketing component:
Bulk dealers and retailers are coached in marketing the cookstoves and in working out an equitable profit margin for all stakeholders in the chain. For distribution sustainability, it is best not to subsidize purchases. A promotional campaign with users is conducted at the same time.

Project duration:

The implementation of improved cooking equipment distribution projects depends on the stages involved in the distribution.

It is advisable to do a test run in a limited geographical area to demonstrate feasibility and to do so within a three-year time frame.

Successfully getting the improved cookstove distributed to a broader extent than its traditional counterpart in a large area (province, country) takes 10 to 15 years with regular coaching (production quality, distribution control, and promotion).

Skills required:

Mastery of the technology of biomass fuel cookstoves, marketing, and supply chain organisation.

Implementing energy plantations

Targets:

Forest-based communities, local authorities

Yields and performance:

The yield levels and service life of an energy farm are variable. The span between rotations depends on soil fertility. Moreover, each tree type has its specific needs in terms of pH, soil quality, water, and drainage. Management is a key factor in final yield levels: mulching, initial close planting followed by thinning, use of fertilizer, etc.

For instance, an acacia plantation follows a 5 to 10 year cycle. On poor sandy soil, an average volume of 10 m^3/ha/year may be obtained, or 50m^3/ha for a 5 year rotation. Given that a cubic metre of wood weighs 300 kg, a 5-year acacia plantation cycle would yield a total of 15 tonnes/ha. These figures are given as a guide only, with final yields depending on many parameters that vary according to the location of the energy farms.

Technological maturity:

There is overall mastery of suitable tree types and growing patterns. The technological maturity for setting up and running an energy farm is therefore not a genuine obstacle to their distribution. A greater challenge seems to lie in mobilising communities on these farms, which includes sharing work in plantation upkeep and settling potential conflicts involving land allocation for such plantations in a land-based community.

Essential aspects of project guidance:

- Raising community awareness with regard to the energy farm concept (participatory workshops).
- Identifying a strategy for putting in the farm; i.e. the needs, tree type, identification of available land, rules governing beneficiary accessibility, plantation management plan including technical tree growing and harvesting routines.
- Training/communication (tree growing and harvesting practices).
- Monitoring (mortality rate, growth rate, replacement of dead trees).
- Capital building by developing a project monitoring or decision-making tool, validation of practices.

Project duration:

Rotation cycles for energy farms range from 5 to 10 years. Support projects for setting up farms generally have a 5-year timeframe, with an additional 2 years for monitoring.

Skills required:

Agronomics and forestry, community-based approach, rural development.

Positive and negative impacts, risks

Economic and social

- ⬆ Improved access to energy due to reduced supply costs
- ⬆ Reduced workload for wood gathering, especially for women
- ⬆ Micro-enterprise consolidation through the training of cookstove manufacturers
- ⬆ Job creation in essentially rural areas through support given to establishing marketing channels (dealers and distributors)

- Improved cookstoves have a lower level of emission of particles in suspension and pollutants compared to traditional cookstoves, which improves the living conditions of their users
- An improved cookstove costs more than a traditional one where scavenging the biomass prevails
- The additional workload involved for energy farms may result in a competition factor with other agricultural activities on the crop growing time line
- The problem of land availability for energy farms, risk of conflict between agricultural use for food and energy use

Environmental

- The use of improved cookstoves is part of an overarching approach to streamline the fuel wood supply chain and help mitigate such things as ever increasing pressure on forests. This contributes in turn to a reduction of non-renewable biomass consumption and thereby CO_2 emission which is part of the fight against climate change.

CONTRIBUTING TO CLIMATE CHANGE MITIGATION

Challenges

In some cases, the improved cookstove results in a saving of the use of the non-renewable biomass, i.e. wood scavenged from a forest that is not replanted, thereby contributing to a reduction of carbon dioxide (CO_2) emission.

The improved cookstove also has an adaptation impact by precluding the disappearance of the forest cover that helps in soil fixation, thus limiting erosion.

Energy farms involve long-term crops, meaning that they are operated over a period of several years. They play a mitigating role by storing carbon in the vegetative parts not collected as a biomass source. This aspect will be expanded upon in Fact Sheet 5.3 Forestry plantations. For information: To be eligible for a *Clean Development Mechanism* (CDM) type arrangement for reforestation, the project must demonstrate that the energy plantation zones were "deforested" prior to 1999.

Turning emission reductions to account

Improved cookstove distribution projects are eligible under CDMs as small-scale projects, which are included in type II. "energy efficiency" projects. The AMS-II.G "Energy Efficiency Measures in Thermal Applications of Non-Renewable Biomass" methodology provides the formulae for calculating emission reduction. The reductions only count if it is proven that the fuel for which consumption has been reduced is sourced from a *non-renewable biomass*, one that emits carbon dioxide.

An "Improved Cook-stoves and Kitchen Regimes" methodology is now being developed for the voluntary market at the incentive of the *Gold Standard* organisation.

Illustration: Distribution of improved cookstoves in Cambodia

Project operator: GERES Cambodia
Project status: *Voluntary exchange market*
Type of carbon credit: VER with a *Voluntary Carbon Standard (VCS)* accreditation
Source of information:, www.geres-cambodia.org.
Crediting period: 2003-2012
CDM Methodology: AMS-II.G "Energy Efficiency Measures in Thermal Applications of Non-Renewable Biomass" methodology

Background and principle of emissions reduction

This project involves the distribution of improved cookstoves to urban users in Cambodia. It started in 1997. Carried out by GERES, it aims to distribute fuel-efficient cookstoves to achieve a 20-% average reduction of consumption. Fuel wood or charcoal consumed by the users originates from forest destruction, a non-renewable source. In the absence of the project, a larger amount of non-renewable fuel would have been consumed nationally. The reduction in consumption therefore corresponds to a reduction of carbon dioxide (CO_2) emissions. The marketing of emission reductions (VER) will provide part of the funding for the 2008-2012 project phase.

ER estimates

By late November 2006, 151,448 families were equipped with the fuel-efficient model. Thus, 314,000 tonnes of CO_2 equivalent were avoided.

1.Available on UNFCCC website: www.unfccc.org.

CASE STUDY

CAMBODIA SAVING FUELWOOD PROJECT

Project funded by: European Commission.
Scope: Large-scale project
(annual budget of € 200,000-1,000,000).
Time frame: 2 phases: 1997-2001 and 2002-2006.
Operator: GERES Cambodia,
www.geres-cambodia.org.
Partner: Ministry of Industry, Mines and Energy.
Beneficiaries: Cambodian households, cookstove manufacturers, *forest-based communities*

Context:

There is a substantial consumption of fuel wood and wood by-products (charcoal) for urban household cooking in Cambodia, 300,000 tonnes of charcoal produced each year, sourced mainly from the natural forest. The demand for charcoal is constantly growing in rural communities and is not dropping off in large urban centres. Due to the increase in the price of natural gas, middle-class urban dwellers are going back to using charcoal.

Project activities:

Starting in 1997, GERES set up a comprehensive programme to increase the efficiency of the fuel wood supply chain. This programme was linked to implementation of a sustainable management strategy for fuel wood used for cooking.

The saving fuel wood project has several objectives:

- Professionalisation of fuel wood-efficient cookstove manufacturers and achievement of a broad national distribution (150,000 equipments in 4 years).
- Technical and economic validation of sustainable charcoal production for the domestic market, established in partnership with forest-based communities.
- Research activities and development focusing on charcoal production kilns, high-capacity post-combustion stove pits for cottage industry use (sugar making), charcoal briquettes made from unused agricultural waste originating from crops such as sugar cane and coconut.
- Support for the establishment of a consultation space to design a fuel wood management policy. This process involves a body of decision-makers and aims to strengthen an existing NGO network for management of fuel wood in rural communities (Wood Energy Network of Cambodia - WENetCam).

Finishing an improved cookstove

Cooking rice

Outcomes:

The first years were spent coaching the traditional household cookstove production and distribution chain. This seemed to be a more viable approach than setting up a parallel supply chain for improved cookstoves. Several models of fuel-efficient stoves were tested and some of them were validated at the pre-distribution stage (up to 5,000 units) but eventually only one model passed the large distribution test (one of its key features being ease of transport by wholesalers). This was the New Lao Stove (NLS) model that yields a charcoal saving of some 25 % compared to the traditional model. Current production stands at 100,000 units a year.

By late November 2006, 151,448 families were equipped with the fuel-efficient model, resulting in an aggregate saving of US$ 4 million to that date. The added value injected into the marketing channel using this new cookstove is US$ 92,000 a year.

CASE STUDY

SETTING UP ENERGY PLANTATIONS

and monitoring wood collection patterns in Cambodia

Project funded by: GERES Cambodia (own-source funds)
Scope: Pilot project with a budget below € 50,000 a year
Operator: GERES Cambodia, www.geres-cambodia.org
Key partner Local authorities (commune councils)
Time line: Since 2006
Number of beneficiaries: 12 private growers, 1 *forest-based community*, 3 institutions

Context:

Since 2005, GERES Cambodia has been exploring different approaches to social forestry. GERES Cambodia is targeting the Tonle Sap alluvial plain and the southeastern part of the country. This region is characterized by a centuries-long population sedentation pattern. Development of agricultural land and agricultural practices virtually stamped out the forest. Some provinces have only 2 % of their forest cover left. The traditional landscape is made up of rice paddies with earth bunds and scattered stands of sugar palm trees. Additionally, major forest destruction is resulting from charcoal production. For many reasons, trees are not a major feature of the countryside. GERES Cambodia therefore sought to initiate a concept of growing groves of trees, Cambodian style.

Project activities:

• A body of pilot initiatives was launched to put in plantations of different fast-growing tree types in order to explore the various potentials that could be developed. Local communities were involved to the extent possible in making choices affecting the community (location of the plantations, management procedures, etc). Tree nurseries were set up, with the villagers contributing financially to their management. Each year, planting operations took place in August and September.

An individual approach to households was also taken. Assistance was given to put in live hedges around rice paddies and enhance garden areas.

• *Geographic Information System* (GIS) used to monitor wood collection channels

Assessing the biomass renewal rate is a critical component of social forestry projects. It is a means of determining whether the local environment is regenerating or degenerating.

For this study, GERES developed mapping tools using geographic information systems (GIS) and satellite images making it possible to superimpose maps of soil cover, wood productivity, population densities and population %ages that use wood or charcoal as an energy source. Collection zones were identified through field surveys.

Young acacias plants

This enabled a visualisation of the balance or imbalance being created between the supply and demand for wood, i.e. between energy farm productivity, natural forest regeneration and human pressure on the ecosystem brought on by such things as wood collecting.

Provisional outcomes:

The approaches were complementary rather than in competition with one another.

Garden areas were enhanced with the planting of fruit trees or multipurpose trees with a focus on village food security. Hedges were developed using fast-growing tree/bush types that combined production (fuel wood, forage) and protection (erosion, uncontrolled grazing, and windbreaks). Village groves were planted with local and exotic tree types for the production of lumber and fuel wood to counteract the destruction of forests due to the energy demand.

Garden spaces are of particular value as far as food security is concerned. There is overall good use being made of such spaces and their proximity to dwellings facilitates their management. Where conditions are favourable, garden spaces provide up to 80 % of the family's fuel wood needs.

For more information

Websites:
HEDON- Household energy Network: www.hedon.info
Bio-Energy distribution list: www.stoves.bioenergylists.org
GERES Cambodia: www.geres-cambodia.org
CIFOR - Center for International Forestry Research) :www.cifor.cgiar.org
ICRAF- World Agroforestry Center: www.worldagroforestrycentre.org

Solar cooking

> **Related Fact Sheets:** *Fact sheet 4.1 Making charcoal briquettes from farming residues, Fact sheet 5.5 Sustainable charcoal production*

Cooking food is a daily operation in Southern countries and requires on average 600 kg of wood per person per year on a world scale. In rural areas, this need is mainly met by the use of biomass, especially wood, which is, for the most part, not commercialised. In urban areas, families buy charcoal or gas, which are fuels which are becoming increasingly scarce or more expensive.

One possible alternative is to offer solar cooking to these groups. The objective is to concentrate solar energy and convert it into heat by means of appropriate equipment. This fact sheet deals with the dissemination of solar stoves in countries of the Global South. This is one of the many opportunities to reduce the social, economic and environmentally negative impacts of cooking.

DOMESTIC COOKING IN COUNTRIES OF THE GLOBAL SOUTH

A major human and environmental challenge

In rural areas, the poorest groups often cook in a rudimentary way on a three-stone stove, made up of stones laid on the floor supporting a pot while others use traditional stoves usually made from local materials. In cities, people often buy bottled gas but in limited quantity owing to its high cost (where no government subsidies are available).

To ensure their fuel supplies, families buy charcoal, gather wood from the forest or use dried dung. Where the quantity of wood gathered is greater than the capacity of the forest ecosystem for renewal – a common occurrence – this is considered as non-renewable fuel wood, which is a cause of deforestation. In addition, collection time increases the difficulty of work, especially for women, and takes time away from other activities (education, income-generating activities, etc.).

Finally, food is often cooked in poorly ventilated areas. Pollutants concentration can be very high, e.g. fine dust levels may exceed the WHO approved standard by up to ten times. Each year, an estimated 1.6 million people die after inhaling domestic fumes.

Thus, this daily operation poses both human and environmental challenges.

Solar cooking, an alternative solution for traditional cooking

In areas where fuel is largely inaccessible or too expensive and where there is enough sunlight, solar cooking may be worthwhile. It relies on equipment that enables solar energy to be concentrated in order to produce heat. The use of a solar stove necessitates longer cooking time but it enables wood gathering and the use of kerosene to be eliminated. Two main types of solar stoves will be outlined here.

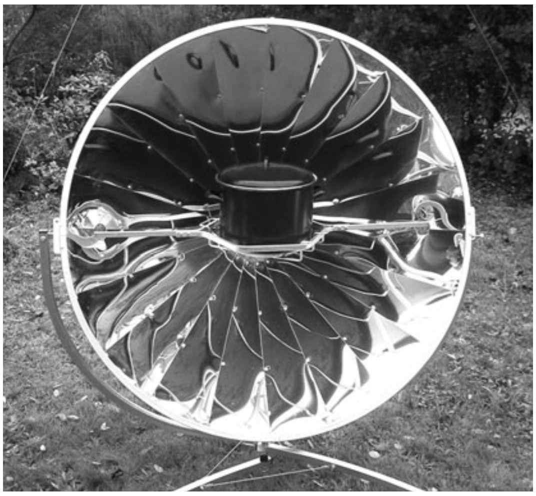
The box-type stove

This is made from an insulated wooden box, with double-glazing, one or more reflectors, and with an internal aluminium tank, at the bottom of which a black steel sheet is placed. Solar rays pass through the double-glazing, striking the black steel sheet, which in turn emits infrared rays which are contained inside the tank. The infrared rays cause the temperature to rise. Solar rays are reflected by the external reflector as well as inside of the tank because of the reflective aluminium walls. Thermal insulation material, placed between the inner tank and the wooden box, enables heat to be retained. This stove can achieve temperatures of up to 190°C which is much longer than for a traditional stove. Its use is mainly domestic.

A box-type stove (©Bolivia Inti-Sud Soleil)

The parabolic-type stove

This is based on the principle of solar concentration. This stove is made up of several highly reflective (anodised) aluminium strips. Laid in a parabolic shape, these strips concentrate solar rays on one focal point where the cooking pot is placed. Heating is quicker than with the "box-type" model but it does not allow for heat retention. It also requires regular adjustment to ensure its continuous accurate orientation towards the sun. It enables food to be fried as it can achieve temperatures over 200°C. Its power varies directly in relation to its diameter, e.g. a 1.40 m. diameter parabolic mirror generates 700 W. Such a stove, with its large parabolic mirrors may be suitable for collective use. It can also be used to sterilise medical equipment.



A parabolic-type stove (©Bolivia Inti-Sud Soleil)

A technology which requires guidance

Solar cooking implies a radical change of mentalities, and it requires longer meal preparation time, and a different approach to cooking, i.e. a total change of habit. It is imperative to understand well the food practices of the target populations in order to determine whether such equipment suits their way of life. Furthermore, it is necessary to provide guidance to improve their grasp of the new equipment and how to adjust their cooking to the new conditions. The role of field operators (mainly NGOs) is therefore crucial to enable the introduction of this equipment. A successful pilot experience is the only way to convince people of the utility of solar stoves.

DEVELOPING A PROJECT APPROACH

Primary diagnosis

Climate situation

In the first instance, an assessment of sunlight quality is required (clear sky, without mist or clouds). Humid or cloudy areas and polluted urban areas are not suitable, even though outside temperatures may be high.

Cooking energy and type of meals

A study of fuel supply and demand is primordial. This study needs to establish a list of the fuels most used (mainly wood and kerosene in rural areas) as well as their financial and technical accessibility. For instance, in a poor area even with a lot of forest, people are often reluctant to use solar stoves. It is also worthwhile to consider the time needed to look for fuel and to identify the family members responsible for gathering the fuel. When fuel is purchased, it is important to identify the proportion of the budget dedicated to this item.

Understanding the types of meals to be prepared is vital in order to preview the changes required in cooking methods with the introduction of solar stoves. The timing of meals also needs to be studied, as well as kinds of dishes to be prepared, cooking implements required, the persons responsible for meal preparation, etc.

Supporting the dissemination of solar stoves

Targets:

Families and communities (solar stove type to be defined)

Equipment functionality and performance:

The box-type solar stove requires twice as long as a traditional stove to cook food. Nevertheless, the time is not an issue since the stove does not require any adjustment (slow cooking). A stove will last about 15 years on average, provided it is properly maintained, i.e. protecting it from the rain and keeping it well painted. On average, when combined with the use of traditional stoves, it enables fuel savings of up to 80%.

The parabolic solar stove also enables food to be fried since temperatures over 200°C are achievable. Correctly oriented to the sun, it can be used effectively immediately, however, the cooking process needs to be monitored. As the parabolic mirror needs to be correctly oriented to the sun (owing to its operation by means of concentrating solar radiation), it is imperative to adjust its position regularly. Depending on the diameter of the mirror, which defines its power, cooking time is more or less equal to gas or wood cooking.

Technological maturity:

Box-type solar stoves can be made from locally available materials (wood, glass) and it is easy to build them. The cost per unit is about € 50 (depending on the country) when manufactured on a large scale. This estimate only includes material but not labour and training costs.

The parabolic model requires quite sophisticated materials which are not always produced in developing countries. Thus, burnished aluminium reflectors are mainly imported from industrialised countries. Assembling the different elements is easy. The cost price for a parabolic solar stove will not be less than € 100 (based on large quantity orders).

Finally, the most difficult step to achieve for both kinds of stove is adoption by the communities concerned. People need to be guided in changing their methods with the help of international development stakeholders (NGOs, technical cooperation agencies, etc.) or local stakeholders.

Essential aspects of project guidance:

- Research and development aspect: Dissemination of solar stoves needs to take account of local resources (materials), characteristics of the target group (activities, type of dishes eaten) as well as local competencies.

- Awareness aspect:
People's commitment to these "fire-free" stoves is crucial. To achieve this, the project operator will need to provide demonstrations, preparing traditional dishes, with the help of local "resource-persons", who will be the ones most able to diffuse the message. This awareness needs to be reinforced by the progressive adoption of this new tool by the people while putting it into practice.

- Dissemination aspect:
Whichever option is chosen, training and guidance in the use of solar stoves us crucial. Several options are presented below:

1- Dissemination through training of trainers, manufacturing of solar stoves in kit form, which will be assembled by the beneficiaries during the assembly training sessions.

2- Dissemination can also be considered through assembled solar stove direct sales (without self building by the future owner). This option requires the existence of a handicraft production facility and commercialisation of finished products.
Nevertheless, self-assembly seems to greatly improve the adoption of solar stoves.

3- Dissemination after demonstration sessions or after solar cooking training, which offers the potential beneficiaries the opportunity to borrow the solar stoves. As a follow up to the loan, option 1 or 2 may be proposed.

- Financial support aspect:
Financial participation in the purchase of the stove by the future proprietor is an important factor to involve him in the project. At the time of purchase, families may also be offered the option to spread the payment over several months. Nevertheless, subsidising the purchase price is almost impossible since the tools are still quite expensive, regardless of where they are manufactured.

- Follow-up aspect:
The follow-up can be organised in regular meetings, during which the discussion is moderated by a local coordinator. Discussion includes everybody's experience: success, doubts, explanation.

Project duration:

Experience shows that the dissemination of solar stoves needs to be planned over the long term, since guiding the beneficiaries itself requires several months (follow-up stage). Switching from a traditional stove to a solar stove implies significant behaviour change.

Skills required:

Mastery of solar cooking, participative approach, capacity for training and moderation, nutrition knowledge, etc. .

Positive and negative impacts and risks

Economic and Social

- ⬆ Reduction of domestic fuel expenses (wood, charcoal, gas and kerosene);
- ⬆ Reduction of toxic fume inhalation and of back problems from wood gathering;
- ⬆ Better access to potable water providing the opportunity to produce drinkable water by means of solar stoves;
- ⬆ Reduction of wood gathering time, especially for women;
- ⬆ Strengthening of women's role: gain in time, money, efforts, self-confidence;
- ⬆ Better nutritional quality of the food cooked in the box-type solar stove (slow cooking which preserves nutrients);
- ⬆⬇ Change of cooking practices

- Risks of burns or blinding with the use of a parabolic solar stove if training in the use of the equipment is lacking or inadequate
- Risk of poor functioning of the box-type solar stove if training in the use of the equipment is lacking or inadequate (repeated opening of the stove will affect its efficiency);
- High to very high purchase price; flexible payment mechanisms need to be developed.

Environmental

- The solar stove makes use of solar radiation, which is a clean and inexhaustible energy source. This reduces the use of fossil fuels (gas) or of non-renewable fuel wood and thus contributes to the fight against climate change and against deforestation.

CONTRIBUTING TO CLIMATE CHANGE MITIGATION

Challenges and Turning emission reductions to account

The solar stove mitigates climate change since it enables the substitution of non-renewable fuel wood by renewable solar energy. This also generates a reduction in CO_2 emissions. It also has an impact on adaptation by preventing the disappearance of forest which contributes to maintaining the soil, hence limiting erosion.

Solar stove dissemination projects are eligible for *Clean Development Mechanism (CDM)* as small-scale projects. These projects are classed as Type I. Renewable Energy projects. The AMS I.E "Switch from Non-Renewable Biomass for Thermal Applications by the User"[1] methodology provides methods for emission reduction calculation. Such reductions are only counted where it can be proved that the reduced-consumption fuel originates from *non-renewable biomass* which therefore emits carbon dioxide.

Illustration: Solar stove manufacturing and dissemination project in Peru

Project operator: Bolivia Inti-Sud Soleil
Project status: *Voluntary exchange market*
Type of carbon credit: *VER* with a Gold standard accreditation
Information source: www.boliviainti-sudsoleil.org, www.actioncarbone.org
Crediting period: 2007-2016
CDM Methodology: AMS I.E. "Switch from Non-Renewable Biomass for Thermal Applications by the User" methodology

Emission reduction principle

In Peru, the project consisted in the manufacturing and dissemination of box-type solar stoves with families from the rural area of Colca (208 stoves disseminated). If the project had not been implemented, families would have continued to use traditional local stoves that mainly use firewood or kerosene. The introduction of box-type solar stoves enables the consumption of these two fuels to be reduced and also enables carbon dioxide emissions to be reduced.

ER estimates

An estimated 0.65 ton CO2 eq. per year is saved by each box-type solar stove disseminated by the project. Thus, the project provides a reduction of about 104 tons CO2 eq. per year. The sale of these carbon credits on the voluntary market also provides additional financing for solar stove dissemination projects implemented by Bolivia Inti-Sud Soleil (Bolivia and Peru).

1.Available on the UNFCCC website, www.unfccc.org).

CASE STUDY

SOLAR STOVE MANUFACTURING AND DISSEMINATION IN PERU

Project financed by: Dotations des Solidarités Nord-Sud, Ministry of Foreign Affairs,
Sale of carbon credits (VER)
Scope: Small-scale project with a budget of less than € 50,000.
Operator: Bolivia Inti-Sud Soleil
Main partnership: Caritas Felices association
Execution date: June 2006-March 2007
Number of beneficiaries: 208 families

Context and activities implemented by the project:

50,000 families live in poverty in Arequipa. High prices make energy unaffordable for poor people. Energy is thus a very significant expense for families, which can take up to 40% of monthly income. In Arequipa, families use kerosene and wood for cooking. Kerosene and wood combustion (often of poor quality) pollutes the surrounding air and damages users' health. At the same time, sunlight in the Arequipa region could easily provide the necessary energy for cooking meals.
The project implemented by Bolivia Inti aimed to establish a local team to be responsible for organising training sessions in how to build and distribute solar stoves. Once the team was up and running, the project enabled target families to be selected and guided in building their stoves.

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Results:

Thirteen training sessions took place at nutrition centres in three Arequipa neighbourhoods, resulting in the construction of 208 solar stoves. Sixteen persons received training on solar stove building and nutrition at each training session, i.e. 208 families, or about 1,250 people (85% women, mostly single mothers).

For more information
Bibliography:
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IWebsites:
Bolivia Inti – Sud Soleil website: www.boliviainti-sudsoleil.org
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Household Energy Network website: www.hedon.info

Natural gas-efficient equipment

> **Related fact sheets:** *Fact sheet 1.1 - Fuel-efficient cooking and biomass energy*

Liquefied Petroleum Gas (LPG) is a source of domestic energy that is used mainly in urban of developing countries due to its low market cost. In some countries it is the preferred fuel for domestic cooking. Given its increasing cost, improving equipment efficiency is a relevant short-term solution. It can also prove to be a wise alternative to the use of *non-renewable biomass* in urban areas if there are no rural fuel-wood markets or controlled supply chains. "LPG" refers to gases such as butane and propane that come from oil or natural gas purification. LPG is commonly used in the singular, even though it refers to several gases.

EFFICIENT USE OF A FOSSIL ENERGY

LPG or non-renewable biomass - the challenges

Biomass is an important energy source in developing and emerging countries. Gleaning for it is putting tremendous pressure on surrounding forest ecosystems. Furthermore, wood gathering, generally performed by women and to a lesser extent by children, is a real grind, requiring long-distance walks and taking a lot of time on top of routine household tasks.

For lack of smart *biomass energy* management, LPG use is proving to be a lesser evil due to its favourable effects: lightening of household tasks, reduction of indoor air pollution. Thus, some countries have chosen to offer subsidies to promote its use and penetration rate, especially in rural areas.

It is essential to raise peoples' awareness and coach them in the use of low-cost, high-performance gas equipment. This approach will be developed here.

Efficient equipment principles

Gas is generally used for household cooking and/or space heating. The cooking or heating appliances used are locally manufactured at a very low cost but often of a quality so poor as to make them downright dangerous. The result is overconsumption of gas due to thermal loss (lack of insulation) or to poor combustion (unburned or partially burned gas) because of faulty burners.
High-performance gas equipment can therefore be proposed to replace traditional equipment that burns wood or gas, but with very low energy yields (ratio between payload energy output and consumed energy). Replacement options have a longer service life (enamelled housing, stainless steel fixtures, etc.) and ensure maximum safety (oxygen control burner on gas stoves). As for domestic use, its applications are gas water heaters, stoves, and heat boxes.

Such equipment comes with a properly sized atmospheric gas burner together with enamelled housing. The handles, base, and cover are made of insulating materials, which is a plus in comparison with traditional equipment. This newer equipment is better insulated and there is less risk of getting burned when it is moved or used. It has the best potential for fine-tuning when very specific uses are called for (such as bread baking only).

The approach then will be to develop a range of equipment that is not available in the conventional industry sector (gas oven for family-scale bread baking) in a way that best fits in with local use.

Involvement of the public authorities

The public authorities have a role to play in regulating gas rates to make it affordable to poor communities in areas where alternative energy is based on the use of non-renewable biomass. They can also enact regulations (equipment standardisation) to encourage the dissemination of high-performance equipment rather than equipment that consumes a lot of energy and/or is dangerous to use.

DEVELOPING A PROJECT APPROACH

Feasibility study

Analysis of the cooking energy demand

A study of the relevance of introducing gas equipment in a given territory is part of a broader issue of analysing the cooking energy demand. Such an analysis will characterise energy behaviours, equipment used, and consumption levels in the area targeted by the project. Analysis of the supply will attempt to characterise biomass use for cooking (forest trees, bushes, agricultural waste, cow dung, and other waste), its yearly productivity level, how it is gathered (seasonality, tools) and stored, as well as quantities gleaned from the different types of trees identified. The aim is to see what sources are becoming inadequate and determine the needs.

The supply and demand study must be designed to highlight potential obstacles to development linked to cooking and taking energy supplies from the biomass, as well as the environmental impacts of current practices.

Determining the size of a domestic energy project (cooking and heating)

For the pilot phase, information is needed on the number and types of families concerned, the type of equipment that would meet the needs (available model or new design) and an appropriate way to disseminate it. When biomass is almost non-existent in the area or is more expensive than gas (see case study in Afghanistan), the aim would be to facilitate access to gas. The objective is to validate avenues of disseminating the equipment and parallel management of the biomass or gas supply.

Situations conducive to introduction of such equipment

Emerging countries such as those of the Maghreb, China, and Brazil have communities whose living standards enable them to afford gas. Nevertheless, the equipment used performs poorly or the people remain attached to the tradition of using wood as energy. The introduction of this type of gas equipment is particularly relevant in these countries as it is a means of promoting energy-efficient development.

Supporting dissemination of efficient gas equipment

Target:

Family units

Functionality, performance:

The technical characteristics of the gas equipment are assessed according to their power and energy yield, as well as their safety level. Important parameters to take into account are combustion quality, limiting of thermal losses, quality of the gas circuit up to the injector, presence of a gas safety device, and ergonomics. In the case of the family baking oven that will be outlined in the case study further on, it has a proven gas saving of 40 percent.

Technological maturity:

The general principles of the thermal insulation and ergonomics of cooking equipment are now well understood and applied. The challenge remains of bringing together modern technologies to produce equipment with an affordable end price. Nevertheless, international equipment distributors are specialising in the low-income household market. Affordable, energy-efficient equipment is increasingly seen, notably in countries where quality standards prevail.

Key steps to introduce efficient equipment:

- R&D:
Look for examples of similar equipment and conduct lab tests to develop new or improved approaches. The equipment is then set up in a pilot phase with volunteer households to validate the suitability of the technology with a view to its subsequent dissemination.

- Pre-dissemination stage:
Dissemination is carried out through traditional equipment distributors (gas cookers, ovens, stoves) who thereby become associated with the project. They ensure the logistics as far as availability of materials and promotion is concerned. A parallel awareness-raising initiative can be conducted by a local partner association. A micro-credit system can be proposed to facilitate access to the equipment because it is generally more expensive than the original that people are accustomed to using.

Assessment and large dissemination phase:
Once the production processes have been validated and standardised on a large scale, a broad public information campaign can take place (TV spots, posters, etc.). The thrust will be to guarantee the quality of the end product (label, industrial certification, etc.).

Project duration:

Thermal equipment R&D, marketing, microfinance, structuring of the production and distribution chain, certification.

Skills required:

Recherche et Développement équipements thermiques, commercialisation, microfinance, structuration filière de production et distribution, certification.

Sustainability:

Promotion with the target population to highlight the value of using better performing gas equipment is necessary to keep the dissemination initiative going.
Support to organisation of the private sector in charge of producing or marketing cooking or heating equipment is also relevant. This would involve such things as encouraging the establishment of inter-industry associations of producers and distributors, supporting the emergence of a quality label, or even encouraging the implementation of local equipment distribution relays.

Positive and negative impacts, risks

Economic and social

Where an existing gas system is improved:

- ⬆ Savings in gas consumption and hence a lower household energy bill.
- ⬆ Dissemination of such equipment develops a new activity, which means additional income for traditional equipment distributors.
- ⬆ Less risk of accidents due to the use of faulty equipment.

Where a switch has been made from a wood energy system to an improved gas system:

- ⬆ Reduction of the drudgery of gathering wood for those who switch from wood to gas, an impact that particularly concerns women.
- ⬆ Reduction of respiratory ailments caused by fumes and particles emitted by burning firewood.
- ⬆ Ease of use and better workplace ergonomics.
- ⬇ LPG costs more per kWh than wood (free) or charcoal (affordable) and there is a risk of the price of gas being pushed up even higher if it is subsidised and the State becomes unable to maintain its incentive.

Overall:

- ⬇ Higher equipment cost, limited access for the poorest of the poor, access dependent on micro-credit.

Environmental

Where an existing gas system is improved:

- ⬆ The energy efficiency of the equipment makes it possible to reduce CO_2 emissions and thus contribute to climate change mitigation.

Where a switch has been made from a wood energy system to an improved gas system:

- ⬆ Switching from fuelwood to gas helps reduce wood gathering, thereby limiting deforestation.
- ⬆⬇ LPG is a fossil energy whose combustion generates emissions of greenhouse gases (GHG). In fact, it is not a sustainable environmental solution. Nevertheless, in some circumstances, its impact may prove to be less harmful than that of using non-renewable biomass.

CONTRIBUTING TO CLIMATE CHANGE MITIGATION

Challenges

Energy-efficient equipment generally has an overall positive impact in the fight against climate change.
Where an existing gas system is improved:
In this case, the equipment enables a reduction in fossil fuel consumption and hence a reduction of GHG emissions.
Where a switch has been made from a low-performance wood energy system to an improved gas system:
When wood or charcoal comes from non-renewed sources (forests, coppice, etc.), the appliance makes it possible to replace a non-renewable biomass fuel with a fossil fuel. Both are sources of GHG emissions. However, the gas appliance is more efficient than traditional appliances, so the result is less emission for identical service delivery.

Turning emission reductions to account

However, eligibility for the Kyoto Protocol's institutional and financial framework varies according to the energy source saved. Each case is to be looked at on its own merits.

Where an existing gas system is improved:
Equipment dissemination projects are eligible under the *Clean Development Mechanism (CDM)* arrangement. This fact sheet focuses on small-scale, type II "Energy efficiency" projects, which can result in an energy saving of up to 60 GWh a year for each project.

The AMS-II.C methodology "Demand-side energy efficiency activities for specific technologies" provides formulae for calculating emissions reduction. It applies to projects that provide for the introduction of energy-efficient appliances such as low-energy light bulbs, neon lights, refrigerators, motors, fans, air conditioners, etc. on many sites. Such technologies must replace existing equipment or be installed in new sites.

Where a switch has been made from a low-performance wood energy system to an improved gas system:
To date, there is no approved *CDM methodology* for projects involving a switchover from non-renewable biomass to a fossil energy. The "Switch from non-renewable biomass to lower emissions fossil fuels for thermal applications by the user" methodology has been filed. It is currently being studied by the Executive Board and approval is pending.

Illustration: Dissemination of efficient gas baking ovens project in rural Morocco

Operator: *GERES*
Project status: *Voluntary exchange market*
Type of carbon credit: *VER*
Information source: www.geres.eu
Methodology: AMS-II.C methodology and "Switch from non-renewable biomass to lower emissions fossil fuels for thermal applications by the user," approval pending at time of writing.
Crediting period: 2008-2011 (extension planned)

Context and principle of emissions reduction

This project is being implemented in two communes of Chefchaouen province in northern Morocco. Its key focus is to address energy efficiency problems of the cooking equipment used in rural areas and the ever increasing pressure on forests stemming from wood gathering for cooking.

1. This price difference between gas/biomass will evolve with the depletion of forest cover in developing countries, which will mean an increase in the price of charcoal.
2. Available on the United Nations Framework Convention on Climate Change (UNFCCC) website: www.unfccc.org.

FACT SHEET 1.3

The project is providing for the distribution of 1,250 gas baking ovens between 2008 and 2011, which will replace inefficient wood ovens or older gas ovens. Thanks to this project and to the proposed equipment, users will consume less gas (fossil energy) or fuelwood (non-renewable energy) to bake bread.

ER estimates

According to calculations made using the indicated methodologies, distribution of these 1,250 ovens will turn to account a total reduction of 4,500 t CO2 equivalent from 2008 to 2011.

CASE STUDY

DISSEMINATION OF EFFICIENT GAS BAKING OVENS IN RURAL MOROCCO

Project financed by: Fund raising underway
Scope: Medium-scale project (annual budget from € 50,000 to 200,000)
Operator: *GERES*, through MNED (North Morocco Sustainable Energy)
Main partner: *GERERE*
Secondary partner: A Moroccan micro-credit organisation, a network of gas and oven distributors
Implemention date: 2008-2011
Beneficiaries: Local communities, local development associations, local craftsmen and gas oven manufacturers, local energy-efficient equipment distributors.

Context

Baking bread with a traditional wood oven accounts for over 50 percent of the fuelwood consumption of a rural family in Chefchaouen province. Its performance ratio is about 5 percent, making it one the least efficient items of traditional cooking equipment.
Furthermore, the fuelwood supply/demand balance shows a shortfall of 3.1 million tonnes per year in Morocco. This deficit is unevenly shared among the provinces of Morocco but it is very high in Chefchaouen province where forest destruction is taking place. Forest depletion is making wood gathering by women increasingly burdensome. The project monitored a pilot initiative to distribute 90 high-performance gas ovens from 2006 to 2008. An extension is planned with a goal of 1,200 ovens.

Project activities

Raising awareness among the target population
The traditional wood oven is currently used by over 90 percent of rural families in northern Morocco. Wood gathering is a major activity for every household. Nevertheless, gas cooking is available, and over 15 percent of households us a gas oven on special occasions and in wintertime. Thus, most households are equipped with a 3-kg gas cylinder for food cooking. The wide-scale distribution of improved gas ovens requires a great deal of effort to raise household awareness and help people understand the issues involved with fuelwood. Awareness-raising and demonstration initiatives aim at highlighting the value of such equipment, i.e. the possibility of escaping from the drudgery of wood gathering as well as curbing deforestation.

Supporting the production and distribution of improved gas ovens
The lab study of two brands eligible under the project (Sofacuis and Afifi) showed that potential gas savings amount to about 40 percent if existing models are improved. Models were developed in the lab and tested with volunteer families. Field tests validated the technology chosen for improvement.

Consolidation to prepare for large-scale extension and replication (future)
Specifications have been drawn up. A partnership agreement has been signed with a local gas oven producer (SOMMEDTABE) for the pre-distribution phase. Extension work done by an MNED team member is facilitating promotion/dissemination. The producer takes care of equipment delivery and a local association is in charge of distribution in the douar.

Improved gas bread oven in northern Morocco (©MNED)

Outcomes

The project now underway is about to launch its predissemination phase (August-September 2008). Analysis is going on regarding a financial solution to enable easier access to the equipment. The most probable option is the creation of a fund with the local partner association. Large-scale dissemination will start in 2009, with a goal of 1,250 ovens in Chefchaouen province.

CASE STUDY 2

GAS HEATING FOR PUBLIC BUILDINGS IN AFGHANISTAN

NB: Although this fact sheet mainly deals with the domestic use of gas, the aim of this case study is to expand the introduction of efficient gas equipment to other contexts to better demonstrate its application.

Project financed by: *FFEM* (French Fund for the World Environment)
Scope: Pilot project with a budget under € 50,000
Operator: *GERES*, www.geres.eu
Partnership: *ADEME*, *GTZ*
Implementation date: First six months of 2008
Number of beneficiaries: Currently limited, project in pilot phase (2 hospitals)

Context

Insulation of public buildings in Afghanistan is considered to be quite poor, which is compounded by the fact that the wood or fuel-oil heating systems used in them are notoriously inefficient. The result is an indoor temperature much below European standards during the hard winter, as well as noxious fumes emitted by the fuels used. It is very difficult for hospitals to maintain the minimum temperature required for patients. In such a context, what is needed is to set up heating systems that are more efficient, as well as cleaner for the environment and users.
After several assessment missions, it became obvious that the heating system best suited to the Afghan urban context is the moveable gas stove.

Project activities

Diagnostic analysis of the heating system
The first step of the project was an assessment of locally available heating systems, identification of dealers and their availability. Pre-selection of the heating system(s) that would be recommended was based on this assessment (financial, efficiency, and consumption analysis, availability on the market, fuel availability, heat output, etc.). A number of gas heating systems were pre-selected.

R&D
The second step was a lab test of several models to determine which one was the most suitable. Four models were given a benchmark test. The output, efficiency, and safety of the different systems were assessed based on a protocol aimed at recording temperatures, gas consumption, and CO_2 emissions.
After these tests, the latest Delonghi model proved to be the most satisfactory, given its top rating for efficiency (least energy consumed) and comfort level provided.

In the field
The third step involved two "field" tests. The selected stoves were installed in a Kabul hospital. Control rooms of a size and use similar to the test equipment rooms were also chosen. Consumption and temperatures were recorded in both the test and control rooms. Comments from the users (medical staff and patients) were also collected.
The equipment was also installed in several individual homes where similar data was collected, and households using traditional heating systems were used as a control.

Moveable gas stove, DELONGHI model

Outcomes

The test results for use in public buildings are most interesting. The new heating system improves the comfort level, reduces fuel consumption as well as heating costs. There is an approximately 80-percent reduction of CO_2 emission.

Fuel	Daily consumption (kg / day)	Energy by surface area (kWh/m2/yr)	Cost (€/m2/yr)	CO2 emissions (t CO2 eq./m^2/yr)
Gas	0.9	79	5.7	0.02
Wood	11	59	9.6	0.12
Savings			**40%**	**80%**

Domestic application was also tested, but the results argue against continuing in that direction, mainly because the improved gas stoves are single use. In traditional heating systems, one appliance is used for both cooking and space heating. Getting people to change their habits and accept something new is too daunting a task. Furthermore, energy consumption is not reduced since the traditional stove still has to be used for cooking.

Efficient gas stoves will therefore be recommended for use in public buildings where certain conditions prevail (availability of gas in urban areas, scarcity of wood, rooms small enough and well ventilated, qualified person present to take care of the stoves). In any case, dissemination has to be done in conjunction with an awareness-raising and training campaign to encourage acceptance and correct use of the innovative heating systems.

Photovoltaic battery kits

> **Related fact sheets:** *Fact sheet 3.3 - Small solar and wind power plants*

Access to electricity in rural areas is a necessary condition for access to modern technologies. Electricity is vital for some productive activities, but also for the improvement of living conditions (lighting, telecommunications, etc.). It is therefore a major need in rural communities. But the development of electricity infrastructures poses economic and technical problems, which in many countries rules out the option of an extensive interconnecting grid. Developing decentralised electricity distribution or even power plants for individuals is therefore the way to go. Solar energy is available virtually anywhere, and has a strong potential in countries with little in the way of other resources (such as the Sahalian countries of Africa), and is a possible solution to the problem of rural electricity distribution.

For reasons of technical suitability and cost, specific support programs are needed to promote photovoltaic solar systems. From the standpoint of supply, it is necessary to make available to users complete kits of appropriate size and design, common appliances such as lights must be optimised, and after-sales service provided. The full support of State agencies, companies, and NGOs is legitimately required to develop, produce, and deliver such systems.

ACCESS TO ELECTRICITY IN DEVELOPING COUNTRIES

Electric supply and distribution

In broad terms, there are three major approaches to the supply and distribution of electricity in a country:

Interconnecting electrical power grid

Such a grid is generally developed nationally/internationally and supplied by all forms of fossil or renewable energy. It is a very costly system to set up and is geared to supply areas of high population and industrial density, busy metropolitan areas or manufacturing zones. Extending the grid to rural communities comes only at a very high cost (as was the case in Europe after the Second World War) and it does not usually cover isolated homes.

The cluster or "village" grid

This is a stand-alone grid supplied by a small or average size electrical plant designed to serve a community. Diesel gen-sets are most common, but the plant may also be powered by water, sun, wind, biogas, etc. It generally has a sufficient capacity to supply the domestic and handicraft production sector, sometimes even small-scale industries, with a typical installed capacity ranging from 10 to 1,000 kW.

Power plants for individuals

Batteries recharged on the network, gen-sets, or photovoltaic kits, sometimes even small windmill generators or biogas driven engines power these setups. They are able to meet domestic needs only or self-employment activities (small business or handicraft production with a low energy demand). The generating capacity is typically from 50 to 500 W.

Here, we will deal with systems for individuals, with a more specific focus on photovoltaic battery kits.

Issues regarding access to domestic electricity

Access to domestic electricity is a pressing need in developing countries. Where available at the domestic level, electricity provides communities with:

- A lighting service that far surpasses other means (candles, oil lamps), enabling people to have a longer working day and enjoy a greater level of safety.
- Audiovisual services (TV or radio), giving people information links.
- Battery recharging for both larger storage batteries and those used for cell phones.

Nevertheless, a large proportion of people living in Least Developed Countries (LDCs) have no access to electricity. They live mainly in areas of low population density that may be mountainous or desert-like, or simply communities far away from economic or political centres. Where populated areas are scattered, network connection is a costly affair, and users simply cannot afford it. Where people do not have access to a modern energy source, they use local sources for lighting (wood, candle), although individuals who are better off can sometimes afford generators. But these solutions are getting more expensive (increase in the price oil, gradual depletion of fuelwood) and detract from enjoyment of the living space (forest devastation, toxic fumes or exhaust).

Photovoltaic kits are a means of addressing the two issues of improving energy availability and ensuring the cleanliness and sustainability of its supply.

General principle of a photovoltaic kit

Photovoltaic kits are individual systems in which solar energy is captured for domestic use (lighting, radio, etc.). The system is made up of a solar panel, battery, and regulator and is used in a context of low-energy demand (fluorescent lights, etc.).

The solar panel, made up of photovoltaic cells, ensures the direct conversion of sunlight into electricity. It can generate 6, 12, or 24 V. The energy is rarely used immediately, so must be stored for later demand. One or more batteries are used for this. A regulator is a must because batteries are fragile, which means charging / discharging must be managed in appropriate cycles (batteries must not be overcharged or allowed to completely discharge).

Solar panel in Koury, Mali (©SSD Yeelen Kura)

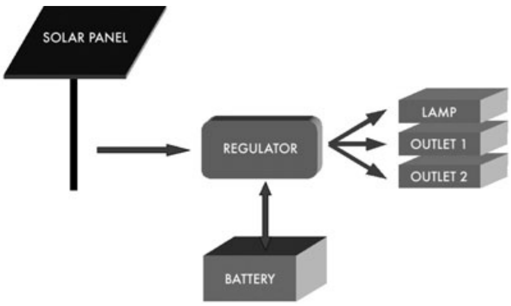

Diagram of a solar kit

Low-voltage current (usually 12 V) is output to the user; thus, low-voltage appliances (12 V) can be operated. However, the use of a transformer allows standard 230 V appliances to be used with a corresponding voltage. In order to keep the production size down, these devices must be optimised (low consumption) so that less energy is consumed while service quality remains equal.

The main weakness of photovoltaic kits is the short life span of the batteries. They wear out even more quickly if the right charge / discharge loads are not complied with. They have to be replaced regularly, and that entails a financial and environmental cost. To avoid negative impacts as much as possible, it is necessary to properly size and design the equipment, train users, and monitor distribution effectively.

Types of photovoltaic kits available

The cost of photovoltaic equipment for individuals is high. For example, in South Africa, a photovoltaic kit with a module capable of delivering 55 peak watts, battery, regulator, wiring, and accessories is marketed for € 550 (including delivery and installation). In Mali, a kit with an output of 28 peak watts that can be used for two lights and a radio goes for about € 530. Given the high capital cost, dissemination programmes for photovoltaic kits generally offer two options:

- Purchase of the equipment:

Users get their kit and appliances (light, TV) by direct purchase or on credit via the program and are responsible for upkeep. This approach implies that users have the financial means and are able to be given basic technical training in equipment upkeep.

- Purchase of a service:

An operator (electricity distribution company, NGO) sells lighting and/or an audiovisual service to customers who sign up or who rent the equipment. The operator provides the kit and suitable appliances but retains ownership. He is in charge of replacement in case of breakdown.

In the event an electricity grid is put in later on, or if the user wants to expand or cancel his contract, the kit can easily be dismantled for use by someone else or resale by the user if he owns it.

Involvement of development stakeholders

Public authorities

Incentives can take the form of a regulatory framework, funding assistance, or tax breaks. Legislation can provide for the institution of technical specifications to shore up delivery of reliable, quality materials. The government may decide to cut tax on photovoltaic equipment (customs duty and/or usually VAT) or implement subsidy measures. Where rural electrification agencies exist, their mission is to promote and coach the dissemination of suitable technology and provide an operational focal point for the public authorities.

Stakeholders in photovoltaic kit dissemination

Project organisers may be found among development operators (NGOs, technical cooperation agencies, local institutions, etc.), as well as private stakeholders. In general, they work under the umbrella of large-scale programmes in which services are delegated (such as a territory concession granted by a government institution, agency, etc.).

DEVELOPING A PROJECT APPROACH

Feasibility study

Market study

A market study focuses on defining the project profile, in particular the number of potential users, their needs, current energy sources and the use being made

1.Unit used to represent the maximum electrical power delivered by a solar electric power system for a standard solar irradiation of 1,000 Watts per m² at 25°C.

of them, and the financial means available. To achieve this, the study is not simply a matter of listing potentially interested persons. It must also seek to understand the expectations, needs, means, and use patterns of future users. The market study is carried out by the project organiser who uses the opportunity to raise awareness of the target group regarding the specificities of electricity generated by a photovoltaic kit (as will be developed further on).

In addition to the selection of services, boundaries must be established for the various action areas. Although the kit can be installed anywhere, it is important to take into account such things as the distance to travel for maintenance and the fact that agents have to be on hand for payment of fees by customers who wish to purchase services. Thus, operators look for a minimum population density in a given area for an installation.

Size and design of the kits and proposed services

Determining the size and design of the kit implies familiarity with the needs of the future users (number of lighting points, type of material to be connected). The next step is to calculate the consumption level of typical equipment and determine the type of installation needed to meet it. Here is a helpful rule of thumb to measure the family's potential energy needs:
- Lighting (10 W light), 3 hours a day: 30 Wh
- Audiovisual (15 W b&w TV and dish antenna), 3 hours a day: 45 Wh
- News (10 W radio), 4 hours a day: 40 Wh
- Cell phone battery: 5 Wh

The daily consumption can be estimated based on the above service definition. Then, a suitable power kit must be selected to meet this need. The energy produced per day depends on how much power the panel can output, the potential amount of sunshine, and battery capacity. A 75-peak watt photovoltaic kit can deliver 270 Wh of energy a day. A range of kits can therefore be offered so as to best meet user needs. Some examples of use:
- Panel power of 60 peak watts: 2 lights and a black & white television.
- 120 peak watts: 3 lights and a colour television

Supporting kit dissemination

Targets:

Individual households

Technical data:

A solar panel has an average service life of 20 years, while that of a battery is about 3 years (with 70 % of its capacity).

Technological maturity:

For decades now, standard PV kits have been available. Automobile batteries are generally used. Although these do not always offer the best technical quality / price ratio, they are nevertheless the most readily available equipment in developing countries.

Essential aspects of project guidance:

- Technology transfer:

The material is rarely available locally, so an initial step would be to set up supply channels (solar panels, batteries, low-energy appliances). The parts are then assembled into kits designed to meet the needs identified.

- Training in equipment dissemination and use:

Training is meant for future users as well as for local technicians in charge of disseminating the equipment on behalf of the private operator or development operator. Two points need to be highlighted: the cost of operating the equipment in terms of replacement, such as batteries, etc., and its proper use (upkeep, not allowing batteries to become completely discharged).

- Making contracts with users and study of a market model:

This component focuses on implementation of a mechanism enabling collection of payment from customers. The project organiser has to find a compromise between bringing a service to the largest number of people and selecting a minimum number of users with a good credit rating in order to guarantee an acceptable collection rate. Consideration can be given to using micro-credit systems to broaden access to this technology and increase the number of users. The users themselves will often do a good job of advertising.

Project duration:

Dissemination of photovoltaic battery kit systems is a mid-term venture (3 years).

Skills required:

Electricity distribution for individual users, battery management, training and capacity building, extension, marketing.

Sustainability:

The sustainability of photovoltaic kit installation projects are predicated on the ability to manage replacement of used equipment items (mainly batteries) and find ways to take on new users. Battery replacement is particularly important and thus funds must be available. In the long run, it is also necessary to take the service life of batteries into account and devise a means of recycling used ones in order to avoid pollution.

Positive and negative impacts, risks

Economic

- ⬆ Creation of a company managing photovoltaic kits (jobs for agents and technicians).
- ⬆ Use of a solar kit can reduce the cost of domestic lighting in comparison with previous costs entailed by the use of batteries, candles or lamp oil.
- ⬇ Initial cost is high for poor communities.

Social and health

- ⬆ Improvement of lighting conditions at night: comfort, safety.

- ⬆ Access to news (radio or TV) and thus to educational programs.
- ⬆ Possibility of servicing health centres with lighting and refrigeration.

Environmental

- ⬆ Decrease of greenhouse gas emissions.
- ⬆⬇Risk of soil or water source pollution due to discarded batteries, but less air pollution (when oil use is discontinued) and soil pollution (when solar cells are used).

CONTRIBUTION TO CLIMATE CHANGE MITIGATION

Issues, turning emission reductions to account

Photovoltaic kits work with solar energy, which is renewable. When used to generate electricity instead of a fossil fuel (diesel, coal, etc.), photovoltaic kits offer a means of mitigating climate change.

Photovoltaic kit dissemination projects are eligible under the *Clean Development Mechanism (CDM)* arrangement where type-I. small-scale "renewable energy" projects are involved, which refers to systems with a maximum aggregate power output of 15 MW. The AMS I.A "Electricity generation by the user" methodology provides formulae for calculating emissions reduction.

Illustration: Photovoltaic kits to light up rural households in Morocco

Operators: *SCET-Maroc* and *GERERE*
Project status: *CDM*
Reduction unit type: *CER*
Information source: www.unfccc.org
Methodology: AMS I.A. "Electricity generation by the user"[2]
Crediting period: 2007-2016

Context and principle of emissions reduction

The average irradiance in Morocco is about 5.5 kWh/m2, which means that solar energy has an important potential. This project is aiming for a distribution of 101,500 photovoltaic kits nationwide for the electrification of rural communities in Morocco.

Each household is equipped with an individual kit including basic items for domestic use (plug-ins, light). Each kit has a daily average energy delivery of 0.45 kWh provided that the system is in full productivity for 6 hours a day. Without the project, the villages where the photovoltaic kits are being introduced would use electricity produced by diesel-fired (fossil fuel) generators.

2. Available on the United Nations Framework Convention on Climate Change (UNFCCC) website: www.unfccc.org.

ER estimates

The greenhouse gas emission reduction obtained with the 101,500 kits installed is estimated to be an average of 38,637 t CO_2 equivalent per year over the 2007-2016 period.

CASE STUDY

DISSEMINATION OF PHOTOVOLTAIC KITS IN SOUTHEASTERN MALI

Project financed by: SSD Yeelen Kura, government of the Netherlands
Scope: Large-scale project (annual budget from € 200,000 to 1,000,000)
Operator: Yeelen Kura (a decentralised service company)
Shareholders: EDF (50 %), NUON (50 %)
Execution date: 1999-2005
Project area: Ségou and Sikasso region, southeastern Mali
Beneficiaries: 1,200 PV kit users (2007)

Context

Yeelen Kura, a decentralised service company (SSD), was established in May 2001. It produces electricity and markets energy services in some 50 villages in the cotton-growing area of Mali, east of Bamako. The services provided are based on the use of photovoltaic kits as well as micro-grids powered with diesel fuel.

Project activities

The services offered by the company focus mainly on domestic use and are based on the delivery of photovoltaic kits that output from 60 to 120 peak watts at the individual household level. Users are bound by contract and pay a set price depending on the specific service provided. The basic offer includes access to lighting for two light sources, with further expansion possible to include three lights and a plug-in for a radio and colour TV.

Example of service delivered (rate before AMADER partnership):

	Service 1	Service 2
Service type	2 lights 1 plug-in of 30 W, 12 V maximum 60 peak watt PV kit	3 lights 1 plug-in of 70 W maximum 120 peak watt PV kit
Price	Connection and guarantee: 21,240 CFA Francs (€ 32.38) Monthly rate: 5,900 CFA Francs (€ 8.99)	Connection and guarantee: 29,500 CFA Francs (€ 44.97) Monthly rate: 9,000 CFA Francs (€ 13.72)

3. Nuon is a Dutch company for the production, transport, and distribution of energy (gas and electricity).

Protected battery (©SSD Yeelen Kura)

Indoor installation with light and TV (©SSD Yeelen Kura)

Outcomes

After six years of activity, Yeelen Kura has over 1,200 users hooked up to a PV kit out of a total of over 30,000 customers. There are more than 30 Malian employees on the company's payroll. Other households are interested in having a kit installed. A number of customers backed out, mainly farmers suffering financially because of the cotton crisis or persons who got a micro-grid connection.

The project is continuing with the installation of new solar kits. The Yeelen Kura Company has received additional grant assistance from the Malian Agency for the Development of Domestic Energy and Rural Electrification (AMADER), giving it the means to buy 400 kits. After receiving this subsidy, Yeelen Kura agreed to lower its rates. In partnership with *GERES*, Yeelen Kura is setting up an activity chain for the processing / recycling of its used batteries.

For more information

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SECTION 2

ENERGY AND BUILDINGS

It was decided to devote this section to buildings in cold regions, therefore excluding tropical, subtropical, and desert regions. For the poorest of the poor in cold regions, achieving a satisfactory level of comfort entails a very high cost in terms of energy used and money spent for heating. Buildings in hot climates are often very uncomfortable because of not being equipped with air conditioning or other cooling equipment, but in this sense they are not major contributors to the climate change equation, except for the wealthier members of communities and operators of commercial buildings.

Different approaches are proposed depending on whether individual homes or public buildings such as hospitals, schools, and service industry buildings (business offices, factories, etc.) are involved. Based on the type, the building materials and durability differ, as well as the needs and sources of energy for heating.

Energy used for heating may be of fossil origin (public and service industry buildings) or of the biomass energy type (dwellings). The thermal engineering of buildings is often poor and much heat is simply wasted. Heating entails costs and/or an expenditure of time and energy to scavenge for wood or burnable waste (brush, dung, etc.), as the case may be. Heating energy may furthermore have an impact on the environment and climate when the fuel type is sourced from the *non-renewable biomass*.

There are currently a number of technical alternatives that help mitigate these energy problems. Improved building energy efficiency and use of solar power in complement to traditional energies used will be developed in this section. These initiatives are a fundamental engine for human development. For home use, they improve the comfort level, reduce the heating bill and/or lessen the grind of having to go out and scavenge for wood, and thus can help families expand handicraft production during the cold months. More generally, these approaches contribute to environmental protection and thereby to combating climate change.

Bioclimatic architecture in cold regions

A lack of funding, available materials, or skills often results in a problem of poor quality buildings in developing countries. In cold regions, the thermal insulation of buildings often proves to be far less than adequate. Additionally, in order to heat a building, payment must be made for fuel and/or time spent to go out and gather wood, as the case may be. Furthermore, the fuel used for heating may have an impact on the environment when the fuel is sourced from the *non-renewable biomass*.

Enhancing building energy efficiency and thus cutting down on the need for fuel is a significant challenge for developing countries. For this reason, bioclimatic architecture is of particular interest in cold regions. With upstream planning of the building's physical orientation, its design, and insulation, it is possible to reduce the need for heating energy and thus scale down fuel consumption. Bioclimatic architecture can also make a building more comfortable to be in and healthier for its users.

Two types of building will be dealt with in this Fact Sheet: public (or general service) buildings and rural dwellings. The challenges differ from one type to another and require an appropriate approach. Two case studies will be presented to fully bear this out.

BIOCLIMATIC ARCHITECTURE IN DEVELOPING COUNTRIES

The constraints of heating

Least Developed Countries (LDCs) located in cold regions, frequently with mountainous terrain, are greatly challenged by the problem of heating buildings in winter.

The poor quality of heating systems, the loss of ancestral architectural knowledge, and the use of modern materials that are cheap but inefficient from the standpoint of heat engineering (cement and the like), mean that heating dwellings and public buildings requires a great deal of energy and therefore high fuel consumption.

Public buildings are faced with high heating costs; for dwellings, women have to spend much time out scavenging for dung or tree branches.

Creeping desertification coupled with the fact that such regions are often isolated means that fuel is increasingly rare and comes at an ever-higher cost. In winter, the fuel shortage together with the poor quality of buildings means that a proper level of heat cannot be achieved. Temperatures rarely go above 12°C in both public buildings and private dwellings.

Overview of bioclimatic architecture

Bioclimatic architecture is a way of designing buildings and manipulating the environment within them. This is accomplished by balancing the design and construction of habitat with the climate and environment, as well as the life pattern of their inhabitants. It can be used for many types of buildings, those in the construction stage as well as older buildings for which renovation is contemplated. It frequently involves a revival of ancestral concepts. The target of a renovation job or building venture must also fit in with the local cultural context with regard to both aesthetics and functionality.

The aim of bioclimatic architecture is to cut heating needs, which may result in a reduction in fuel consumption of 50 % or more, along with an increase in temperature of several degrees. Put another way, a significant increase in temperature is achieved for the same amount of fuel consumed.

Bioclimatic architecture in cold climates makes it possible to achieve a saving in energy use by maximizing heat that can be gleaned from the sun and minimising heat loss. A number of techniques are available, but the general principles remain the same: capturing and using energy from the sun, and conserving heat.

Capturing and using energy from the sun, and conserving heat

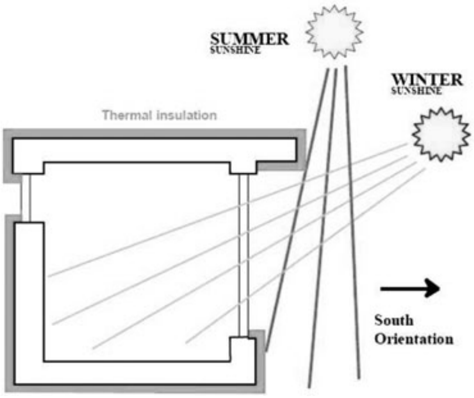
Capturing energy from the sun is achieved through a proper configuration and orientation of a building as well as the addition of components that promote heat gain. Sun energy capture is optimised if buildings are designed asymmetrically to capitalise on their southern exposure and having large windows put in on that side, while limiting the northern exposure. The layout provides for larger rooms to be located to the south and secondary rooms to the north.

Putting an "attached greenhouse" on the south side of a building can contribute to its passive heating with energy from the sun (see Case Study). Another arrangement is the "Trombe wall," a dark-coloured wall covered externally with a double-glazed panel. Solar radiation passes through the glass and is absorbed by the wall. The wall picks up heat during the day and releases the warmth to the interior during the evening and night hours. However, this is not necessarily an aesthetically pleasing alternative.

Attached greenhouse on a dwelling in Afghanistan

Heat distribution is achieved by means of the "thermal mass," which may be one of the components of the building (floor, wall, covering, partition) with the capacity to store heat during the day and release it during the night. The capacity of the thermal mass depends on its thickness and the material it is made of (sundried brick, earth or stone, clay, ceramics). A good thermal mass is one that brings the temperature up to a comfortable level through the gradual delivery of heat at night as the outside temperature drops.

Heat is conserved by means of insulation (roof, wall, floor) and by the use of double-glazing and cover curtains during the night. In summer, overheating can be prevented by putting up a roof overhang to block off the sun's rays.



Importance of proper building configuration

New buildings that are put up in keeping with these rules are more efficient than renovated (or rehabilitated) buildings. Much of the efficiency depends on the design of the building and its orientation, which are unchangeable once the building is up. Insulation can be used in all types of buildings, but techniques to capture solar energy apply only to buildings with a southern exposure. In an urban setting, obstructions and street layouts may make it difficult to apply techniques of capturing energy from the sun.

NB: The southern and northern orientations described here apply to buildings in the northern hemisphere. This is inversed in the case of buildings in the southern hemisphere.

Implementation contexts

Two cases have been selected for study in this Fact Sheet.

Public or general service buildings

Public or general service buildings have a high capital cost because the building materials are often "modern," such as concrete and steel. Fuels are those commonly marketed such as natural gas, fuel oil, coal (fossil fuels) or wood. The cost of heating such buildings may be very high. Thus the heating budget of a hospital can be as much as 20 % of its total operating budget. Such buildings are most often used during the day, rarely at night, except for hospitals. One good approach to capture solar energy directly is to put in bay windows on the southern exposure.

Rural dwellings

In rural areas, the occupants themselves often put up dwellings using locally available materials and the services of local tradesmen (carpenters, masons). Heating is most frequently provided by burning wood or dried dung gathered in the environs (ordinary forest or coppice forest), to which there is generally access at no cost. Gathering can take several hours a day and require travel over long distances. In this case, a modification of the dwelling may enable families to cut down on the gruelling workload and time spent at it. Any unused dung can be used for soil improvement. Dwellings of course are for both day and nighttime use. Where a solar energy capture system is used, the heat is stored during the day in the thermal mass (walls, partitions) and released during the night hours.

Role of the public authorities

The public authorities would generally be responsible for disseminating among communities, institutional stakeholders, NGOs, and private companies the concept and techniques of bioclimatic architecture so that they become the construction standard. Institutional coaching will be illustrated by one of the case studies hereafter.

DEVELOPING A PROJECT APPROACH

Feasibility study

Pre-selection of intervention sites

Renovation or new construction projects that will use the principles of bioclimatic architecture in cold regions are of particular value where a number of factors come into play:

- Very cold zones (long, hard winters) where heating needs are extremely high.
- Zones where there is a shortage of biomass fuels, leading to forest destruction and/or desertification.
- Isolated zones where fossil fuels are used. Problems involve the long, costly, and cumbersome transportation chain used to get fuel in, which itself requires high energy input.

The above three factors are not at all uncommon, and some zones suffering from extreme cold are virtually desert-like and cut off from the main stream. Projects are most welcome when a number of factors can be addressed on a large scale.

Finding ways to cover the capital cost

Building construction or renovation using bioclimatic techniques will entail supplementary costs about 10 % above traditional techniques. The study will need to analyse what input is available from the project beneficiaries (public authorities, local authorities, individual households) in terms of covering the capital cost, and then formulate proposals for a funding package in the form of loans, grants or micro-credit.
Where dwellings are involved, the study will look into access to materials (those available locally, either sold commercially or obtainable by bartering) as well as self-help, traditional and modern loan systems. Target groups are identified (communities, local authorities, business people, craftsmen) to be included in the survey process.

Characterisation of available skills and materials

Once an intervention site has been selected, stock must be taken of the skills base and tradesmen available in the zone. Urban centres may have construction companies, while rural zones may have tradesmen that work on a small scale. These people will be the focal point for disseminating bioclimatic architecture techniques and can be given training as one of the project components.
Attention must also be given to the local availability of materials, including those to be used for insulation. There is sometimes a risk of creating competition for the use of a material, straw, for example, which is an efficient insulating material often recommended to reduce heat loss in dwellings. But straw is also important in animal husbandry (forage). So the potential for competition between different uses of a material is something that must be looked for in the feasibility study.

Using bioclimatic architecture in a renovation or building project

Targets and stakeholders to get involved:

For public or general service buildings, the project will target the concerned ministries for a standard design, as well as for planning and organising the construction process. It will also involve construction companies and small-scale manufacturers of insulating materials who need to be informed about and trained in these new technologies.
With regard to dwellings, the project will target masons and carpenters who will assist families to work with the techniques. An effort will be made to involve community representatives who will play a role in project promotion, alongside small businesses that supply materials in isolated zones.

Functionality, performance:

When the above principles are applied, the following results may be achieved:
- A reduction of heating needs as high as 70 %.
- A 5- to 15-degree increase in building temperature.

Technological maturity:

In developed countries, bioclimatic architecture and technology are routinely implemented and constant improvements are being made in this field. But the applications are relatively costly and not well suited to developing countries in which bioclimatic technologies are in a state of constant flux.
What is therefore needed is an adaptation of the new technologies developed in the West, with a simplification of techniques and a drastic reduction in costs, along with an effort made to "rediscover" ancestral techniques that have fallen by the wayside for various reasons (sustained conflict, influence of "modernism"). Adaptations, research, and enhancements will be needed to get optimum efficiency from the technology, reduce its cost and promote integration into the local setting. These efforts will give attention to natural, locally available insulating materials (cotton, sheep's wool, dung, rushes) or the development of building materials with insulating properties using simple procedures (mud and straw brick, packed earth).

Essential aspects of project guidance:

A renovation or building project involving bioclimatic architecture has many steps, including awareness raising, technology transfer, training, and support for supply channels of materials. The key steps are as follows:

- Establishment of demonstration sites to disseminate the concept and techniques:

Bioclimatic architecture is based on technology that is unfamiliar to most of the communities for whom it is intended, so it is difficult to introduce it without an upstream information campaign, training sessions, and demonstrations. To convince future users of the value of this type of construction, one of the most effective approaches is to set up demonstration buildings. These should be selected from among those most used by people in the community (community houses, strategic locations in markets, dwellings of community spokespersons, dwellings near places of worship). The demonstration sites should be places that readily lend themselves to frequent visits, with the users themselves making the presentation.

-Technology transfer with tradesmen, development of micro-businesses:

The technology used will generally be something of a novelty for the target communities or partners. It is therefore crucial to ensure a transfer of technical knowledge so that the tools can be properly disseminated. The main focus will be building managers, technical crews in particular, and local tradesmen (carpenters, masons).

After gaining hands-on experience on a number of construction sites featuring bioclimatic techniques, these stakeholders should be in a position to handle them on their own from size calculation and designing to project completion. They will become familiar with the various possible choices in regard to engineering, materials, suppliers, finding "customers," and facility maintenance.
In rural communities, craftsmen will be targeted to help families do their own home renovations. Where a larger work site is involved, such as a public building, work will be done using building companies.

Greenhouse under construction

- Awareness-raising campaign in regard to renovation and construction, promotion of acquired know-how:
As a complement to the demonstration site, it is always advisable to raise the awareness of the stakeholders with regard to building energy efficiency and the financial savings and comfort enhancement that are thereby made possible. The use of communication tools (folders, outreach meetings, etc.) is a way of disseminating these concepts and promoting the newly acquired skills of tradesmen who have attended training sessions.

- Maintenance training (for passive solar installations):
One of the technologies for private homes that can be transferred to public buildings is the addition of a wood-frame veranda covered with plastic sheeting on the southerly exposed façade of a building. The plastic covering, removed in summer to avoid overheating, will need replacing from time to time. The job is simple, but requires some skill just the same and users need to be trained in how to perform it. The choice of the plastic cover is also important, because it is the key to achieving the best results as far as the service life and cost-efficiency equation is concerned. It is of paramount importance to provide users with training in the maintenance of attached greenhouses.

- Developing the materials market:
Conventional insulating materials are rarely available in remote regions and are of middle-of-the-road quality in urban centres. To ensure project sustainability and replication, it is important to have a supply of these materials (polystyrene, fibreglass, plastic) available. Insulating materials are often a source of pollutants. This entails working up a recycling channel in parallel with the market. Natural insulating materials (straw, dung, cotton, wool, rushes) that are locally available may rarely be used as insulation or building materials. The developer therefore has the dual task of promoting use of such technology but not creating an imbalance in the existing markets.

- Monitoring and evaluation:
Monitoring and evaluation include the energy components and social factors, along with impact studies. A specific, thorough energy monitoring process (temperature, fuel consumption, and comfort) is necessary. It must focus on renovated buildings and comparable traditional buildings. A field monitoring session may be required to make a correct assessment of things if specific, reliable theoretical data are unavailable.

Project duration:

The average length of a project is from 3 to 5 years. As a guide, the first year would include a diagnostic analysis of buildings. The second would be devoted to arranging partnerships and putting up demonstration buildings. During the third year, actual building and/or renovation jobs can be undertaken, with monitoring and dissemination operations taking place during the fourth and fifth years.

Skills required:

Architecture, civil engineering, materials engineering, rural development, building heat transfer technology, economic evaluation, community development, microfinance.

Positive and negative impacts, and risks

Economical and social

Overall

⬆ Marked increase in inside building temperature.

For dwellings

⬆ Significant reduction of household heating expenses (as much as 70 %). This is the main wintertime expenditure where fuel is purchased.
⬆ Reduction of time spent gathering fuel, which time can be spent in other activities.
⬆ Increase the time potential for handicraft production activities (improved comfort).
⬆ Development or specialisation of existing trades (carpenter or mason).
⬆ Less illness caused by cold or smoke from heaters or furnaces, especially for children.
⬇ High cost of renovation, which may require the development of suitable financial tools, such as microcredit.
⬇ Maintenance costs may sometimes be very high for users.

Public or general service buildings

⬆ In the long run, reduction of heating costs for public buildings.

- ⬆ Increase in comfort for users (patients, school children) and staff.
- ⬇ High cost of renovation for local authorities who often work with limited budgets and have other priorities.

Environmental

For dwellings

- ⬆ Takes pressure off natural resources given the reduction in consumption of wood fuel.
- ⬆ Reduction of greenhouse gas emissions from consumption of fossil fuels or fuels for heating sourced from the *non-renewable biomass*.
- ⬇ Where natural materials cannot be used, it is necessary to introduce materials that sometimes have a polluting effect (plastic, polystyrene, fibreglass) and that require the establishment of a recycling channel.

CONTRIBUTING TO CLIMATE CHANGE MITIGATION

Challenges

Bioclimatic architecture has a mitigating effect on climate change by cutting down on the consumption of fossil fuels or energy derived from the non-renewable biomass. It is particularly relevant if the project implementation zone is already desert-like or being affected by desertification. The fuels used for heating buildings are fuel oil (in a minority of cases) or fuel from the biomass that is either gathered or purchased (brush, wood, dung). Where reduced consumption is achieved for heating purposes, there is a saving of fuel and a reduction in *GHG* emissions.

Turning emissions reductions to account

Bioclimatic architecture projects are generally eligible under a *Clean Development Mechanism (CDM)*. There is interest in small-scale, type–II. CDM projects which include energy efficiency projects. The AMS-II.E "Energy Efficiency and Fuel Switching for Buildings" methodology[1] outlines the formulae for calculating emissions reduction.

Illustration: Moldova energy conservation and greenhouse gases emissions reduction

NB: The thrust of this project is putting energy-efficient technologies in buildings in cold areas. Although it does not involve bioclimatic technologies per se, it illustrates the importance of saving energy in buildings as a means of fighting climate change.

Project status: CDM
Source of information: CCNUCC, www.unfccc.org
Carbon credit: CER
Methodology used: AMS-II.E Energy Efficiency and Fuel Switching for Buildings and AMS III.B Switching Fossil Fuels
Crediting period: 2006-2015

Background and principle behind emissions reduction

Moldavia has a temperate continental climate. Winters are of medium intensity and short, while summers are long and can be very hot. The mean annual temperature is 8-10°C, depending on where one is in the country. The coldest month is January, with an average temperature of about 5°C. Many public buildings are of inferior quality from the standpoint of heat engineering and poorly suited to the wide temperature range. Much heat is lost in winter.
The project calls for the renovation of 32 public buildings (hospitals, schools, etc.) to enhance energy efficiency (insulation, window and door replacement). The result will be a reduction of fossil fuels (fuel oil, coal, and natural gas) consumed to heat the buildings.

ER estimates

Between 2006 and 2015, an average saving of 11,567 t CO_2 equivalent a year is forecast for the 32 buildings.

1. Available on the UNFCCC website, www.unfccc.org.

FACT SHEET 2.1

CASE STUDY

INTRODUCTION OF PASSIVE SOLAR SYSTEMS FOR DWELLINGS IN AFGHANISTAN

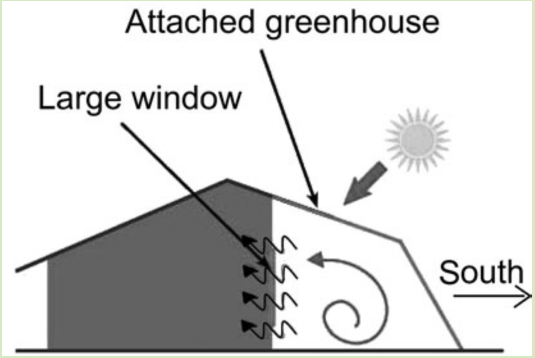
Project funded by: European Commission
Scope: Medium scale project (budget from € 50,000 to 200,000 per year)
Operator: *GERES*
Partner: MADERA
Implementation date: 2007
Number of beneficiaries: 50 direct family beneficiaries (approximately 350 persons)

Context

The two districts of Behsud in the Afghan Hazarajat hinterland are in a very isolated, quasi-desert mountain area (a three-day drive from Kabul or a day and a half from Bamyan). Villages are scattered throughout valleys that are difficult to access and located at altitudes varying from 2,500 to 3,500 metres. These regions experience very long, tough winters, with the temperature dropping as low as 30°C, paralysing the region and its inhabitants for over five months each year. Heating is a real challenge. Wood is very scarce, and the most frequently used fuel is a dried dung and straw mixture, along with brush collected in the "neighbouring" mountains. Brush gathering actually requires a walk of several hours, and each year the distance becomes farther. In this setting a bioclimatic architecture project for dwellings was put forward.

Activities implemented by the project

A greenhouse attached to buildings is a special application of bioclimatic architecture. The wood frame covered over with a plastic tarpaulin enables a considerable heat gain while limiting losses. The new room thus created becomes a pleasant, warm space. To help get warm air from the greenhouse into the house, windows must sometimes be enlarged and renovated. Typically, such windows are of poor quality, with a space between the wooden frame and wall or no sealing strips, which downgrades the insulating of the house. Putting in a second pane of glass or double-glazing is another way of limiting heat loss and reducing heating needs. The roof is also insulated with a layer of straw or sheep's wool between the wooden joists. On the average, a full renovation job with the capacity to heat two rooms costs € 330 (Kabul, 2008). The attached greenhouse alone comes to € 230 (10 m × 2 m).



How a passive solar system works

Dwelling with a passive solar system installed

Outcomes

When the outside temperature is -10° C, the temperature inside the house doesn't get lower than 20° C, even during the middle of the night, while a traditional dwelling virtually never gets warmer than 10° C. The consumption of fuel for heating is cut in half on the average. This project was widely accepted by the members of the community. It is a sustainable project, as shown by the fact that some people were seen replicating it themselves on their own homes during the second year.

CASE STUDY

ENERGY CONTROL IN PUBLIC BUILDING CONSTRUCTION IN AFGHANISTAN

Project funded by: *FFEM* (Fonds Français pour l'Environnement Mondial)
Scope: Large-scale project worth € 13 million, 11.65 for capital costs
Programme coordinator: *ADEME*
Field operator: *GERES*
Afghan institutional partners: *NEPA*, Ministry of Public Health, Ministry of Energy and Water, Ministry of Education
International partners: *BMZ, GTZ, DED, USAID*, World Bank, Asian Development Bank; *UNEP, UNOPS, UNDP, IOM*
Private sector, NGO: *TMF, AEP*, Afghan local communities (Shura), CARITAS Germany, Ibn Sina, KROA, AFRANE
Project duration: 2006-2009
Targets: 100 buildings featuring bioclimatic architecture (schools, clinics), 350 engineers trained, 2 demonstration buildings accessible to the public, over 200,000 direct and indirect beneficiaries.

Context

Over 148,000 hectares of woodland were wiped out in Afghanistan between 2000 and 2005. The price of a kilogramme of wood quadrupled in six years and stands at € 0.65 per ser (Afghan unit amounting to 7 kg) as of 2008. Hospitals and clinics are currently under-heated due to the lack of means, and this despite the fact that over 30 % of the operating budget is allocated to the cost of heating. Schools are not heated at all and are forced to shut down in winter, which results in a crippling of the school curriculum. Reconstruction projects call for the completion of 5,000 schools and 400 clinics throughout the country over the next four years.

Activities implemented by the project

Building construction:
The project calls for the construction of pilot buildings. Heat engineering simulations will be conducted in order to better prepare for new building construction.

Training and capacity building:
The training sessions will centre on the introduction of insulating techniques and dissemination of good practices. Their principal focus will be construction industry stakeholders.

Support to materials suppliers:
The project has a component to promote development of the market for insulating materials and efficient heating systems. Priority will be given to the development of supply chains for local, natural insulating materials.

Communication on the theme of energy efficiency:
The awareness-raising component is geared to policymakers to make them conscious of the need for building energy efficiency. Contractors will be targeted to acquaint them with new construction technologies.

Provisional outcomes

Some 264 buildings (165,000 m^2 of liveable space) are now in the construction or renovation phase; although the initial target was only 100 buildings. Much yet remains to be done to have this new savoir faire become part of public policy in the most concerned ministries and to enlarge the activity sectors (commercial sector).

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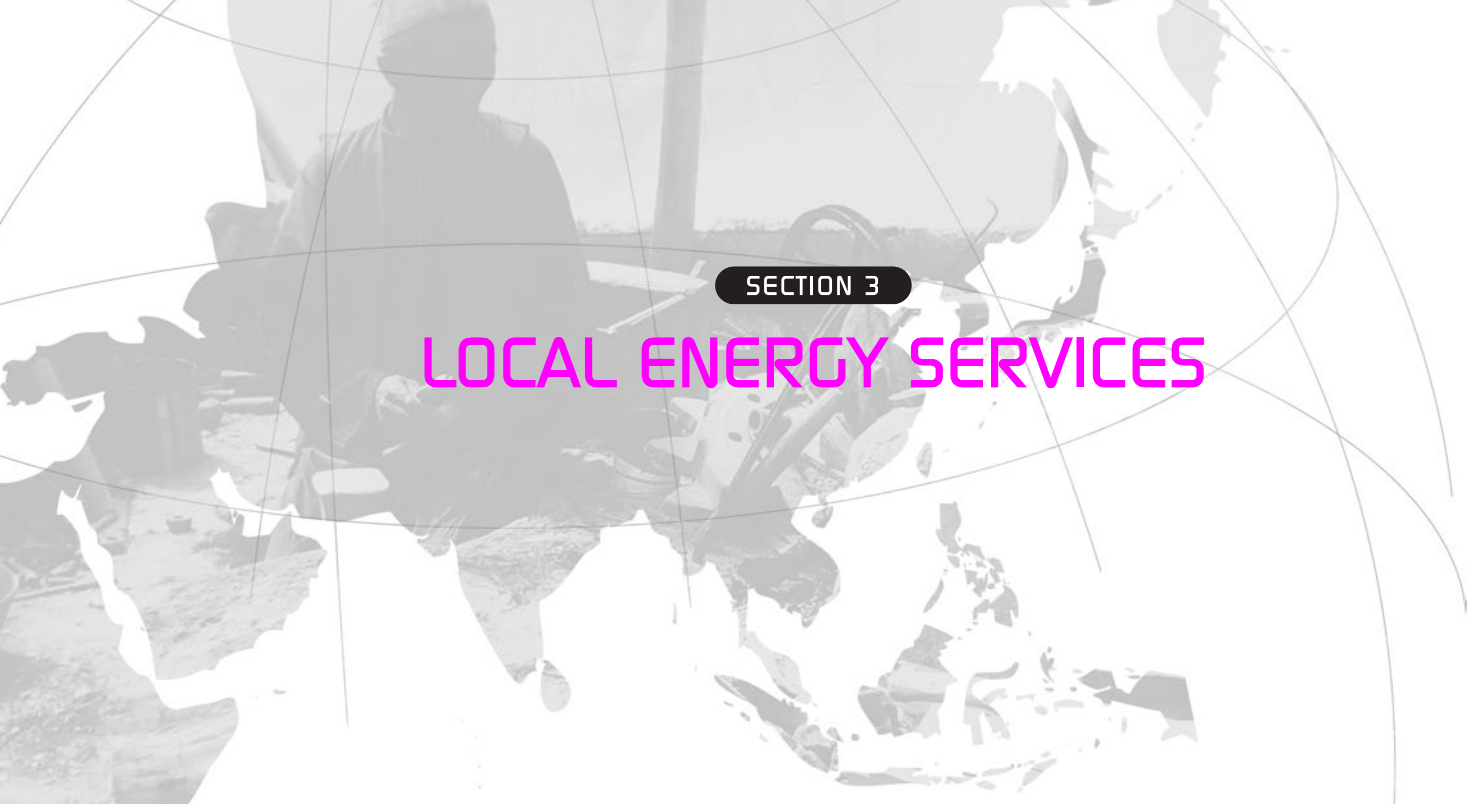


SECTION 3

LOCAL ENERGY SERVICES

People living in developing countries suffer from limited access to energy, notably in poor, remote, locked-in zones, and more frequently simply because of the spiralling price of fossil energy. Yet, energy is crucial at the household level just as it is for the development of economic activities. Thus, processing of agriculture productions, making handicrafts, and supplying services for businesses or public amenities (heat, lighting) all demand productive energy. These activities are conducted for the purpose of making money, which makes them an important first step in the climb out of poverty.

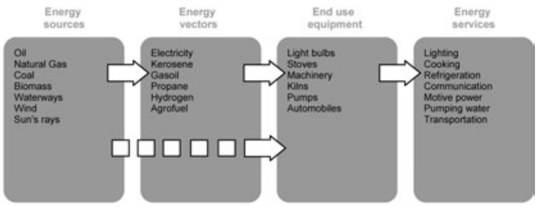
The purpose of this section is to introduce examples of how "energy services" can be made available to communities, small and medium size businesses (SMEs) and/or public amenities (as the case may be) in developing countries (sometimes referred to as countries of the South). Operations are generally designed to achieve several different objectives: put affordable energy services in place and enhance energy efficiency (equipment). Wherever feasible, such services are operated through the use of renewable energy forms (solar or wind power, agrofuels, etc).

ENERGY—AN ESSENTIAL DEVELOPMENT DRIVER

Notion of energy services

Energy services are the last link in what is commonly referred to as the "energy chain," which encompasses the collection of energy resources, in some cases conversion into energy vectors, until arriving at the final stage when the product can be used.

Energy services likewise include the channels that supply both the energy itself and the appliances that require energy to operate. Examples are lighting, heating for cooking food, house heating, energy for transportation, pumping water, powering a mill, and a number of other utilities such as telecommunications that are made possible by different kinds of fuel, electricity, or mechanical energy.



It is important to understand the notion of energy services and to make a distinction among different types of energy sources. From the viewpoint of a consumer in a village, an SME or a public amenity, the important thing are availability and accessibility of the service, not its source per se. Services that meet these needs have the potential of contributing to poverty alleviation.

Productive energy: issues and impacts

Productive energy requirements at the local community level are many:

- Access to water for drinking and agricultural activities.
- Processing and preserving agricultural products (cooking, drying, refrigeration). These needs are common to individual farmers, processing co-operatives, and small or medium size agro-industries.
- Production of construction materials such as bricks, essential for the growth of towns and cities.
- Enabling a business or public amenity to provide services: kitchens in public amenities, Hammam bathhouses, etc.
- The performance of small handicraft-making operations requires the use of various machines: drills, grinders, sewing machines, welding units, etc.

In the poorest areas, energy is still basically supplied by human or animal labour, or it may be sourced from the biomass in the case of heat needs (wood, agricultural waste, etc.).

The use of biomass energy places excessive pressure on the natural environment if the source (forest, coppice or spout forest, or savannah) is not renewed. When the energy source is a fossil fuel (natural gas, petroleum products), the steady increase in its price is an additional obstacle. And the use of such energies is not sustainable because they are only available in limited quantities in the mid-term.

Overall, energy is being used in an inefficient manner because equipment is badly adjusted or run down from use and there are no means available to repair or refurbish it. The lack of access to modern energy services that feature clean energy and high-performance equipment is a hindrance to improving productivity in developing countries.

ISSUES FOR DEVELOPMENT STAKEHOLDERS

Areas of intervention

Development stakeholders are faced with a broad array of objectives. Some of them include expanding the supply of energy services for communities and small-scale handicraft producers, especially via access to electricity. Not to be overlooked is the desire for SMEs and public amenities to reduce their power bill. And a further important consideration is limiting the environmental impact caused by the use of biomass energy.

This brings two key operational scopes of action:

• Improve energy efficiency.

To achieve this, development operators must seek to promote equipment that is affordable, reliable, and properly suited to the productive uses of energy.

Fact Sheet 3.4 - Heat needs of small enterprises and public services;
Fact Sheet 3.5 - Multifunctional platforms.

• Vary available options by promoting sustainable energy supply channels.

This operational pillar is achieved by ensuring technology transfer and making investment in new devices that make it possible to:

- Set up renewable energy channels.

Fact Sheet 1.1 - Fuel-efficient cooking ;
Fact Sheet 3.1 - Local production of agrofuels;
Fact Sheet 3.2 - Small and micro water power stations;
Fact Sheet 5.5 - Sustainable charcoal production

- Get value from waste and residues.

Fact Sheet 4.1 - Charcoal briquettes from agricultural residues

ENERGY SERVICES AND CLIMATE CHANGE MITIGATION

Impacts on the climate differ depending on the energy source that is used by energy services and its energy efficiency level. For an identical quantity of energy output, coal is the greatest source of greenhouse gases, followed by petroleum products, natural gas, and non-renewable biomass.

There are two meaningful ways of contributing to climate change mitigation, both of which are currently eligible under the *clean development mechanism (CDM)* arrangement:

• Reduce the use of a fossil energy source—one that is non-renewable—by the introduction of energy-efficient equipment.
• Switch from a fossil energy source—energy captured from the non-renewable biomass—to a renewable source.

How to take advantage of this eligibility will be illustrated through the different fact sheets that follow.

Local production of agrofuels

> **Related fact sheet:** *Fact sheet 3.5 Multifunctional platforms*

Agrofuels are the subjects of a recent craze due to the oil price increase and because they are seen as an alternative energy enabling to fight climate change. Nevertheless, their large scale development following an industrial model generates an important controversy, which highlights the potential negative impacts in Southern countries. Furthermore their efficiency to fight against climate change is often questioned.

Nevertheless, in the frame of locally developed productions, where access to energy is limited since the area is too isolated or the cost too high, agrofuels represent an opportunity for electricity production and the implementation of production services (cereal threshing, water pumping). These services are crucial for the development in Southern countries. Therefore, international solidarity organisations have to encourage a local development approach. This fact sheet thus focuses on the local production and use of straight vegetable oil. The aim is to offer a better access to energy to rural populations.

AGROFUELS AND ENERGY ACCESS IN SOUTHERN COUNTRIES

Agrofuels in general

An agrofuel is a fuel made from renewable, non-fossil organic materials. First generation agrofuels range from:

- Straight vegetable oils (SVO): made from oil plants' seeds or fruits such as rapeseed, palm oil, soy, jatropha curcas, etc. SVOs can substitute diesel fuel . It requires a mechanical conversion of the engine (stationary or mobile).
- Biodiesel: made from SVOs or animal oils or wastes of oils transformed by a chemical process called transesterification. Biodiesel can be used without prior modification of the engine.
- Ethanol, produced by fermentation of vegetable crops such as sugar cane, beet, corn and manioc. Ethanol is mixed with gasoline.

Agrofuels of second generation, i.e. which are technologically advanced, are currently under study. For instance, they are based on the decomposition of cellulose under enzymatic control for the production of ethanol or the production of oil from micro-seaweed for the manufacture of biodiesel. The development of these productions, on the date of the handbook's publishing, is at the stage of research and is not marketed yet.

Large-scale agrofuel development limit

Initially promoted as renewable source of energy in substitution of fossil fuels, agrofuels thus theoretically prevent *greenhouse gases (GHG)* emissions and reduce energy dependency. They are the subject of a recent craze in the face of oil price increase and in search of energy source diversification. Many governments have established ambitious development policies in this sector[1], which generally implies the development of industrial scale production modes. These policies are nowadays strongly disparaged.

Indeed, the relevance of agrofuel alternative without prior asserted aim of consumption reduction is questioned (mainly in industrialised countries).

Moreover, the energy balance of some productions show that the impact on climate change is reduced since GHG emissions linked to the production of agrofuels (irrigation, inputs, transportations, process, etc.) are almost as important as the reduction linked to the substitution of a fossil fuel.

Finally, knowing that part of agricultural lands available for the production of energy crops are to be found in Developing Countries (DC), these thus become production places and important potentials for industrialised countries. And yet, there is nowadays a large controversy over the potential negative impacts of the large scale cultivation of land for energy purposes. In addition to the obvious competition over food safety, this phenomenon generates environmental impacts and risks of conflicts over land use, which have already been observed in the past with other intensive agricultural models.

The agrofuel production and use modes are therefore to be considered very cautiously.

1. Thus, the European Union has set a substitution objective of 10 % by 2020 in the transportation sector; which is now strongly criticised

Why local productions?

On the contrary, locally produced agrofuels can provide an opportunity to improve access to energy and reduce energy poverty of developing countries' populations.

Indeed, the productive and economic activities in rural areas suffer from a limited access to energy. Due to a low electrification rate and to the lack of efficient energy equipments, cereal threshing, milling or grinding and water pumping are done by hand. Sometimes, when investment is possible, stationary diesel engines are used. In a similar way, electricity production in remote areas is generators-based. The final sale price for one kWh is often outrageous. The increase of fossil fuels' price is then an additional curb to the perpetuation and the dissemination of these energy services.

Local production and use of agrofuel represent an opportunity to develop energy services where they have disappeared or have never been implemented due to a cost too expensive.

Local production means that a local agrofuel is produced for local use and the benefits return to rural populations. Straight vegetable oil often appears as a symbol of these productions since it is obtained through a quite simple expelling mechanic process from seeds and then through settling/filtering. The "short circuit" approach aims at optimizing production costs and small producers are then at the heart of the production.

The production models described hereinafter are part of a sustainable approach and take into account the negative impacts mentioned before. This fact sheet will focus on the production and use of straight vegetable oil made from jatropha curcas seeds.

Rationales of these productions (jatropha curcas)

Jatropha curcas oil plant

Jatropha curcas, also called pourghere in French-speaking countries, is one of the oil plants presenting a great interest to many development organisations for the production of local agrofuels.

Jatropha is a small tree from the Euphorbiaceae family. Not demanding, it can grow in sandy, dry or degraded soils, contexts in which the production of seeds persists, even if it's poor.

In a plantation, the seed production begins at 18 months and the best yield is reached at 6 years, with two harvests per year. In average, these seeds contain 30 to 35 % of non-edible oil with a calorific content of 40 MJ/kg (against around 44 MJ/kg for diesel oil). Viscosity is more important than that of diesel oil. That's one of the reasons why engines have to be adapted to be able to work with jatropha oil without being damaged.

Bibliography references on yields still reveal a great lack of knowledge of the performance of the culture, data going from 1 to 7 tons of seeds per hectare without specification of cultivation conditions. When planted in hedges, the yield should be of around 0.8 to 1kg per linear meter.

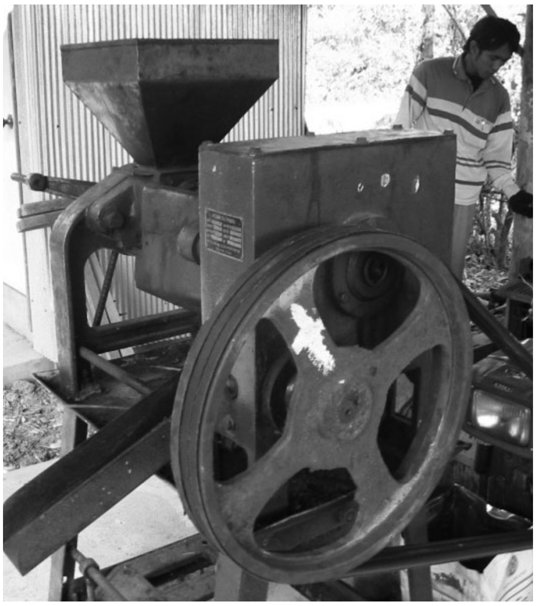
Many parameters are still unknown on the true performance of jatropha curcas plantations, in particular regarding the type of planted variety, the technical itineraries, the need for irrigation or not.

Small holde Jatropha Curcas plantation

Jatropha Seeds and Jatropha oil

Community-based oil seed production

Oil production is a rather simple mechanical process. It requires a process unit equipped with an oil expeller and a settling-filtering system. Oil expelling leads to vegetable oil (SVO) and seed cake. Settling of the particles and filtering (5 to 10 μ) provide pure vegetable oil. The seedcake, rich in nitrogen protoxide, is used as fertilizer.



Mechanical oil expeller, Cambodia

As mentioned before, to run a diesel engine with CJO requires a conversion. This consists in including a pre-heating system on the initial engines, which reduces the oil viscosity. An additional filtering system is also implemented on the SVO entry point into the engine. Another solution to avoid preheating consists in a device of fuel double supplying which enables to start the engine with diesel oil and switch to SVO supplying. The switch occurs as soon as the first combustion chamber is hot enough. Regarding engine conversion, many car manufacturers and research organisations offer standard conversion kits for any type of diesel engines (stationary, mobile, mono or pluri-cylinder, generator). These kits enable to use SVO as well as diesel oil and they are devised to be affordable and simple enough to be used by local mechanics.

Many small-scale agrofuel production models are currently under experimentation by development operators. They differ in production volumes, species' choice, vegetable oil final use, the organisational model selected.

Involvement of development stakeholders

NGOs specialized in advocacy have the responsibility of making influence on public policies so that risks linked to the development of agrofuels would be better taken into account.

Field NGOs, technical cooperation agencies, etc. have the responsibility to implement experimental productions in partnership with local communities. These processes of research-action enable to make technical and socio-economic information available in order to assess the viability of agrofuel productions' implementation in Southern countries.

Public authorities' mission is to define a national political frame for the production and use of agrofuels. For instance, this frame should consider the possible substitution fields (transport if relevant, electrification, local mechanic activities, development of new energy services). It can also establish possible incentives for the use of agrofuels (tax exemption, etc.).

Public authorities must also guarantee a cautious development of the sector through the provision of necessary measures (planning of land use between food and energy production, export tax for the marketing of agrofuels, especially on the domestic market, etc.). Finally, they must support research on agrofuels, for instance on technical performance of agrofuel plants, on the engines' conversion processes, etc.

DEVELOPING A PROJECT APPROACH

Feasibility study

The feasibility study for a local production is vital to ensure the production's perpetuation on the long term. This study will focus on the following elements:

Assessment of the local market for jatropha oil

The assessment takes into account the diesel oil consumption at the whole region scale, mainly regarding stationary engines (since they can be converted more easily) such as generators, multifunctional platforms, cereal threshing machines, shelling machines, joinery and ironwork tools, oil lamps and possibly motorized cultivators.

Identification of the sustainable production potential

The aim is to identify the farms that can integrate this culture and then assess the available lands. It's necessary to make a revenue calculation for each hectare depending on the costs of inputs, maintenance or family working time. Then, we can compare with other types of cash crops to assess its interest.

Feasibility of the oil expelling unit

The plan consists in an economic simulation showing the investment costs, the functioning costs, the provision for depreciation, the monthly revenue, the oil cost price, etc.

Design of a business model

According to the social context, it's a question of the organisation model which:
- maximizes the production's added value,
- guarantees its fair sharing out between farmers, SVO production unit and SVO final users,
- is best integrated in the existing social models.

For instance, the study considers the functioning modes of the oil expelling unit (cooperative or private initiative), the possible access to micro-credit systems.

It must also anticipate possible economic interactions with industrial productions. Indeed, there is a risk of competition on the raw materials' supplying of community and industrial units producing agrofuel.

Impact study

This study requires to be carried out with a socio-economic and environmental impact study given the numerous risks mentioned earlier. It should do recommendations for the projects' implementation and can lead to their abandonment.

To support to the development of small scale agrofuel production

Targets:

Local authorities, craftsmen, farmers

Project scale:

The territory as part of a decentralised energy production approach

Technical data:

- Calorific power of jatropha SVO: About 40 MJ/kg of oil, i.e. a calorific power slightly inferior to that of diesel oil (10 to 15 %).
- Jatropha plantations' maturity: 5 to 6 years
- Plantations' yield: From 1 to 7 tons per hectare, variability which proves the great uncertainty weighting on the farmers
- Oil expelling ratio: 20 %, in average, 4 to 5kg of seeds are needed for 1 litre of oil.

Technological maturity:

Agrofuels are currently in the research and development phase, both from a technical point of view and for the perfecting of viable production models from a socio-economic and environmental point of view

Essential aspects of project guidance:

- Part of agronomic research on the cultivation techniques and itineraries, associations of cultures and agroforest systems integrating oil plant, irrigation, fertilization, possibilities of the harvest small mechanization.

- Part of technology transfer for SVO production, quality follow-up, yields' improvement, byproduct recycling, engines' conversion.

- Part of marketing including SVO promotion as a diesel oil substitute and the dissemination of conversion kits.

- Part of organisation of the sector's stakeholders around farmers, oil producers and final users.

Project duration:

From medium to long-term, a minimum duration of 5 years corresponding to the full yield of jatropha plantations.

Skills required:

Rural development, agronomy, process methods, mechanics, social engineering, marketing.

On the long term…

The development of agrofuel local productions is presently in its experimentation phase, it's then too early to talk of perpetuation. The research process led by various NGOs in Southern countries is under way. The assessment and balance of the first experiments is crucial to have reliable information which is highly needed today. Then, the productions' perpetuation goes along with a monitoring and assessment mechanism which includes technical, environmental and socio-economic criteria.

Positive or negative impacts, risks

Economic

- ⬆ Creation of extra income for the seeds' producers.
- ⬆ Creation of an oil production company.
- ⬆ Saving in energy extra cost for the final users (SME, farmers).
- ⬇ Risk of price disagreement or non-transparency between stakeholders: famer – SVO transformer – SVO consumer, which prevents the production's perpetuation.

Social/sanitary

- ⬆ Job creation, agricultural activity perpetuation.
- ⬆ Income from seeds' harvest, especially for women.
- ⬆ Theoretically, combustion significantly less polluting and toxic than that of fossil fuels since it mainly generates steam and CO_2 and no or little nitrogen and sulfur oxides (NOx, SOx).
- ⬇ In the case of a large scale project, risks of pressure for the use of lands: competition between food safety and land conflicts. .

Environmental

- ⬆ Fight against climate change: 1) thanks to the substitution of a fossil energy for a renewable energy and 2) thanks to the storage of carbon in the plantations (see hereinafter).
- ⬇ Risk of pressure for the use of lands implying a deforestation phenomenon, hence a loss of biodiversity.
- ⬇ Risk of negative impact on the lands and ecosystems due to intensive farming[2].

2. Mainly in the cases of industrial production models.

CONTRIBUTING TO CLIMATE CHANGE MITIGATION

Challenges

Substitution of fossil fuel for renewable fuel

The combustion of agrofuels mainly produces steam and CO_2. Since the latter is stored in the plant during its growth, it doesn't increase the concentration of greenhouse gases in the atmosphere and is then neutral regarding climate change.

Nevertheless, we need to take into account *Greenhouse Gases (GHG)* emissions generated during the production and transport of these agrofuels, which can sometimes be very important.

The energy balance – and hence the impact on climate change – will be given by the analysis of the agrofuel life cycle, i.e. from its production to its consumption. The number of parameters to be taken into account during the product whole life cycle is complex: type of crop, production place, more or less intensive use of inputs, mechanisation, transport, transformation process (grinding up, transesterification).
Some productions don't present a very interesting climate balance as it is the case for instance of a large scale ethanol production based on an intensive corn culture, which requires high level of inputs and an important irrigation.

On the contrary, the case of local productions generating straight vegetable oils in Southern countries, such as it is presented in this fact sheet, would offer, a priori, a positive carbon balance. It's based on a family farm with low-emitting agricultural practices. Furthermore, the oil fabrication process emits less GHG than transesterification for instance.

Carbon sequestration

In the case of perennial cultures, i.e. which are not renewed each year, plants play an additional role of mitigation by carbon sequestration (vegetative part). Species such as jatropha crucas and pongamia pinnata constitute a carbon sink during their whole life (30 years of plantations for instance). This aspect is dealt with from a more general point of view in fact sheet 5.3 Forest carbon sinks.

Valorisation of emission reductions

Agrofuels in the *Clean Development Mechanism (CDM)*

Contrary to other renewable energy sectors, there are only a few projects for the production or use of agrofuels which are eligible for a CDM. Indeed, two reasons now encourage CDM authorities to be cautious:

- There is a risk that emission reduction might be counted twice: first at the agrofuel producer's level and again at the user's level. The *Executive Board* said it was favourable to a counting at the producer's rather than at the user's since follow-up is easier that way.
- The introduction of energy cultures poses the problem of land use shift. Thus, when a sugar cane culture replaces a forest land, it comes down to deforestation. This land use shift, which changed from forest to agricultural land, goes with carbon dioxide emissions (CO_2) and has then a negative impact on the fight against climate change. Then, the impact of the implementation of agrofuel cultures seems to be hard to measure and to control. The CDM must not constitute a financial tool encouraging the land use shift if it means deforestation.

Local agrofuels in the CDM

Even if the local productions described in this fact sheet would prove to be eligible for a CDM, they would represent very low emission reduction volumes. Systems of integration of projects alone, within a same CDM (buddling), would enable the sufficient valorisation of reductions so that transaction costs linked to the formalisation of a CDM would be paid for. For small scale projects, the *voluntary exchange market* represents an easier way to individually valorise emission reductions.

Illustration: "Jatropha biodiesel from degraded land in Madagascar"

Project status: CDM
Project operator: JatroSolution GmbH
Carbon credit: *CER*
Information source: www.unfccc.org
Methodology: Small scale, I.F. Substitution of fossil fuel in combustion engines through biofuel from degraded land[2]
Crediting period: 2010-2017

Emission reduction context and principle

This project has not yet been validated as a CDM project, the process is under way. It will begin in 2010. It aims to produce biodiesel from jatropha plantations (3,000 hectares) to supply a generator in the Finanarantsoa province. The project consists in substituting all the fossil fuel for biodiesel, which is a renewable energy. This project's particularity and the methodology it is based on is the implementation of jatropha cultures in degraded lands. Then, it avoids the problem posed before ensuring that land use shift will not generate GHG since non wooded land (degraded) is used for perennial culture plantations.

ER estimates

The plantation is 3,000 hectares large and will provide (at full productivity) 3,275 litres of biodiesel per year. From its starting point in 2010, the project will enable an average yearly reduction of 3,800 tons of CO_2 equivalent per year, i.e. a reduction of 1.3 tons of CO_2 equivalent per year per hectare of jatropha plantation. jatropha.

2. Methodology submitted to the Executive Board on the book publication date.

CASE STUDY

LOCAL PRODUCTION OF AGROFUELS AND RURAL DEVELOPMENT IN MALI

Implementation date: April 2008- April 2011
Project financed by: ADEME, Foundation Albert II, Foundation Nicolas Hulot,
Scope: Medium scale project (budget from 50,000 to 200,000 € per year)
Operator: GERES
Main partnership: AMEDD, Malian NGO specialised in rural development
Secondary partnership: Local technical operators, research institutes and government agencies
Project area: South-East of Mali
Potential beneficiaries: The 80,000 people living in the project area

Context

The Yéelen Kura company supplies electricity to 6 villages in the Koutiala area thanks to generators. Yéelen Kura, as well as the existing operators offering energy services (cereal mill, etc.), depends on the increase of hydrocarbons' price. In parallel, the beneficiaries of these services have economic difficulties due to the current cotton crisis, which contributes to jeopardizing the operators' economic stability.

Because of the cotton crisis, farmers have available lands and are looking for an alternative cash solution. Furthermore, soils are impoverishing: clearing and wood cutting have accelerated the lands' water erosion and, in many cases, the cotton producer's requirements are not compensated by a suitable management of the land fertility. The interest regarding agrofuels is also growing amongst the producers, who consider them as the cash alternative they are looking for. Nevertheless, the lack of reliable information and of guidance make them dependant on transformation stakeholders and risk to generate disappointments as regards to the expected impacts.

Project activities

- The local jatropha seeds' production and an offer in straight vegetable oil which primarily satisfies local needs: 800 hectares plantations, 2,000 tons of seeds per year, 400,000 litres of straight vegetable oil;
- The strengthening of existing energy services and the access to new services in the areas producing jatropha oil thanks to the installation of several "multifunctional platforms".
- The organisation of jatropha production: upstream-downstream relationships organised on the local scale based on a stakeholders' logic, to ensure their durability (medium term contract, payment conditions);
- The validation of a model operation to establish a sustainable model of 'local production of agrofuel": conception and implementation of a continuous assessment and monitoring mechanism to analyse the socio-economic and environmental impacts.

Collective nursery in Nèrèsso

Participative meeting with farmers

Outcomes

The project is currently under way. On the date of achievement of the handbook, two towns have been targeted for the implementation of local productions, Yorosso and Koury. 700 farmers have made the first nurseries, which corresponds to about 420 hectares of cultures. The transplanting is under way. The results of tests on the working of a Yéelen Kura engine adapted with a bi-carburation kit are encouraging (*CIRAD*).

For more information

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Small and micro water power stations

> Related fact sheets: Fact Sheet 3.5 - Multifunctional platforms; Fact Sheet 3.3 - Small solar and wind power plants

Man has used water power for hundreds of years, first water mills then hydroelectric power stations starting in the 19th century. By harnessing this energy, industry has been expanded in many areas on all continents. As attention now focuses on reducing greenhouse gases, water stands as a totally clean energy. While large water-powered electricity plants induce tremendous changes in ecosystems and may displace entire communities, small and micro power stations have far less impact. Despite their advantages, however, sources of water power in the form of rivers and streams are far from being fully developed, even in countries that are short of electricity in remote areas and that depend heavily on oil or coal. Although very inexpensive in the long run, hydroelectricity does incur high capital costs and setting up hydroelectric systems requires the assistance of experienced specialists. These two points are the main obstacles to developing new projects and are of paramount importance in any such intervention.

HYDROELECTRICITY IN COUNTRIES OF THE SOUTH

Electricity supply and distribution

In broad terms, there are three major approaches to the supply and distribution of electricity in a country:

Interconnecting electrical power grid

Such a grid is generally developed nationally or internationally and supplied with power generated by all forms of both fossil and renewable energy. It is a very costly system to set up and is geared to supply areas of heavy population and industry density: cities, large activity or industrial zones. Extending the grid to rural communities comes only at a very high cost (as was the case in Europe after the Second World War) and it does not usually reach out to isolated homes.

The cluster or "village" grid

This is a stand-alone grid supplied by a small or average size electricity plant designed to serve a community. Diesel gen-sets are most common, but the plant may also be powered by water, sun, wind, biogas, etc. It generally has a sufficient capacity to supply the domestic and handicraft production sector, sometimes even small-scale industries, with a typical installed capacity ranging from 10 to 1,000 kW.

Power plants for individuals

Batteries recharged on the network, gen-sets, or photovoltaic kits power these setups. They are able to meet domestic needs only or self-employment activities (small business or handicraft production with a low energy demand). The generating capacity is typically from 50 to 500 W.

We will develop hereinafter water power plants suitable for supplying village networks.

Pros and cons of using hydroelectricity

Mountainous, hilly or rolling terrain is ideal for setting up small or micro water power plants, provided that the rainfall is adequate. Various energy services can be developed where it is possible to generate electricity or harness water power to drive machines, thus upgrading living conditions for the inhabitants by providing them power for lighting, food processing operations, or even small-scale production industries such as weaving. In areas where agriculture is often confronted with challenges, it may be possible to break new ground in a way that leads to a welcome improvement in the status quo. The power plant may take over from an existing gen-set type system or provide new energy services in an isolated area.

In a water-powered plant project, albeit a small one, a number of points require careful management. First, hydroelectric plants result in big changes to surface water. Local communities may be using it for their water supply or crop irrigation for instance, and it also provides a living space for flora and fauna.

For this reason, consideration must be given at the sizing and design stage to the various uses of the "water catchment." Furthermore, a power plant requires a high level of investment and its structure does not lend itself to renovation as needs evolve. Every effort must be made to avoid wasting this resource and to correctly calculate the size of the installation as a function of identified needs.

Principle of small and micro water power stations

Although there is no standard terminology in vogue, we will use the term "micro" to describe a water power plant with an output of less than 150 kW and "small" to refer to those that may have a capacity as high as 10 MW. The differences show up in the complexity of configuration of the setups.
Both "small" and "micro" power facilities are made up of a number of basic components:
- Water intake structures designed to channel off part of the flow of a watercourse. It is imperative to leave in the watercourse the minimum flow required by flora and fauna and various human activities.
- Headrace and loading structures (intake channel, buf-

fer tank, penstock or pressure pipe). The penstock or pressure pipe is a closed canalisation that will enable the turbine to be driven by the force of the water as a result of the difference in elevation. Water entering the canalisation must be relatively particle-free (role of the intake channel).

- Generating equipment that includes one or more turbines, a generator, transformer, and control system. These components enable conversion of the energy potential of water flowing from a higher to a lower level into mechanical or electrical energy.
- A wasteway structure, usually referred to as the spillway chute.

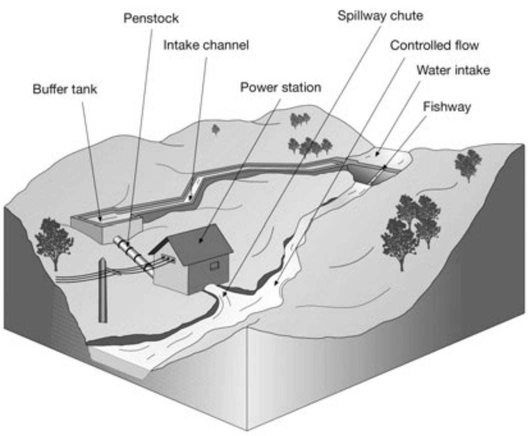


Diagram of a power plant set up on a watercourse (©ADEME)

Intake channel

Penstock

Production equipment

Control station

The size and design of the power generating equipment are crucial, firstly because once the plant is built, it will be difficult to change. Thus, if a miscalculation has been made, invasive work will be required to modify the water intake and supply connection structures. Secondly, water power plants are unable to supply energy consistently throughout the year due to fluctuation in the flow of watercourses. The choice must be made to optimise the installation so as to either guarantee a minimum year-round production (which can be achieved by a smaller installation) or capture even the peak flows.

Each component is designed and sized in keeping with the following criteria or constraints:

- Technical: Function of the site and its capacity to meet the needs (daily or seasonal energy demand, provide access to the site for upkeep and system maintenance, decision to use manual or automatic controls).
- Financial: The project must be economically viable or come within the allocated budget.
- Environmental: It is imperative that the setup be environmentally friendly.

The power plant may supply a small electricity distribution grid. The turbine shaft may also be coupled directly to a mechanical load such as a gristmill or an oil extractor. Another alternative is to install a mixed system, with a micro-grid for night lighting and a mechanical coupling for processing agricultural produce during the day.

The initial capital cost for a water-powered installation and its maintenance costs are high. For instance, a micro plant with an 8 kW output was installed in Ladakh, India, in 2008[1], with an estimated installation and maintenance cost of € 1500 per kW. The total installation and maintenance budget for a micro plant of this type is about € 12,000. The financial factor dictates that plants have appropriate management and operating procedures.

It can therefore be seen that a water power plant venture requires a great deal of organisational and supervision work in both early and later stages. Watercourses are public property, shared by many stakeholders, which means that their utilisation is subject to authorisation processes at different levels. The most common system is the concession, or delegation for a public utility. In this arrangement, the concession holder (often a private company) covers the operating and routine upkeep costs, as well as the capital cost, which are high. The concession holder gets his money back from the users by means of a fee structure spelled out in the concession contract and subject to review based on a variation formula, likewise contained in the contract. When the contract expires, usually after 15 to 20 years, the local authorities become owner of the facility.

Development stakeholder involvement

Development stakeholders (NGOs, technical cooperation agencies, etc.) may coach the setting up of a power plant in different ways:

- Supporting the entity that is handling the project sizing and design.
- Training power plant operators in facility operation and maintenance.
- Setting up local building material supply chains for certain components of the power plant (which may include a workshop for turbine manufacture). The purpose is to build the capacity of local craftsmen with an eye to upkeep of the facility, thereby helping to reduce equipment replacement costs.

The legislative authority and rural electricity distribution agencies play a crucial role in the speed with

1. See the section "Contribution to combating climate change" in this fact sheet

which water power projects get up and running. Their area of jurisdiction may involve:
- Enacting legislation to establish a framework such as a concession system conducive to investment.
- Establishing transparent, fast-action procedures for the assignment of sites and delivery of the various operating licences needed.
- Providing assistance to fund micro-projects.

DEVELOPING A PROJECT APPROACH

Feasibility study

Initial diagnostic analysis

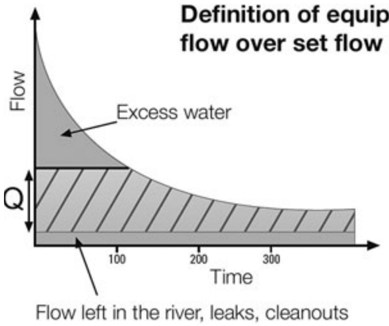
The very first step will be a careful review of legislation governing small or micro water power stations. This is important because government structures in charge of this field often have valuable statistical resources. The diagnostic analysis should enable an identification of needs, which must be long-term, as the service life of the power plant may be in the neighbourhood of 20 years.

The diagnostic analysis must also include a study of the potential of the site, which involves three main factors:
- The flow volume of the watercourse, in particular its minimum flow, which would be determined by an annual record and calculations made of the watersheds that feed it.
- The available height of water or hydraulic head that will take the form of a very steep column perhaps some distance away from the water intake.
- The distance of the power plant from the location where the power will be delivered to users.

Size and design of the installation

The initial diagnostic analysis will only be meaningful if it includes a precise analysis to determine the size of the various components of the power plant.

- Water intake, water flow channel and penstock
The size of the water intake structure must be such that a minimum or controlled flow will be left, while avoiding too heavy a load in times of high water. The intake channel has the dual role of guiding the water to a location of steep gradient and ensuring the filtering out or sedimentation of particles that it contains.



Equipment flow (©ADEME)

- Turbine
The crucial component of the power plant is the turbine, so keen attention must be given to its selection and design. There are several types of water-powered turbines suited to different situations, although their role is identical in all cases, that being to convert the energy from the water head into utilisable mechanical energy by coupling the turbine to a generator or other machine.

- Generator and control systems
The generator converts the mechanical energy produced by the turbine into electrical energy of a specific frequency and voltage. Its size depends on the type of turbine, which is selected in order to obtain an appropriate output.

Organisational and financial decisions

The cost per kW of installed power is a meaningful indicator when studying the cost effectiveness of the installation and comparing different size options. The cost of a kW is calculated by an aggregate of four items: engineering works (water intake and inflow channels), turbine, electrical equipment (generator, regulator) and distribution grid. Because each site is different, the cost per kW will vary depending on:
- Size of the power plant (for identical quality, a micro turbine costs proportionately more).
- Construction work needed on the watercourse.
- Distance between the power plant and distribution grid.

The second factor is the cost per kWh, and this is determined by the utilisation rate of the power plant.
Several approaches to funding are possible. Based on its financial strength, the project host may take out a loan or obtain a grant to cover the capital cost. The earning power of the project will determine to what extent other assistance is necessary or if a fresh look at the project is needed to see whether a different approach to the site and length of the concession would be advisable.
The choice of who will own and who will manage the power plant will depend to a great extent on what status was decided for the venture: public, private, or mixed.

Supporting installation of a hydroelectric power plant

Targets:

Local authorities, businesses

Functionality, performance:

Service life of an installation: 20 years

Examples of generating capacity:

- Height = 30 m, minimum flow = 0.5 m3/s, cross-flow turbine, output = 111 kW
- Height = 50 m, minimum flow = 0.2 m3/s, Pelton turbine, output = 74 kW

Technological maturity:

Hydroelectric technology has been around for a long time, but that does not mean it is easy to come by. Generators are complicated items of machinery. Turbines must be made to function under tremendous pressure. Plans are a must, but even more so is the skills base to properly implement them. From the standpoint of upkeep, the external structures require the greatest amount of attention.

Principle components of a facility support project:

- Power plant design and environmental impact study.
- Building the structure.
- Technology transfer for turbine manufacture.
- Development of new energy services downstream from the power plant.
- Structuring the stakeholders for proper site management.

Project duration:

Coaching the set up of small and micro hydroelectricity power plant facility is a mid-term activity (three years). Monitoring and coaching a management committee (where a user co-operative is organised) will be longer (five years).

Skills required:

Rural hydroelectricity, public works (small engineering works), familiarity with the laws governing concession management.

Sustainability:

Putting in a sustainable hydroelectric power generation and distribution facility is based on the premise that the project itself is anchored in a long-term management approach. This includes regular monitoring, building upon good practices appropriate to the local context and, where necessary, giving a new direction to the venture.
Sustainability also requires establishing a channel for producing or importing power plant components. This second point requires a technology transfer or opening up an import channel. The idea is to have a variety of materials available that can be easily adapted to various scenarios that may be encountered.

Positive and negative impacts, risks

Economic

- ⬆ Additional income opportunities created through infrastructure building work.
- ⬆ Establishment of an electricity company.
- ⬆ Job creation (handicraft producers, technicians, management staff positions) in a context advantageous to energy service operators (low-cost electricity).
- ⬆ Production of a reliable, affordable supply of electricity, provided that the size is adequate.
- ⬇ Initial very high capital cost that may prove to be a roadblock difficult to overcome.

Social and health

- ⬆ Structuring of the watercourse, which will cut down on risks of flooding.
- ⬆ Development of new basic energy services that will improve living conditions for the communities (take the drudgery out of work, etc.).
- ⬇ Risk of conflict with other uses of the water resource (fishing, farming, animal husbandry) over the volume of water dedicated to the power plant.

Environmental

- ⬆ When the water power plant takes over from a thermal generating station, less greenhouse gas emissions.
- ⬇ Risk of water flora and fauna destruction where minimum flow levels in the watercourse are breached, and due to the presence of the water intake structure.

CONTRIBUTING TO CLIMATE CHANGE MITIGATION

Issues, turning emissions reductions to account

Small and micro hydroelectric power plants are based upon harnessing the motive power available in watercourses, a limitless, totally self-renewing energy source. Using water power to generate electricity as a switchover from a fossil source (diesel, coal) is a means of combating climate change.
Small and micro hydroelectricity plants are eligible under the *Clean Development Mechanism* (CDM) arrangement as type-I. small-scale renewable energy projects. Methodologies AMS-I.A "Electricity generation by the user" and AMS-I.D "Grid connected renewable electricity generation[2]" provide the formulae for calculating the emissions reduction.

Illustration: Micro hydroelectricity in India

Operator: GERES India
Project status: *Voluntary exchange market*
Carbon credit: VER
Source of information: www.india.geres.eu
Methodology: AMS-I.A "Electricity generation by the user"
Counting credits: 2005-2012

Context and emissions reduction principle

The project was put in place for the benefit of communities of Ladakh. It called for the installation of 10 micro electricity stations with an average generating capacity of 8 kW to provide power for lighting and mechanisation activities. The plants replace the use of gen-sets or other mechanically driven engine systems, thus eliminating fossil fuel consumption (diesel).

ER estimates

The emissions reductions obtained with a hydroelectric station (output of 48 kWh/year) are estimated at 6.7 t CO_2 equivalent each. Proceeds from the sale of credits over a 10-year period cover 5 to 10 percent of the total estimated cost of the station (approximately € 12,000). The sale of credits in this project is a small but meaningful contribution to funding the equipment.

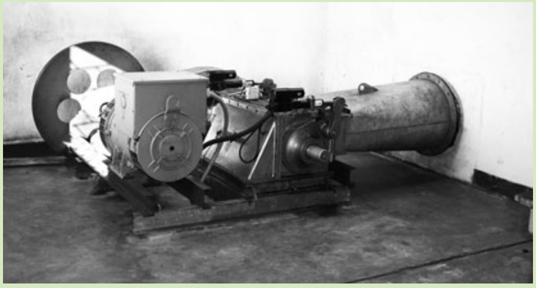
2. Available on the *United Nations Framework Convention on Climate Change (CCNUCC)* website: www.unfccc.org.

CASE STUDY

MICRO HYDRO POWER PLANT IN ANTETEZAMBATO, MADAGASCAR

Project funded by: Walloon Region (Belgium), *IEPF*, Malagasy Ministry of Energy and Mines, "Énergies pour le Monde" Foundation, *EDF, ADEME*
Scope: Small-scale project with yearly budget under € 50,000
Operator: ADITSARA, a local co-op
Main partner: "Énergies pour le Monde" Foundation
Secondary partner: J.-L. Willot/Tenema (supplier/installer of the micro power plant)
Implementation date: Studies: 1999; commissioning: 2002; monitoring: to 2009
Project zone: Antetezambato commune, central Madagascar
Beneficiaries: 186 customers (late 2007)

The plant



Plant components

Context

Antetezambato is a hamlet in Tsarasaotra commune, about 10 km from Ambositra, itself some 250 km south of the capital Antananarivo. Five other hamlets within a 1.5-km radius are supplied with electricity by means of a small local distribution grid connected to the hydroelectricity power plant.

Activities implemented by the project

The following steps were followed in implementing the project:
- Feasibility study of both the site (12-meter head of water with a flow of 544 litres/sec) and the hamlet.
- Size determination and set up of the micro power plant (electricity output of 42 kW).
- Setting up an operating co-op for the electricity infrastructure to care for equipment upkeep, payment collection based on a fee schedule, new customer hook-ups, initiating extension work, and coaching users in proper electricity management. It reports to the commune council and energy department.
- Project monitoring/coaching: A Malagasy engineering firm (Mihiratra) is providing capacity building assistance to the co-op staff.

Outcomes

After the installation was commissioned in late 2002, hook-ups to the grid began taking place, with an initial count of only 54 customers. The use of it for lighting caught on when users realised that electricity was cheaper than oil and candles.

Thus, by late 2007, the customer level had risen to 186 on a 6-km grid with an average installed capacity of about 25 kW. Electricity is used by households for lighting and audio-visual appliances, general services such as the school, health centre, and street lighting, as well as for production activities (basket making, welding, operating a farm school, etc.).

After over five years of operation, the main impacts are as follows:
- Improvement in health with electric lighting replacing fume-producing oil lamps.
- Improved performance at school due to better study conditions. A high school is slated for construction in Antetezambato given the greater number of students now qualifying for secondary education.
- Improved safety and security. Night lighting is a deterrent to animal theft, common in the region.
- Economic development due to the emergence of handicraft activities that can be carried on into the night hours. A number of households have developed small-scale cash income activities such as bag sewing, yogurt making and selling because of having refrigeration, or using soldering irons to do small repair jobs.

Project evolution

At the outset of the project, the co-op did its work manually, but now a computer is used for plant operations record keeping and to make technical and financial projections. Given the increasing customer load, further work has been prompted, including:

- Replacing incandescent bulbs with fluorescent ones to reduce the unit consumption of light sources.
- Replacing the flat-rate charge with a charge based on a meter reading for more cost-effective electricity management.

For more information

Bibliography:

« Guide on How to Develop a Small Hydropower Plant », 290 pages – ESHA, 2004

« Layman's handbook on how to develop a small hydro site », Celso Penche & Dr Ingeniero de Minas, 266 pages – ESHA, 1998 [on line]

Websites:

Small hydropower: www.esha.be
Micro hydropower: www.microhydropower.net
European Commission, energy section: www.europa.eu.int/comm/energy

Small solar and wind power plants

> **Related Fact Sheets:** *Fact Sheet - 1.4 Photovoltaic battery kits*

Development and expansion of electricity distribution is a major socio-economic challenge for most countries of the South. This is particularly true in a context of wide disparities between large urban centres that are generally well serviced with electricity and rural communities where electricity is still all but non-existent.

The issue confronts both the domestic sector where electricity enables rural communities to have access to basic services close to par with those enjoyed in big cities (lighting, refrigeration, communications), and the production sector (cottage industry, business), for which the absence of electricity is a genuine hindrance to development. Several modes of electricity supply and distribution exist and are more or less appropriate to the needs and the various technical and economic settings. Aside from special cases where there is an abundant supply of hydroelectricity, fossil fuels are used to generate most of the electricity produced.

In the recent international context, fossil fuels are costing more and becoming increasingly scarce in countries of the North, thus scaling up the use of large solar and wind power plants. It is therefore only natural that electricity distribution programmes in countries of the South look for broader and more frequent supplies of renewable energy. Some applications, such as small village grids, indeed stand to benefit from an electricity supply generated by small solar or wind power plants.

NB: This article does not apply to specific services to supply communication systems (telephone relays, etc.).

SOLAR AND WIND POWER FOR ELECTRICITY GENERATION IN COUNTRIES OF THE SOUTH

Electricity supply and distribution in countries of the South

In broad terms, there are three major approaches to the supply and distribution of electricity in a country:

Interconnecting electrical power grid

Such a grid is generally developed nationally/internationally and supplied by all forms of fossil or renewable energy. It is a very costly system to set up and is geared to supply areas of high population and industrial density, busy metropolitan areas or manufacturing zones. Extending the grid to rural communities comes only at a very high cost (as was the case in Europe after the Second World War) and it does not usually cover isolated homes.

The cluster or "village" grid

This is a stand-alone grid supplied by a small or average size electrical plant designed to serve a community. Diesel gen-sets are most common, but the plant may also be powered by water, sun, wind, biogas, etc. It generally has a sufficient capacity to supply the domestic and handicraft production sector, sometimes even small-scale industries, with a typical installed capacity ranging from 10 to 1,000 kW.

Power plants for individuals

Batteries recharged on the network, gen-sets, or photovoltaic kits, sometimes even small windmill generators or biogas driven engines power these setups. They are able to meet domestic needs only or self-employment activities (small business or handicraft production with a low energy demand). The generating capacity is typically from 50 to 500 W.

We will develop hereinafter solar and wind power plants suitable for powering village networks.

Solar or wind plants

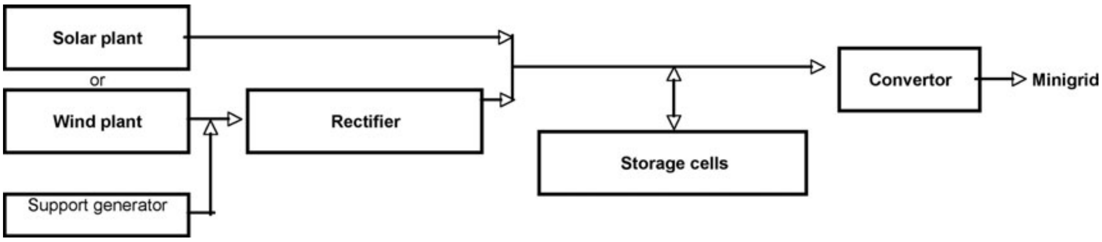
Typology

Such plants are commonly seen in developing villages or small towns.

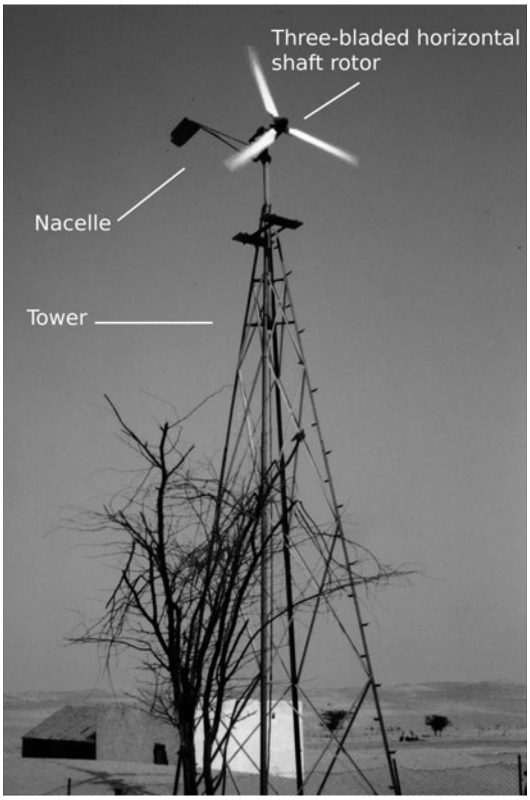
They meet a growing demand for electricity driven by various needs, such as handicraft production and domestic activities that can no longer be supplied satisfactorily by individual means of production and in a context where there is a squeeze on diesel supplies caused by distance or rising prices. Their use also fits in with the trend to use locally available energy sources from the wind, or sun that have no recurring costs as does gas-oil fired equipment. These costs amount to maintenance only, although an occasional purchase of gas-oil may be necessary for a back-up operation (sun-diesel or wind-diesel hybrid system).

Principles of operation

Both types of power plants are set up in a relatively similar fashion, as illustrated below:



Where photovoltaic systems are used, the sun's rays are captured by a series of panels made up of cells that make a direct conversion of the flow of light from the sun into electricity. Thus, the production from a photovoltaic battery plant is cyclical, varying according to the time of day and season. The amount of power produced per day depends on the power of the panel (expressed in peak watts) and the sun power potential.



Wind power plant in Mauritania

Wind power plants involve one or more windmill units set up where a strong, steady wind blows (coast, plain, etc.). A windmill power plant requires a 50- to 110-m high tower. At the top is a nacelle or enclosure fitted with a three-bladed horizontal shaft rotor that turns with the wind. When the wind reaches a minimum velocity, the blades begin turning in a circular motion. The rotor is activated as the blades move and drives the generator to produce alternating current. A rectifier is used to convert the alternating current into direct current.

In both wind and sun power systems, electricity production is variable. It is therefore necessary to store the energy—at least some of it—in batteries for use in the evening (although there is the risk of shut-down when the batteries are depleted) or have a back-up source of power (gen-set) for uninterrupted service when a boost up is needed.

History of development

These types of power plant have been around for over two decades, at least as far as sun power is concerned. However, except for numerous types of set-ups specific to radio communications use, development has been slow because of the low cost of fossil fuels and the high cost of solar or small wind power plants. But things are changing quickly, with very large-scale development of solar power plants in countries of the North. Costs have dropped dramatically (a fourfold drop in 20 years), while gas-oil prices have soared.

The small wind power plant has not yet become popular, but it is now costing much less to install—in its scaled-down version—and comes with a lower capital cost than solar power where a more sizeable plant is envisioned. However, its applications are more specific than those of solar power: Sites with reliable wind are scarcer and maintenance requirements are higher.

It must nevertheless be kept in mind that although the cost of solar and wind power plants has decreased, their capital cost is much higher than for a gas-oil plant, which means that they require special modes of financing.

Challenges for development stakeholders

Development stakeholders are leaders in electricity distribution programmes. Funding for grids as well as for production systems is generally achieved through loans and high levels of grant assistance, most fre-

1. Unit used to represent the maximum electrical power delivered by a solar electric power system for a standard solar irradiation of 1,000 Watts per m^2 at 25°C.

quently from development agencies and international finance institutions.

On-site stakeholders

More specifically, where average sized, decentralized power plants are involved, on-site stakeholders in the form of NGOs and/or local small-scale businesses are frequently the project initiators or play a key role therein. Unlike large network electricity distribution programmes that are designed and carried out in a centralised way based on the concept of energy supply, decentralised projects are based on identification and analysis of local electricity distribution needs. As NGOs undertake development initiatives and programmes, they are often confronted with a lack of power services and therefore with the need to set them up.

NGOs are also often out to identify the most appropriate solutions in terms of social or environmental impact, and this leads them to go for clean technologies. Where electricity generation is concerned, solar and wind power are right up their alley.

Public authorities

Public policy is of pivotal importance in electricity distribution operations, which is normally a major pillar of the government's mandate. Governments generally lack the means for mainline electrification but need to make adequate regulatory provision, including arms for planning, giving incentives and promoting implementation.

It is therefore incumbent upon the public authorities to authorize the generating and distribution of electricity outside of a monopoly for instance, so that community authorities can develop local grid projects. The government can create incentives by planning and making available human and organisational resources (establishment of a rural electrification authority, etc.). It can steer projects toward clean energy by lifting taxes on it (import tax, VAT, easing the local fiscal system) or by offering them direct assistance, such as linking national programmes with national or international financial institutions or providing assisted lines of funding.

As a rule, wind or solar power projects can only come to fruition if the institutional environment is favourable.

DEVELOPING A PROJECT APPROACH

Assessing the relevance of mini-grid solar or wind power solutions

Whether a project can get off the ground or not must be determined by conducting a feasibility study and seeing what potential funding can be tapped. A number of up upstream can be made prior to undertaking any major exploratory work.

Objectives of an initial diagnostic analysis

The initial diagnostic analysis will make it possible to:
- Identify and assess existing and future electricity needs (growing demand for electricity: handicraft production, domestic use, etc.) and the degree to which the undertaking is sound enough to justify the extension of financial assistance.
- Assess the potential for solar or wind power generation commensurate with the identified needs.
- Assess potential organisational and partnership arrangements that can be instituted.
- Analyse the economic viability requirements of one or more project scenarios.

If there is already a village mini-grid in operation (such as a project for the substitution of diesel energy with solar), the initial diagnostic analysis is much easier. Both the needs and organisational potential are quite well known.

Key steps in a diagnostic analysis

- Typology of needs for electrical services:
A market study is required, which includes a survey and analysis of pre-existing electrical equipment as well as the overall uses of energy that can be replaced by electricity.

- Assessment of local capacity for equipment management:
Where a mini-grid is already in existence, the job is an easy one, requiring a simple analysis of the current operating and management process of various services (water supply, health centre management, agriculture product processing, and the like).

There is a trend to think that putting in a solar power plant is advisable when diesel can no longer be purchased or a generator is beyond the point of repair. However, such situations are warning signs of poor management or of a user group that may be financially unsound.

In such a case, it is better to avoid costly solutions such as solar or wind power, despite the fact that the installation cost may be covered to a great extent by grant aid. Both wind power (a rotating machine) and solar power (cells) require maintenance and this entails recurring costs that can only be covered if the market is financially sound.

- Analysis of funding and grant provisions:
Although a mini-grid may already be in operation, the capital cost is much higher (often 3 to 5 five times) than a "diesel" solution, which generally means that a loan or grant is necessary. Both types of financing cover about 90 percent of the capital cost, but that in turn means getting into the pockets of funding agencies: government, bilateral or multilateral agencies, etc.

- The technical context:
The production site must be close to the users because network costs mount very quickly where any appreciable distance is involved.

A wind power plant can only be contemplated in a location with reliable winds, and this is not always easy to determine. An analysis of the wind pool is a costly undertaking. A number of signs (twisted, leaning trees, etc.) can sometimes be indicative, as are "confirmed" wind pool locations (the coasts of Morocco or Mauritania for example), but where there is doubt, it often turns out that the wind pool is inadequate (an annual average less than 7 to 8 m/s). Unlike solar power, a wind pool is often very localised and easily disrupted (buildings, vegetation, topography), and these factors dictate a precise placing of windmill power plants.

The solar pool is less discriminating and generally more easily identified, but a solar installation requires plenty of room in a shadow-free environment and must be protected from animal intrusion.

There is a need to make sure that the materials for a wind or solar power plant are obtainable without undue difficulty (preferably right in the country). The same is true for maintenance (local maintenance capacity). There is generally no problem in this area for solar power, as distributors and installers can be found in most countries. But this is more rarely the case for wind power setups, so an effort must be made to source and assess local capacity for supplies and maintenance. Generally speaking, such plants are more easily set up if the project can come under the umbrella of a broader village electricity distribution programme covering an extensive territory.

Supporting small wind or solar power plant setups

Target:

Individual homes (domestic electricity), villages (street lighting), handicraft producers and merchants (productive electricity).

Functionality, performance:

A mini-grid setup has a typical output ranging from just a few to several hundred kW.

A plant that generates a few kW can provide street lighting with enough electricity left over to supply a few customers in a small town. A plant that outputs 50 kW is suitable for a town of several thousand inhabitants, with a supply for common purposes (street lighting, public service buildings), for household use, and handicraft production.

One of the key points in such a setup is to have energy demand optimisation or load monitoring included in the project.

It is much more cost effective to reduce consumption by encouraging the use of energy-efficient appliances (compact fluorescent lamps, etc.) than to overshoot the size of a wind turbine or solar power system.

A proper choice of tools for demand management (ceiling on contracted power load, etc.) will enable a lid to be kept on demand without compromising service.

Technological maturity:

The technological maturity of such systems is dependent upon certain items of equipment:

- Solar power systems
Silicon-based solar modules are a widely available and very dependable industrial product. But new technologies are coming to the fore, apparently less expensive than silicon (such as cadmium telluride - CadTe), but they have not yet proven their reliability over time. For LDCs, it would be better to stick with silicon.

- Windmill systems
Large wind-powered turbines are standard industrial products, but this is not true of small-scale wind power plants generating from one to ten kW. Such machines are often of limited edition and require special items of equipment that make maintenance more challenging. So in the interests of the long service life of the plant, it is advisable to team up with a larger cluster of projects with a clearly defined, long-term approach to maintenance.

In both systems, the cells used require careful monitoring. One of the weak points of any isolated system is its shorter service life compared to other equipment alternatives.

Essential aspects of ptoject guidance:

The following table provides some general guidelines regarding the steps involved in project implementation. If the project is included in a larger programme, steps 3 to 6 can be adjusted according to the content of the overall programme.

Steps	Stakeholders	Methodologies	Funding	Action
1. Needs identification: market study	Government (ministry, agency) and/or local authorities, NGOs, design engineering departments (DED)	Targeting, surveys, data analysis, forecasting	General public	
2. Production potential	Government, DED, businesses, NGOs, local authorities	Study or assessment of pool, site analysis, supply requirements, etc.	General public	If step 1 is validated
3. Organisational potential, project setup	Government, local authorities, DED, businesses, NGOs	Assessment of local management capacity and organisational/ project setup scenarios	General public	
4. Feasibility and funding plan	Government, DED, businesses, NGOs, local authorities	Technical, economic, organisational, and feasibility study, and impact study	General public	
5. Project marketing (customer commitment)	Users, businesses, NGOs, local authorities	Bid package, contracting process	Public, businesses, local authorities	
6. Project start-up decision	Government and/or local authorities, business if delegation	Analysis of feasibility and finalisation of funding		If step 5 is validated
7. Execution	Government and/or local authorities, business(es)	Implementation support, project supervision, work	Public (grant), local authorities and/or private	
8. Operation, monitoring, and coaching	Local authorities, businesses under delegation, NGOs	Operation, operation data analysis, communication, etc.	Local authorities and/or private, public (monitoring)	

Project coaching components required:

Setting up a solar power station is a standard operation and local technicians generally have no problem with it (similar to telecom setups, for instance). However, this is not true of wind power plants, for in most instances there are no skills available locally and therefore an outside manufacturer or installer will have to be called upon and an effort made to ensure local technical ownership of the venture (technology transfer, training) so that at least part of the maintenance can be handled locally.

In both systems, whenever setting up the electricity distribution service is not institutional, such projects require an upstream job of preparing and structuring the stakeholders who will be responsible for implementing and supervising the project and direct or delegated operation of the facility. Monitoring at the technical and management level is likewise required to ensure the sustainability of the service and the equipment.

Skills required by the operator and partners:

Training provisions, capacity building, technical engineering, project implementation and supervision, systems installation (electrical, mechanical), power plant operation and management.

Sustainability:

- Choice of equipment, size of the facility:
Technical design choices must include provision for normal, long-term operation: service life of equipment and materials sufficiently long under local conditions, effectivity and facility of maintenance, availability of replacement equipment.

- Economic and operational viability:
The operation should yield a good financial balance

sheet (need for sound management). The partnership arrangement and structures involved must be in it for the long run. As for any grid setup process, a very long time elapses before there is a return on the investment (several decades). Thus, a high level of grant aid is necessary (electrical grids are often subsidised to a level of over 50 percent, sometimes as high as 80 percent, regardless of the country). Wind and solar power generation systems likewise have long investment return intervals (in excess of 20 years), so it will be necessary to look for capital grants. Nevertheless, with the soaring cost of fossil fuels, return intervals are tending to become shorter.

- Stakeholder involvement:
Sustainability can only be achieved if there is good local ownership of the project, which means there must be considerable local involvement in project implementation and supervision, along with thorough training of operators and maintenance technicians sourced in the country.

Positive and negative impacts, risks

Economic

- ⬆ Productive activity creation (handicraft, business) made possible by electricity: jobs, incomes.
- ⬆ Establishment of a company to operate the facility (jobs at the management and technical staff level).
- ⬆ Households see their energy bill drop or have better control over it (batteries, recharging, etc.) Other Fact Sheets highlight here the negative side of the financial mechanism.

Social, health, and safety

- ⬆ It is safer to go out at night (street lighting).
- ⬆ Public facilities, such as birth centres and health centres, have refrigeration and lighting.
- ⬆ Household safety: no more risk of fire from oil lamps.
- ⬆ Improvement of home lighting: comfort level, school homework, revenue-generating work can be performed at home.
- ⬆ Access to means of communication: radio, television, cell phones, etc.

Environmental

- ⬆ Reduction of greenhouse gas emissions (diesel and lamp oil are replaced).
- ⬆ ⬇ Reduction of pollution: fewer individual batteries. However, recycling the batteries or cells used in a wind or solar power plant is in an environmental problem that must be addressed.

CONTRIBUTING TO CLIMATE CHANGE MITIGATION

Issues and turning emissions reductions to account

Projects for the distribution of small wind or solar powered generating stations are eligible as Clean Development Mechanisms (CDM) where small-scale type I "Renewable Energy" projects are involved in which the installed capacity does not exceed 15 mW. Formulae for calculating emission reductions are provided in AMS-I.A "Electricity generation by the user" and AMS-I.D "Grid connected renewable electricity generation[2]."

Illustration: Wind farm for electricity generation in Brazil

At time of writing, a number of examples of CDP "wind-powered" projects (or projects on the voluntary market) illustrate the possibility of delivering the electricity produced to so-called "interconnecting" regional or national distribution grids. They do not fully capture the intent of the facilities outlined in this Fact Sheet that enable electricity production in enclaves deprived of access to interconnecting networks. However, one example is given to show an order of magnitude for emission reductions obtainable by a wind farm.

For projects that are based on photovoltaic cells, please see Fact Sheet 1.4 Photovoltaic battery kits.

Project title: Horizonte Wind Power Generation Project
Project status: CDM
Source of information: CCNUCC, www.unfccc.org
Type of carbon credit: Certified Emission Reduction Units (CERU)
Methodology: AMS-I.D Grid connected renewable electricity generation
Credit accounting period: 2004-2011

Context and principle for emissions reductions

The home of this project is Santa Catarina State, in Brazil's extreme south. It has 8 windmills with an individual turbine power generating capacity of 600 kW. The total installed power output of the station is 4.8 mW. The electricity generated is distributed over the regional grid and substitutes for electricity generated from fossil fuels (coal and oil).

ER estimates

An average saving of 6,230 t CO_2 equivalent a year is realized from the 8 wind-powered turbines.

2. Available on the United Nations Framework Convention on Climate Change (CCNUCC) website: www.unfccc.org.

CASE STUDY

PROJECT TITLE: SOLAR POWERED VILLAGE GRID IN KIMPARANA, MALI

Project funded by: SSD-FRES (affiliate of NUON-Netherlands), AMADER (Mali), SSD YEELEN KURA (Mali, affiliate of EDF and NUON)
Operator: SSD Yeelen Kura
Partner: AMADER
Implementation date: Starting in 2008
Budget: 528 million CFA francs
Beneficiaries: The 6,400 inhabitants of Kimparana

Solar power plant in Kimparana, Mali: battery setup (©Yeelen Kura)

Solar power plant in Kimparana, Mali (©Yeelen Kura)

Context

Kimparana is a sub-prefecture in the Ségou region of Mali, where cotton is grown. It is part of a vast village electricity distribution programme led by the Malian Agency for the Development of Household Energy and Rural Electrification (Agence malienne pour le développement de l'énergie domestique et de l'électrification rurale - AMADER). The thrust is the implantation of gen-sets (some fired experimentally by agrofuels), but also includes some with photovoltaic cells and one solar power plant on the Kimparana site.

Activities implemented by the project

The facility host and operator is Yeelen Kura, a decentralised services company with a mandate to bring electricity to 22 towns in the region. It has been operating 1,400 solar cell kits since 2002 (see Fact Sheet 2.4 Photovoltaic battery kits).
The project focus is electrification of the town by setting up a low voltage distribution grid to serve 500 homes (217 by the time the project was up and running in 2008). The grid is supplied by a 72-kW solar power plant that generates 86 mWh/year available to users. The system has a backup gen-set.
Electricity service is provided to both household and production customers. Daily operating hours are from 10 a.m. to midnight.

Something to keep an eye on…

The plant became operational in spring 2008 and a preliminary assessment report should be available by 2010.

For more information

Bibliography:

Rural Electrification by Renewable Energies in Sub-Saharan Africa – 2007. FONDEM publication, available on line at www.areneidf.org.

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Websites:

Light Up the World Foundation: http://www.lutw.org

Heat needs of small enterprises and public services

> **Related Fact Sheet:** *Fact Sheet 1.1 - Fuel-efficient cooking and biomass energy*

Many different processing activities in rural communities have a need for energy, mainly to produce heat. Public services and larger economic units functioning in urban areas have a similar need.

Ever stronger pressure is being put on *biomass energy* (coal, wood, agriculture waste, etc.) due to the increase in the price of fossil fuels. Where management of the biomass is not properly exercised at the national level, forest destruction is exacerbated. Giving attention to equipment performance is a straightforward way of dealing with the problem (in keeping with the financial capacity of the units), with resultant fuel savings in the order of 30 to 50 percent. Development stakeholders often play a crucial role in developing technology, setting up pilot sites and putting in place a sector support mechanism. This makes it easier to hand over the baton, as it were, to the private sector and apply for assistance from conventional funding agencies that are better positioned to fund subsequent extension phases. This fact sheet will review different things that can be done to provide incentives for small enterprises and public services to use energy more efficiently in their activities that require heat.

HEATING NEEDS OF SMALL ENTERPRISES AND PUBLIC SERVICES

Impacts and constraints

Three main categories in developing countries are concerned with the need to produce heat, requiring average power output:
- Family units involved in agri-food processing.
- Public services or institutions (usually for large-capacity cooking).
- Production units operating on a larger scale.

Family units

Rural communities are home to individual families that carry on many different ancillary activities to augment their cash income from agriculture production. For the most part, such activities involve agri-food processing such as milling or hulling locally grown grain, smoking, distilling, pasteurising, jam making, small-scale food services, etc. Heating requirements take various forms: steam for curing or processing, low or high volume cooking, or keeping food hot for extended periods.

Appliances are often of a makeshift sort, made from locally available materials. Low-cost biomass (agricultural waste, sawdust, local wood, etc.) is used for fuel. Combustion technology may amount to no more than the three-stone cookstove with or without a grate. Performance is poor, around 20 to 30 percent, with a power generation of around 10 to 50 kW.

Family units belong to an informal sector that receives little support from public authorities. Furthermore, there is little incentive to improve things because production costs are low, poor quality is tolerated on the local or national market (no food labelling is involved, the market is haphazard). Working conditions are often hostile (low level of workplace mechanisation and ergonomics, smoke-filled working environment, high temperatures, etc.).

Public services

This heading covers institutional establishments such as training centres, orphanages, prisons, religious centres, and health centres. Their main need for heat is high-volume food cooking or medical equipment sterilisation.
Appliances are similar to those used by families who do small-scale food processing and their performance is likewise about 30 percent. The power range may be between 10 and 50 kW. Little attention is given to workplace ergonomics and the working environment is smoke-filled.
The financial capacity of such public services depends on the budget given them by the government ministry having jurisdiction over them. Biomass is usually purchased on the basis of a yearly contract with wholesalers. In some cases, the institutions may have a place for fuel storage (where wood may be dried).

Larger scale production units or services

Production units under this heading include brick and pottery manufacturers as well as textile industries that do cloth dyeing and washing. As for service establishments, examples of such include the Hamman public baths common in northwestern Africa. The power range required by such facilities is around 100 to 500 kW, thus higher than that of the previously mentioned categories.

Technology varies, but the equipment used is by and large of low energy efficiency. Technological alternatives are indeed available and generally accessible to these types of businesses. Improvement efforts lie mainly in the hands of the people managing the facilities. Their location in urban or peri-urban areas can be a major source of air pollution. Pottery-making enterprises often fire their kilns with tyres or used motor oil. Low-temperature, incomplete combustion of such materials generates a high level of pollution. The source of the pollution may not be managed, but an attempt is sometimes made, as seen in Morocco, to reduce nuisance in the immediate neighbourhood, such as by putting high chimneys on the wood-fired boilers of the Hamman bathhouses to take away the smoke.

Technical alternatives for family units

Using more energy-efficient appliances

In this informal sector, work is done to order and not generally very well structured. A simple approach is to promote the use of more energy-efficient appliances (see Fact Sheet 1.1 - Fuel-efficient cooking), which may require a financial support package to assist with the capital cost.

Furthermore, the design of the new equipment should be such that the end product is improved. Cooking, for instance, can be made easier and more energy efficient through more precise temperature control, 'smoke flavour' can be eliminated from food, and more appropriate kitchen utensils can be used.

Regarding the aspect of energy efficiency, it is best to work with institutional equipment on the basis of a mutualisation of activities rather than providing many individual units. Using the same technology, greater fuel savings can be realised with a group equipment provision, as downtime and heat loss through external surfaces are reduced.

Modifying the manufacturing process

An approach that does not entail any modification of the cooking or heat-producing equipment itself requires intervention at the level of the manufacturing process. For example, for brick baking, it is advisable to use hollow clay bricks or add small-particle combustible material (coal dust, rice chaff, or sawdust) to the clay. Not only does this procedure yield a 20- to 30 percent energy saving, but also the bricks have stronger mechanical properties due to their being baked to the core. The same principles apply to agri-food processing operations. These may be altered to include a blanching phase, cutting the item to be processed into smaller pieces or grinding it to start with, in order to cut down on the amount of energy needed in the remaining processing phases.

Taking a holistic approach

It must nevertheless be acknowledged that improved equipment is but part of the solution in the quest for sustainability. The whole commodity chain must be studied out. A holistic approach will seek to improve the quality of the end product, giving it added value at the selling stage. Producers may have to be repositioned with regard to middlemen. It may be advisable to set up a co-op type organisation to manage access to fuel, raw materials, and production tools. Other challenges may have to be overcome in the production stream in addition to resolving the energy aspect (providing potter's wheels equipped with ball-bearings, equipment for mixing clay, sheds for drying, etc.).

Making good use of combustible waste

One meaningful option for these units is to make good use of waste from food preparation (coconut husks, groundnut shells, corncobs, sugar cane fibre, mango pits, etc.) for fuel. If some of these materials have too high a moisture content to be burned directly, a good alternative may be to use a digester to produce biogas from the regular supply of fermentable waste (see Fact Sheet 4.3 – Family biogas systems).

Technical alternatives for public services

For institutional cooking, similar technologies to those already described may be used, although the approach will differ. It is assumed that one or more demonstration sites have been successfully set up. The next step is to enter negotiations at the provincial or national level to garner the support of the public authorities. This approach is intended to facilitate equipment standardisation and thus guarantee broad distribution and consistency in performance.

Technical alternatives for small enterprises requiring a higher power range

Choice of fuel a primary concern

Where factors such as affordability and customer concentration are not an issue, the approach will focus primarily on choice of fuel. Supply security is more important than opportunistic procurement. The fuel must have a low environmental impact and, if possible, create job opportunities and local added value. This means selecting the fuel in the light of a number of criteria, including the price for a payload kWh, effect on forest destruction, employment generation in the industry, local added value, air pollution, security of access, price fluctuation, mid-term price performance, and so on.

The fuel type that best meets all of these requirements is often unused biomass waste (rice chaff, plant or tree trimmings, olive husks, sugar cane fibre, etc.). Where such is available, the supply chain will require structuring and technologies enabling its energy potential to be tapped need to be introduced (see Fact Sheet 4.1 - Charcoal briquettes from farming residues).

These units should be located where there is a local supply of raw materials and long-term access to the fuel they require. For example, brick-making enterprises set up near rice hulling operations will have a ready supply of low-cost rice chaff available.

Fuel-efficient technologies

Developed countries have all but abandoned technology involving vertical shaft combustion on a grate as requirements regarding the quality of smoke or fume emissions rule it out. Biomass combustion conditions have been optimised (separate control for primary air and secondary air, high combustion temperature, no lower than 900°C).

Fuel switching

Where other alternatives are not possible due to a lack of local biomass resources, the only choice may be fossil fuel, at least as a stopgap measure, given the difficult choice confronting developing countries that do not have their own resources to draw from. Where there is no alternative, an effort must be made to facilitate introduction of fuel-efficient technologies, such as using throwaway coal dust or coal slag, but being sure not to use poor quality coal slag with the inefficient burners of traditional cookstoves.

Liquefied petroleum gas or GPL is the most relevant replacement fuel because of its high combustion performance, low cost, and low pollution characteristics. It can be used in many different ways as long as the cost of the end product is consistent with the market involved. A case in point is mango drying using high-performance recirculation dryers in Sahel countries. Mango is very difficult to dry, but energy consumption can easily be cut in half when gas dryers are used and the end product is of optimum quality. An export industry has now been developed, but it can only remain viable to the extent that the price of gas remains stationary in the regions concerned.

Combined heat and power generation

Some types of production units, especially in a rural context, dictate the choice of a system that combines heat and power generation. Three quarters of the energy payload may be devoted to heat production (steam, cooking, etc.) and the remainder for electricity production, supplying a local mini-grid, for example.

Challenges for development stakeholders

Energy choices and technical alternatives for small enterprises and public services can have a major impact on the problems of pollution, forest destruction, resource wastage, etc.

Development stakeholders in the form of NGOs or funding agencies are called upon to coach projects and support the decision-making process of small enterprises and public services in such areas as:

- Smart management of combustible biomass waste and setting up energy farms.
- Technology transfer for energy-efficient, low pollution appliances.
- Raising awareness through setting up training centres and demonstration sites.
- Promoting access to funding mechanisms that enable technology transfer (loans, funding mechanisms under the Kyoto Protocol, such as the Clean Development Mechanism).

The public authorities have a role to play in:

- Strategic planning of energy choices at the national level by seeing to consistent distribution of existing energy resources used.
- Standardisation of energy-efficient appliances.
- Establishing a tax system that encourages use of renewable biomass and energy savings (tax credit, tax abatement, etc.).
- Support to analytical thinking at the sector level (task force, research) on the energy needs of small enterprises and public services, with a focus on technology watch, fuel diversification, making better use of biomass waste, or carrying out impact studies.

Specific working procedures

Projects targeting the private sector and public services need to be aware of and work along with the way these units operate. This may mean implementing working procedures such as sister or service companies in order to promote the structuring of supply chains or the long-term viability of public services.

Sharing risks among small enterprises by setting up a sister company

Establishing a relay structure is of crucial importance in marketing energy-efficient products (see "upstream management" case study). This may take the form of a sister company under the control of the development operator (NGO, technical cooperation agency, etc.). Its goal is to market high-quality equipment items with a profit margin, where feasible, so that extension is possible and the viability of family units engaged in production is ensured. The specific legal status that such a structure would have varies from country to country. Where there is no specific status, it could be a registered private business. It would assume the risks of introducing a new technology and facilitate distribution of high-performance, durable equipment. This is a powerful tool for supply chain organisation that eliminates middlemen, thus guaranteeing a fair determination of the end price.

The business could target the informal small-scale family production sector, for instance, wherein money for large investments is usually hard to come by. A financial risk may be involved due to the newness of the concept or equipment. But this is a way of breaking the poverty cycle caused by low investment capacity, unfamiliarity with the market, lack of supply chain organisation, etc. Focus is put on more productive activities using high-performance, low pollution equipment.

This approach may prove to be more effective than imposing a collectivisation of production tools, which often results in conflicts. Technology transfer based on such an approach does not seem suited to the informal sector.

Setting a company for public services

Where there is a high demand for heat, this activity can be organised in the form of energy service suppliers, as is routinely done for heating plants in industrialised countries (hospitals, hotels, swimming pools, residences). The most representative example is the Hamman public baths in urban centres of the Maghreb. Morocco alone has over 5,000 such facilities, each one consuming at least 200 tonnes of wood per year. Managers of such establishments cannot afford the required renovation of their boiler systems to cope with the increased cost of wood and the pollution problems spawned by these systems. The best approach to technology transfer is for the public authorities to introduce a system of energy service companies charged with managing public service equipment and their energy consumption. These companies could operate on a results-oriented basis, with their own profit tied to fuel savings. This is an incentive for them to promote the introduction of high-performance boiler plants, train their personnel, and regularly monitor equipment performance. Such companies could thus become specialised as the need be: heating, water network control, etc.

Traditional Hamman boiler plant in Morocco

DEVELOPING A PROJECT APPROACH

Study the heat needs of the small enterprise and public service sector

The initial diagnostic analysis will enable identification of opportunities and constraints regarding the use of high-performance equipment. The tools and/or steps of the diagnostic analysis can be listed as follows:

Choice of the intervention zone

The site must provide a demonstration and be representative of other public services or small enterprises in the sector and be easy to access, with the people in charge open to innovation and able to play a key role in subsequent steps (training, demonstration). Feasibility of the long-term fuel supply is one of the main factors to take into consideration (availability of a fuel source not currently being tapped).

Description of the industry

Each small enterprise has its place in an industry characterised by the raw materials it uses (clay, meat, grain, or the like), its production tools, organisation, seasonal patterns, distribution and sales channel, set of problems currently confronting it (competition, standards, access to sound markets, diversification, cost of fuel, etc.), and present trends (positive or negative growth). The diagnostic analysis must identify the issues and priorities facing the industry stakeholders based on surveys, production unit monitoring, meetings with industry leaders and representatives, etc.

Identifying priorities in conjunction with the interested parties

The choice of intervention priorities must be made with those who manage the small enterprises or public services by highlighting the crucial points gleaned from the diagnostic analysis, articulating them clearly (calculation of production cost, long-term projections, various scenarios arising from different technologies, organisation and impact on productivity, hourly wages, end price, etc.). During feedback meetings, a priority-driven action plan will be drawn up jointly, including such things as the choice of pilot sites for kicking off the anticipated actions.

Choice of fuel

The following aspects will need to be considered: price of the payload kWh, control of forest destruction, job creation, local added value, air pollution, security of access, price fluctuation, and mid-term price evolution.

Choice of equipment or technological adaptation

The size of the equipment will depend on its energy functions, i.e. required output, service life, specificities of the heat transfer, anticipated yield, combustion quality, etc. A number of financial constraints must also be addressed, governed by the type of available materials, user friendliness, ease of upkeep, local climate conditions, level of standardisation, and availability of electricity.
A hard choice will have to be made between monofunctional, low-performance equipment that may be easy to use or multipurpose equipment with a higher heat transfer ratio, hence better performing and more complex to design, but that can be adapted perfectly to the context in which it is to be used.

Implementing appropriate technical solutions

Targets:

Small enterprises and public services.

Technological maturity:

Improved cooking techniques and the introduction of high-performance equipment require technology transfer. According to the context, this transfer can take place right in the country or be brought in from a country with a similar context. Or it may mean adapting an industry-level technology to a medium-size production setting (scale reduction, use of local materials and skills, simplification of equipment control or monitoring devices).

If technology transfer has to be brought in, certain precautions are in order. It is not advisable to simply copy equipment plans, drop in for a visit and start implementing the project on one's own. It is better to call upon an experienced distribution expert from the host country (such as a designer or builder). In this way, a high-performance model can be developed and pitfalls avoided (choice of proper materials, construction skills, correct size, etc.). Construction of the first model can provide an opportunity to open a work-site school where local builders can receive hands-on training.

Essential aspects of project guidance:

When the initial diagnostic analysis confirms the value of supporting a small enterprise or public service to improve its conversion processes and/or introduce energy-efficient equipment, the project steps will be as follows:

- Design and validation of prototypes:
Designing and validation of a new item of equipment first of all requires laboratory testing and approval of prototypes (boiler plant, efficient kiln burner, etc.) in order to get a proper grasp of the parameters that affect their performance and fine-tune them.

- Implementation on a pilot site:
Once the laboratory work has been completed, use of the equipment on a pilot site will make it possible to validate how it should be used, the production rate, quality of the end product, user friendliness, ergonomics, and performance (specific consumption, fuel saved for a similar service delivery). Definition of testing protocols enables various installation types to be compared.

- Monitoring and assessment:
Monitoring the equipment in actual use on a site enables analysis of equipment performance through an evaluation of fuel volumes consumed, cooking temperatures, user friendliness, and the end quality of the processed product. Monitoring is also done by measuring certain parameters as well as surveying users regarding their level of satisfaction with the equipment. In this way, changes can be made to the technologies proposed so they can be adapted to their context and thus achieve optimum performance.

- Distribution phase:
The distribution phase follows on-site validation of the equipment. An initial step of standardisation comes in here. This does not mean centralising production, but rather holding to a stringent set of specifications and efficiency control procedures. Prototype boiler plants, efficient cooking burners, etc., are tested and proven on pilot sites, then standardised prior to wider distribution.

The do-it-yourself approach to equipment production is not recommended here because performance can vary and too much is required by way of human resources to give individual training to each future user. The emergence of one or more production units will be facilitated, thus building up a local skills base with a small number of builders who will get a proper handle on the final performance level of the equipment.

Project duration:

For a project focusing on energy demand (equipment and manufacturing processes), the project would vary in length depending on the initial context and degree of maturity of the technology that is being introduced.

Generally speaking, for a project requiring validation of a new technology, a pilot phase of two or three years is needed so that initial lessons can be drawn. Where seasonality is involved in certain manufacturing processes, especially in agro-industry, slowdown times also enter into the picture.

When a large distribution phase is involved that will have a strong impact on the whole sector involved, at least ten years will be necessary to complete the project. Furthermore, the distribution component will require considerable financial resources.

Skills required:

This type of project requires a multi-disciplinary team that will have the following challenges to overcome:

- Combustion-heat transfer technology: making good use of materials and biomass waste, performance testing methodology, definition of experimental plans and metrology, computer integrated manufacturing.
- Industry structuring, participatory approach, quality control procedure, distribution follow-up.
- Marketing.
- Commercialisation.

Sustainability:

Some associated measures will contribute to project sustainability:

- Promotion of products made from energy-efficient equipment, highlighting their commercial image (specific label, industry certification).

- Organisation through the setting up of industry sector associations of farmer-producers, equipment distributors, and end product retailers.

Positive and negative impacts, risks

Economic and social

- ⬆ Establishment or consolidation of a high-performance, energy-efficient equipment production industry, increase in national added value, acquisition of new skills.
- ⬆ Greater energy independence due to use of energy available within the country (trade balance, currency purchase).
- ⬆ Increased productivity of high-performance, energy-efficient units (reduction of fuel costs), improved viability of the unit in the face of rising fuel costs.
- ⬆ Positive effect on health due to the reduction of polluting emissions.
- ⬇ Risk of the cost of improving energy efficiency being carried over to end product price.
- ⬇ Risk of some small enterprises being privileged unfairly if the transfer is not made accessible to all.

Environmental

With the use of better performing equipment and/or turning agriculture residues (waste from the renewable biomass) to account:

- ⬆ Reduced pollution.
- ⬆ Reduced forest destruction caused by the growing needs of small enterprises and public services for fuel wood.
- ⬆ Saving of fossil fuels or fuels from the *non-renewable biomass* and thereby a reduction of greenhouse gas emissions and a contribution to combating climate change.

CONTRIBUTING TO CLIMATE CHANGE MITIGATION

Measures to improve cooking techniques and the introduction of high-performance equipment have a positive impact on climate change. Projects including such measures may therefore be eligible under the Clean Development Mechanism (CDM) and/or voluntary exchange market. Depending on the scope of the improvement measures undertaken, CDM methodologies for calculating GHG reduction are available, summarised as follows:

Improved efficiency of fossil fuel use

This area involves projects that call for the introduction of energy-efficient devices such as low-energy lamps, neon lights, refrigerators, motors, fans, air conditioners, etc. on many sites. These technologies are expected to replace existing equipment or be installed on new sites. The AMS-II.C "Demand-side energy efficiency activities for specific technologies" methodology provides formulae for calculating emissions reduction.

Improved efficiency of non-renewable biomass use

This provision is for projects that cut down on use of the non-renewable biomass. The AMS-II.G "Energy Efficiency Measures in Thermal Applications of Non-Renewable Biomass"[1] methodology provides formulae for calculating emissions reduction. The area covered is the introduction of high-performance, energy-efficient cooking or baking appliances (cookstoves, ovens) and dryers that operate on biomass energy.

Fuel switch

Switching from fossil fuel to another lower-emission fossil fuel

This may involve conversion from oil to natural gas. Natural gas produces less GHG for the same amount of energy produced. The AMS III.3B "Switching fossil fuels" methodology contains guidelines for calculating reductions in the industry, residential, commercial and institutional sector or for electricity production.

Switching from fossil fuel to renewable energy

The renewable energy may be hydro or solar power, as well as from use of biomass waste (rice chaff, wood chips, sawdust, etc.) or organic waste (biogas system). The AMS I.A "Electricity generation by the user" methodology provides guidelines for calculating the emissions reduction for an electricity generating project based on a renewable energy source. In our case, this can apply to agro-industries that turn their waste to account (combustion, gasification) and capture the electricity produced for their own energy needs or to supply a local grid.

Switching from non-renewable biomass to renewable energy

The AMS I.E "Switch from Non-Renewable Biomass for Thermal Applications by the User" methodology makes provision for this possibility for thermal uses of energy. Replacement energies may be from solar power or biogas systems.

1. Available on the *UNFCCC* website: www.unfccc.org.

CASE STUDY

SETTING UP AN ENERGY-EFFICIENT PALM SUGAR INDUSTRY IN CAMBODIA

Project funded by: European Commission, World Bank, Ensemble Foundation, sale of carbon credits (VERU)
Scope: Pilot project with an annual budget below € 50,000
Operator: GERES Cambodia, www.geres-cambodia.org
Main partner: DATe (Cambodian NGO), national NGO network (WENetCam)
Technological partner: Planète Bois
Implementation date: Started in 2000, ongoing
Number of potential beneficiaries: 5,000 families

Context

Palm sugar production is a traditional activity in Cambodia's rural communities. Palm sap is first collected from the crown of the sugar palm tree. The sap is very unstable and becomes unfit for consumption (fast-working fermentation) just a few hours after being tapped and must therefore quickly be boiled. After 85 percent of the water content has evaporated off, a brown-coloured sugar paste remains, which has a shelf life of six months. The paste, sold in local markets, is very popular with Cambodian consumers. Palm sugar production is facing a stiff threat due to increasing difficulty in finding a biomass energy supply. Furthermore, the quality of the finished product is often inconsistent (due to sap fermenting prior to boiling, presence of a smoke taste, browning or scorching of the sugar at the final stage).
It is estimated countrywide that 20,000 families in Cambodia produce palm sugar. They are among the lowest income earners in the country.
Palm sugar production is one of the few activities accessible to farmer families that can generate a cash income. Furthermore, it fits in well with the rice-growing calendar, as these activities follow one another in time with no overlapping.

Step 1: Minimalist approach and its limits

The project focused on the province of Kampong Chhnang, 60 km north of Phnom Penh. The first step was to implement a conventional approach in the context of an informal industry with a low profit margin, i.e. test out a low-cost burner (€ 6-8) and provide training in its construction and upkeep. The burner simply improved heat transfer, not the quality of combustion. It was moderately successful to the extent that fuel costs could be cut by about 20 percent. However, its distribution required a great deal of coaching. Moreover, because the venture was not involved in marketing quality palm sugar, it was merely a temporary solution, not something that could take this industry beyond the level of a subsistence economy and make it into a long-term source of supplementary income. Further innovation involving combustion quality had to stop at this point because of inadequate investment capacity. The short service life of the equipment limited the dynamics and hence sustainability. The impact on decreased forest destruction remained low because of the absence of a mechanism to manage the biomass that is taken from it.

Sugar palm trees

Step 2: An approach focusing on management of downstream results

In order to secure the survival potential of this traditional industry, it was decided to provide more extensive support and coach it from a professional standpoint.

- Managing the end quality of the sugar and supporting the marketing process
Work was done to improve the sugar production process in order to make sure the palm sap did not ferment, control the boiling process (bring the sap to a boil quickly and limit sugar browning), eliminate smoke flavour, and develop a method of producing sugar in granulated form which is easier to market than the traditional paste.
Work was done to promote a quality product with a view to entrenching it in national and regional markets, thus making the industry viable. A parallel project is also underway to have Cambodian palm sugar come under a registered label of origin or geographical indication.

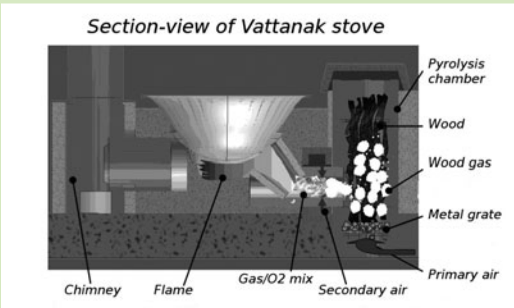
Boiling down sap from the sugar palm

SUITE >>>

CASE STUDY

- Designing more efficient equipment
The technology used for the stove (high-performance inverted lateral combustion) was developed by Planète Bois and enables optimisation of biomass fuel combustion. It promotes high combustion temperatures, which significantly decreases fine particles and carbon monoxide (products of incomplete combustion). This new stove concept is very user friendly. Combustion is stable and the working environment is healthier with the absence of fumes and the temperature around the stove not being excessively high. The most common model now distributed to sugar producers has been dubbed the Vattanak stove.

The Vattanak stove, a high-performance cooker for palm sugar making



Schematic operation of the Vattanak stove

- Distribution of standardised equipment
The stove is built from a kit containing prefabricated ceramic parts, which facilitates standardised production and distribution that can be managed locally. This stove costs € 35 to produce, while a traditional stove comes to about € 50. The leading objective of transferring low-cost, state-of-the-art technology has already been achieved.

- Setting up a sister company
GERES Cambodia is setting up a sister company to support marketing of products made using this energy-efficient method. Palm sugar is the first product being handled. This initiative is opening up new prospects for producers who comply with clearly indicated specifications (use of an energy-efficient stove, production of quality sugar, minimum yearly production quota, etc.). The price paid to the producer is an incentive for him to get into the system because of its higher profit margin. The sister company can compensate for the cost of acquiring an energy-efficient stove due to the final selling price fetched by quality sugar. Profits are channelled to stove distribution and increasing quality sugar production.

Outcomes

Distribution targets are tied in with the marketing capacity of the sister company. The loss leader is the Vattanak stove for many producers interested in getting one. A goal of 1,000 stoves has been set. New life is being injected into the Cambodian palm sugar industry. The project's aim is to maintain the industry while effecting a maximum reduction of its environmental impact.

For more information
Websites:
Introduction to vertical shaft brick kilns (VSBK): www.vsbkindia.org
Information on do-it-yourself biomass burning cookstoves: www.bioenergylists.org
GERES Cambodia: www.geres-cambodia.org

MULTIFUNCTIONAL PLATFORMS

> **Related Fact Sheets :** *Fact sheet 3.1 Local production of agrofuels, Fact sheet 3.2 Small and micro water power stations, Fact sheet 3.3 Small solar and wind power plants*

Rural populations in developing countries suffer from a limited access to basic services such as water, modern lighting, or more generally, electricity. Access to these services is closely linked to the availability of energy sources (wood, charcoal) or to their supplying, which is more or less regular and costly if the areas are isolated (diesel oil, gas). Nevertheless, the development of suitable energy services is an essential condition not only to the satisfaction of fundamental needs but also to the increase in importance of productive activities such as the transformation and conservation of cereals, which enable a greater added value and are the only guarantee for a long-term rural development dynamic.

Nevertheless, there are two aspects which limit their development. The first comes from the difficulty to keep perennial services, both from a technical and financial point of view. In contexts with poverty and a lack of education, the experience proves that it's difficult to develop this type of activities. The second one is the difficulty to connect these services to clean energy sources. Then, they are pollution sources.

One of the solutions offered nowadays consists in introducing energy service companies in rural areas; they are called Multifunctional Platforms (MFP). They enable to centralise mechanisation activities within one and only platform. This system offers a complete range of energy services and furthermore, it improves the optimised management of energy.

Results in Western Africa are encouraging and invite to keep on with the dissemination of these tools. Nevertheless, the first results show that success conditions are based on an initial structured support, which gives room for the actions of organisations such as NGOs.

MFP, A KEY ENERGY SERVICE FOR RURAL AREAS

Challenge of mechanisation for development

Technical evolutions regarding mechanisation enabled the popularisation of neighbourhood mills as service providers. This evolution is limited to big cities and to the grinding operation, and also depends on diesel oil as energy source in most cases. There is a risk that, in rural areas, food handicraft would work mostly thanks to human energy and would need a lot of workforce.

Village woman using a pestle to grind shear (©UNDP)

Thus in African rural areas, the most common technique to transform cereals and tubers is still the use of mortar and pestle. These tasks are generally performed by women who spend a lot of time doing it.

The situation's direct consequences are:

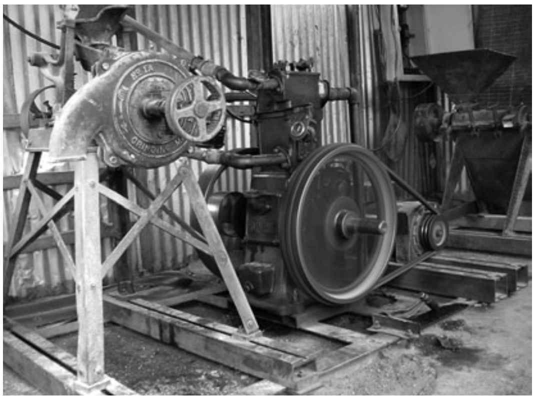
- hard living conditions for women (up to 18 hours of work per day);
- immobilization of workforce. Hence, women can't spend more time on gardening, nor girls can go to school, which is a necessary condition to the improvement of their situation;
- low level of food conservation due to a basic transformation.

Furthermore, the connection of energy services to clean energy sources is not usual. Craftsmen often have to use heat engines, which are strong but very polluting.

The implementation of MFP rural companies, initiated by the United Nations Development Programme (UNPD) and adapted by other organisations, has two objectives: first, the mechanisation of hard works performed by women (in particular cereal grinding and water transport), and second, the sustainable access to model energy services (milling, battery charge, etc.).

MFP general principles

A platform is made up of an element which supplies driving energy (engine, generator, electric connection), which directly activates several tools (mill, sheller, battery charger, etc.). It is conceived to optimise the energy source use, and can thus work regularly and in better conditions.



(©UNDP)

Today, the main energy source used for the functioning of MFP is diesel oil. In some cases, it can be coupled together with a micro-hydraulic installation which enables a clean functioning. Finally, substitution of diesel oil by a locally available agrofuel is now being considered. For example, pourghere oil in Africa can be a substitute for diesel with a prior modification of the engine. Pilot projects are under way in Mali and Benin for instance, to combine the introduction of platforms to the organisation of the local pourghere production. In any case, these alternative energies have the advantage of preventing the users from depending on the fossil energy price increase (especially diesel oil). They also represent a neutral platform functioning balance regarding GHG emissions.

In any case, MFP enables the optimisation of energy use for the performance of various tasks, which is a key factor for the installation's perpetuation on the long-term. That's why MFP is often considered as an energy service company in rural areas. MFP concept thus constitutes a technical solution which can be easily adapted and which uses locally available technologies.

Challenge for development stakeholders

The development stakeholders' actions are divided in two types of action:

- Guidance and support to the project bearers and beneficiaries:
  MFP concept requires the implementation of consultation frames, use of tools and trainings.

- Implementation of financial solutions:
  The question is to support both the investment and the platforms' day-to-day management (maintenance). Part of the equipment purchase can be subsidised. Micro-credit organisations can also be associated to the MFP financing.

Public authorities can integrate the MFP tool when defining policies of access to energy in rural areas.

DEVELOPING A PROJECT APPROACH

Feasibility study

Pre-selection of an action area

The action is meant for isolated areas which need to improve their access to energy services. The choice needs to take two other points into account:
- The population must express their need for this new tool,
- They must be ready to organise in groups (in the case of collective management of the platform) in order to be able to be a stakeholder in the project, especially women who are the first concerned by the reduction of their work hardness.

Analysis of the needs and economic viability of the platform company

The operation success firstly depends on economic and social criteria. The study should enable to analyse the needs of various target groups in the target area. Are there enough to guarantee the profitable functioning of the energy services to be installed? Furthermore, are the socio-organisational factors favourable to the insertion and perpetuation of the platform?
To do so, a participative diagnosis can be used, also called participative feasibility study (PFS). The word "participative" implies an active collaboration with the villagers in the process, firstly with the future beneficiaries and stakeholders such as women groups. This makes the beneficiaries' individual and collective decision-making easier.
This approach is made up of four important steps:
- The village social and economic characterisation: available resources or capacities, existing associations;
- The sharing out of MFP project essential principles and the conditions of its implementation;
- The cross-checking of social observations made during the pre-study;
- The taking into account of the village needs to which the platform is an answer.

Village meeting during a participative feasibility study (©UNDP)

Dimensioning of the installation

The engine is the platform central element. Its adequate dimensioning enables to ensure all the modules will work correctly. Furthermore, the main cost being fuel or electricity, the engine efficiency will highly weight on the exploitation financial results. The engine choice requires to precisely forecast the installation functioning, establishing a model day if needed.

Support a MFP implementation

Targets:

An installation lifetime can be up to 20 years if the maintenance is correctly performed. The required power for a small installation is for instance a 10 CV engine.

Equipment functionality and performance:

A platform is made up of material whose technology is mastered. It's an engine which activates several modules such as a generator, a mill, a sheller.
When forecasting to supply the platform engine with agrofuel (straight vegetable oil), it implies that the engine has to be converted (see Fact sheet 3.1 Local production of agrofuels). Technology transfer must then be performed.
The tricky point doesn't stem from technological aspects but from organisational ones. Models suited for any situations have to be developed.

Essential aspects of project guidance:

MFPs are mainly meant for areas with little energy services, where the local populations' know-how can sometimes be inadequate to manage the equipments (whether technically or financially).

Hence, the main actions expected from external organisations aim at:

- Dimensioning the installation after the participative feasibility study (PFS) and assessing the final beneficiaries' financial capacities (see section "Feasibility study")

- Strengthening the project stakeholders' capacities through the identification and training of a manager (associative or private organisation):

Several management modes are possible, where the owners, users, managers would be companies, associations, cooperatives or else individuals. This choice must take into account the real situation (who has invested? who is managing the daily situation?).
In the case of collective management, the question is to support the creation of a management committee. It's made up of representative from the village (mainly women), and is in charge of organising the platform functioning and its financial management.
It's also about supporting the stakeholders in establishing the rates. These financial choices will define the project profitability. The price of services must take into account both the functioning cost but also the buying power of the rural areas' populations.

- Training technicians in the use and maintenance

The MFP targeted areas are isolated villages without short-term possibility of access to the network. It often corresponds to populations with too little experience or who don't have the sufficient business capacity to be able to directly manage a MFP. To reach this goal, it is then necessary to identify competent craftsmen able to ensure the equipment's maintenance and to guide them.

- Guiding income-generating activities

The proposition of new energy services enables, in theory, to diversify the communities' economic activities. Nevertheless, it's important to support the creation of these new activities (know-how, creation of new marketing sectors)

- Ensuring the MFP functioning monitoring

It's is hard to propose a model which can directly be adapted to the situation. In general, it's necessary to adjust the rates of the proposed services. It must be done in the frame of the monitoring part which enables to propose the services' assessment and evolution scenarios.

Project duration:

about 3 to 5 years. The 1st year enables the diagnosis and installation, and the 2nd year the setting in motion and training. The following years consist in a decreasing monitoring.

Required skills:

Rural development, participative meetings' coordination, competencies in mechanics for the platform dimensioning and implementation.

Sustainability:

It's important to ensure in-house training for the teams in charge of the platform maintenance. The presence of craftsmen ensuring the repairing of damaged pieces is also a technical insurance of the platform maintenance on the long term.
If external financing proves to be necessary to ensure the implementation, if not the activity launching, the MFP financial durability lays on the activity equilibrium, between receipts and expenses, which enables to anticipate the cost for the equipment break-down or replacement. As such, the possibility to connect the platform to a renewable energy source is a means to control energy costs (in comparison with a diesel oil scenario) and to improve the financial viability of the whole system.

Positive and negative impacts and risks

Economic

- ⬆ Creation of extra revenue for the management committee members or for the private manager. Extra appreciation for farmers who transform and obtain longer conservation products.
- ⬇ Competency of the platform with existing transformation services (milling and threshing mills, etc.).

Social and sanitary

- ↑ Job creation through the platform use (at least one manager and one technician, one miller), agricultural activity perpetuation (through the sales' improvement).
- ↑ Improvement of women' living conditions (substitution of hard works) and of girls' schooling (released from some tasks).
- ↑ Development of new energy services answering vital needs (drinking water conveyance, school lighting, literacy and health centres).
- ↓ Risk of conflict between the village groups, in case of non-recognition of the management committee, or after the choice of the platform place.

Environmental

- ↑ Better energy efficiency through the use of optimised energy sources.
- ↑ ↓ Increase of greenhouse gases (GHG) if the platform functions with a diesel oil generator. Neutral effect if the generator is supplied with agrofuels.

CONTRIBUTING TO CLIMATE CHANGE MITIGATION

In most cases, a multifunctional platform works with a fossil energy (generator with diesel oil, diesel engine). When it substitutes a manual work, it generates more greenhouse gases in the atmosphere.
Nevertheless, the implementation of minimum energy services in the poorest rural areas is an essential factor for human development. This example shows us that the "right to development" in Southern countries implies to recur to fossil energies and that it is more important than the fight against climate change.

Nevertheless, it's important to remember that a platform enables to rationalise energy use, for instance when it replaces individual mills. Then, for the same service, it is considered to represent a reduced energy cost, hence a reduction of GHG emissions.

Furthermore, as mentioned before, recurring to clean energy sources to supply the platforms is more and more frequent. They are mainly hydro-electricity and agrofuels. The development of a coupled system clean energy - MFP can indeed become extremely relevant and show very interesting complementarities.

Thus, coupling the creation of a MFP company with the installation of a hydraulic micro plant guarantees the regular use of the produced energy and the hydro installation profitability (see Fact sheet 3.2 Small and micro power stations).

In the same way, the MFP can be a part of an agrofuel production such as jatropha curcas oil (see fact sheet 3.1 Local production of agrofuels). A module enabling to press the seeds and extract the oil is installed in the MFP equipments. Furthermore, its engine is then supplied with jatropha oil instead of diesel oil.

Both energy supply options present a neutral greenhouse gases' emissions balance and encourages an economic system which doesn't depend on fossil energy price increase.

CASE STUDY

NATIONAL PROGRAM FOR MULTIFUNCTIONAL PLATFORM DISSEMINATION IN BURKINA FASO.

Execution date: Under way since 2004
Project funded by: The Republic of Mali, Aarhus United, Cooperation from Luxembourg, Bill & Melinda Gates Foundation, Shell Foundation, PNUD.
Project scope: large scope project with a budget between € 200,000 and 1,000,000 per year.
Operators: Tin Tua Association, Naam Groups National Federation, Group of 2 NGOs: ADIS/AMUS, OCADES
Partnership: Ministry of Finance
Project area: 7 regions are concerned by the project i.e. 27 provinces and 220 villages.
Beneficiaries: Population of 220 villages with an average of 260 clients per village [1]

Context

Burkina Faso is a Sahelian country in the heart of Western Africa with a population of about 13,730,000 inhabitants of whom 80% live in rural areas. These last years, it has known significant progress but the majority of the population is still in alarming poverty. In the definition of the priority axes of the Strategic Frame to Fight Poverty (SFFP) implemented by the government, a MFP pilot program was launched in the East of the country in 2000.

Project activities

- Implementation of equipments in target locations;
- Guidance for the development of economic activities around MFPs, especially the development of local services such as soldering, battery and cell phone charge, cooling, lighting, etc.;
- Strengthening of women's capacities in literacy and MFP company management.

Outcomes

At the current MFP dissemination stage, there are 7 regions benefiting from the program, 5 operational support-advice units within NGOs, 220 MFP installed, 7 lighting networks under way, 1 operational water network.

1. On the date of the guidebook's publishing

From the different analysis, the balance is positive from the economic and social point of view. Income-generating activities led by women prove to greatly improve the household living conditions.

For more information

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ENERGIA website: http://www.energia.org/
Access to energy services in Western Africa website: www.energie-omd.org

SECTION 4

WASTE AND RESIDUES VALORISATION

Processes to extract value from waste materials (anything that is disposed of) and by-products of human activities are generally both labour- and cost-intensive, and that makes it challenging to implement them in countries of the South. Turning waste materials to account involves salvaging, recycling or reprocessing operations, as well as the further effort to reuse the materials and/or capture energy from them. This is an opportunity to set up various handling channels, thus creating jobs; scare or valuable raw materials can be recovered.

ISSUES FOR DEVELOPING COUNTRIES

Difference between waste materials and by-products

Developing countries generally recycle and renew the value of by-products by using them in different ways. This is most often seen in the case of *biomass* residues that, depending on their nature, are reused as a source of energy (heating or electricity) or for agriculture applications (fertilizer, compost, animal feed), and there is a profit to be made in the process. This is true of agriculture waste such as rice chaff (by-product of rice hulling), corncobs or corn husks, or wood waste (chips, saw dust), coconut shells, etc.

However, it must be kept in mind that overall, waste materials/by-products are rarely freebies. They have an economic value because the work of salvaging them has direct or indirect costs.

The term "waste" carries the idea of something at the end of the line, i.e. something that has served its full useful purpose and has no more value[1]. This term is often used in the case of urban refuse, usually spoiled, or processing residues that may be contaminated or dangerous.

Difference between getting value from, recycling and disposal

The idea of extracting value from something infers a processing operation in which there is not necessarily any preservation of the material, at least in its initial form. For example, rice chaff is generally used as a household fuel for cooking or in kilns, thus to produce heat energy.

Recycling carries the idea of a processing operation where some or all of the material from the initial pro-

1. In English, waste is also comprehensive; it may indicate something that is unused or rejected in one operation but that it is possible to use in another capacity or under different circumstances.—Merriam-Webster's Unabridged Dictionary.

duct is preserved. Although it has become waste through use, it is made into new a product, identical or not. For example, plastic wrapping can be collected and factory reprocessed into "secondary raw materials" from which other plastic products can be made. In some LDCs, automobile tyres are often carefully cut into pieces and made into sandals. Other waste is often simply reused, such as glass or plastic bottles.

This section will primarily focus on operations to extract value from waste materials rather than recycling them.

Obviously, when it is not possible to extract value from or recycle a material, it has to be disposed of by burning or burial. In most developing countries burning simply takes place out in the open. The incineration process is not managed; combustion is partial and unconfined, which creates a serious environmental and health hazard. Similarly, waste burial in developing countries is not subject to handling regulations designed to prevent water, soil, and air pollution due to the release of leachate and toxic fumes.

Between handling costs and potential value

Limited access to technologies and skills, the lack of large private investors and the absence of a regulatory framework prevent developing countries from handling waste properly. Generally speaking, getting value from waste requires a costly investment, but it is economically viable to the extent that costs can be reduced, a profit can be made, or where it is promoted by institutional will.

There are two complementary channels for extracting value from biomass residues (in the energy and agriculture fields) that fit different settings and needs. Waste, although a bountiful source of energy, is currently still often underestimated, but it is getting more attention in the context of the need to diversify energy sources.

Environmental and health impacts

The notion of waste renewability, meaning in the human time line, is also important.

Thus, waste composed of non-renewable resources (plastic, metal, etc.) intrinsically has a dual impact on the environment. First, it consumes natural resources that are not regenerated (fossil energies, metals); second, it has a high potential for causing soil and/or air pollution in their waste state. Obviously, any effort to extract value from such waste through recycling is going to cost money.

On the other hand, waste items composed completely of renewable natural resources (sustainably managed biomass) will have a minor environmental impact because their chemical components will be reabsorbed and regenerated through natural cycles into new renewable resources. Less investment cost is needed to get value from this type of waste.

Waste management is a tremendous environmental and health issue for developing countries. Where a waste burial site is not properly managed, such as the very common open-air refuse dump, immediate soil, air, and water pollution is induced. Partial combustion of waste in an open fire, again all too common in developing countries, also induces a health risk due to massive smoke emissions that contain both pollutant gases and toxins.

ROLE OF DEVELOPMENT STAKEHOLDERS

Waste management in developing countries is chaotic, if it even exists. When one or more regional industry-level channels have been set up for waste handling or recycling (including border countries), management of the waste involved becomes organised because it is driven by the economic interest at stake, i.e. the cost of raw materials. Thus, metal, glass, paper/cardboard and some plastic waste items are generally recycled quite effectively. However, with the exception of these few throwaways, the lack of holistic management is the major obstacle to getting value from biomass residues. Yet, it is obvious that getting value from most waste materials has a high economic potential, especially if at the scale of a whole country. Moreover, the depletion of natural resources is an increasingly valid argument for setting up effective waste management systems.

Legislation is a necessary tool to provide an organised framework for industry channels as a whole and to ensure that people in developing lands get maximum benefit from them. The current informal framework is often dictated by immediate economic concerns, with little regard for the future.

In addition to a legal framework, intervention on the part of public authorities and development stakeholders is necessary on the following fronts:

- Making an assessment of the potential available and/or accessible from the waste pool.
- Leading an analytical thinking process on how to set up a waste-handling industry with operational arms designed to develop the energy and/or agriculture potential therein.
- Effecting a technology and/or skills transfer to get value from waste and for waste disposal.
- Implementing concrete measures in the areas of getting value from, recycling, and disposing of waste.

This guidebook will outline three types of operations among several that development stakeholders can put in place in this regard:

Fact Sheet 4.1- Charcoal briquettes from farming residues
Fact Sheet 4.2 - Composting organic waste
Fact Sheet 4.3 - Family biogas systems

CLIMATE CHANGE MITIGATION

When organic residues decompose in anaerobic conditions (no oxygen), they enter into a fermentation phase and generate biogas, a gaseous effluent mainly containing methane or CH_4. Methane has a *global warming potential (GWP)* 23 times higher than that of CO_2. An open-air city refuse dump in a large developing country where no specific waste handling is done is a huge generator of methane emissions.

Biogas extraction technologies have been developed and enable the methane to be captured and used to produce heat or electricity.

Broadly speaking, processes to get value from waste are a way of combating climatic warming because they cut down on the use of raw materials and proportionately the quantities of energy—usually fossil—needed for their extraction, for the production of goods or provision of services (metal or plastic recycling, for instance).

The same is true of extracting energy from biomass residues. Thus, when a switch is made from fossil fuels (oil, coal, gas) or other types of non-renewable biomass (wood gathered from a disappearing forest, for instance), fuels made from biomass residues will only emit, when burned, the quantity of CO_2 stored within them, and this will be reabsorbed by the biomass still in the growing stage.

Charcoal briquettes from agricultural residues

> **Related fact sheets:** *Fact Sheet 1.1 - Fuel-efficient cooking; Fact Sheet 3.4 - Heat needs of small enterprises and public services*

Some 2.4 billion people in the world routinely use firewood, which accounts for 70 to 90 percent of primary energy consumed in sub-Saharan Africa. In rural areas where firewood is often collected from fragile ecosystems, it is usually free of charge or costs very little. Wood charcoal is sold mainly in cities. The charcoal-making process and collecting the wood itself are often informally organised with little control exercised over it by the authorities. This is a threat to forest resources and ecosystems and is accelerating desertification in some regions.

Agriculture is commonly a source of large volumes of waste materials and residues, and this is true in most developing countries. Such resources contain a major energy potential that is far from being fully developed and could be used instead of traditional fuels after conversion into briquette form, with properties similar to wood charcoal. The manufacture of such briquettes is a means of turning residues into fuel; sustainability would also be a byword in such an undertaking.

However, dissemination of briquettes in areas that still have healthy stands of forest resources remains difficult because the production cost of wood charcoal (prior to transportation) is often at its lowest. So briquettes are mainly competitive in regions where wood is rare; getting people to use them is a genuine contribution to the fight against forest destruction.

When briquettes are used in place of fuels referred to as non-renewable (as is the case of charcoal made at the cost of destroying forest), their production and use help reduce greenhouse gas emissions and therefore mitigate climate change.

ENERGY PRODUCTION FROM AGRICULTURAL WASTE

From agricultural residues to briquette production

Agricultural residues are very abundant, with an estimated total volume worldwide of 4 billion tons produced a year[1]. Many crops farmed in the tropics are a source of residues. At harvest time rice provides straw and chaff (husks separated from the rice grains in threshing or processing). Sugar is made from sugar cane, but a by-product is bagasse (the crushed, juiceless remains of sugar cane as it comes from the mill). Cotton plant, millet, and sorghum stems are also good sources of biomass, mainly in Africa.

These forms of refuse are traditionally used as an ingredient in animal foods, as well as for handicraft making or soil fertilisation.

To the extent that it does not enter into competition with other common uses, turning such waste into briquettes is therefore an alternative in places where a shortage of energy is being experienced, in order to cover local energy needs or cut down on some of the costs of supplying fuel. It is also a means of taking pressure off forested areas or woodlands due to gathering wood for making wood charcoal.

The residues have to undergo a compressing / agglomeration or densification process to make them into briquettes. These operations give the material the consistency of wood or wood charcoal. The necessary cohesion can be obtained by adding a binder (starch, gum arabic, clay, etc.), followed by a compressing or fusing the lignin in the residues resulting from the heat effect generated during the densification process.

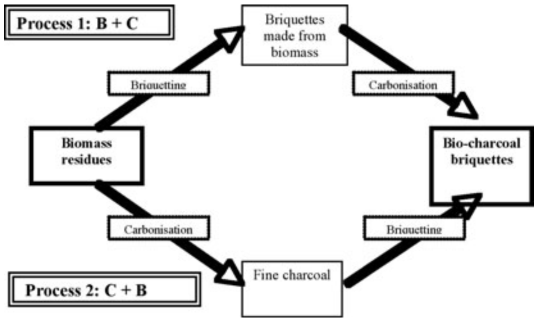
The advantage of charcoal briquettes is that a standard product of consistent quality can be achieved, which is not always possible with wood charcoal, the quality of which fluctuates greatly from one country to the next and depends on manufacturing practices. Briquettes do not spray sparks when ignited, are less messy, and do not have to be chopped prior to use (limiting losses). Their shape lends itself to more convenient packaging and they may have a longer burn time. However, briquettes also have some disadvantages compared to wood charcoal, among them being more stubborn igniting and burning that requires more attention, not to mention that they commonly have a slightly lower energy yield. Some briquettes require the use of a specially adapted stove.

Manufacturing processes

Briquetting and carbonisation

Due to their low energy density and texture, it is profitable to turn most residues into charcoal briquettes. Two processes can be used to achieve this, depending on whether the residues will be carbonised prior to the compression / agglomeration process or after densification:

1. "Potentiel des résidus de cultures tropicales des 15 plus grands pays producteurs en 2003" (Potential residues from tropical crops of the 15 largest producing countries in 2003). Gilles Vaitlingom (CIRAD).



Process 1: Briquetting followed by carbonisation (B + C)
The residues are first densified and the briquettes thus obtained are then carbonised in a conventional type of kiln. This process has the advantage that densified biomass briquettes (prior to carbonisation) can be easily stored or used just as they are for fuel. Densification of raw biomass requires a high-pressure mechanical intervention, which is hard on the equipment used and consumes a great deal of energy.

Process 2: Carbonisation followed by briquetting (C + B)
Residues are first carbonised and broken down into "fines" that are then compressed or agglomerated after addition of a binder. The compression and / or agglomeration process then requires less pressure and lower temperatures because of the characteristics of the input material, and hence lower energy expenses. However, equipment for low-scale carbonisation is still largely in the experimental stage and agglomeration of fines requires the input of a binder, which may be more or less costly.

Overall, and more particularly for the B + C process, the equipment needed for the conversion operation where mid- or large-scale production is involved, is a costly investment. Moreover, whatever process is used, the carbonisation step is a tricky one and the yield is low.

Commercially, briquettes are a meaningful option for large-scale consumers in cities (public amenities, restaurants, handicraft making workshops) or small-scale industries (distilleries, brick yards, etc.) because they use heating systems (continuously fed kilns, chimneys, etc.) in which the disadvantages of briquettes are generally cancelled out.

Manufacturing equipment

The choice of equipment depends on socio-economic considerations that vary according to the level of production and end users (householders, processing companies) contemplated.

Equipment featuring average to high-end technology is available for semi-industrial fuel production at an affordable cost. This application requires the use of semi-industrial presses with a production capacity of about 300 and 1,500 kg an hour.

Basic, sturdy, low-cost equipment is available for small-scale manufacture, the product of which is to be sold in the local market or used for home consumption in rural communities.

Carbonising machines are often made from scrap sheet metal and designed mainly for decentralised use at the village level. They may be set up near stocks of residues collected by the farmers. Their production capacities may be limited, but they are suited to the needs of the rural community.

Issues for development stakeholders

Development operators (NGOs, technical cooperation agencies, etc.) are called upon to coach the briquette-making project at all stages of its implementation: feasibility study, choice of equipment, financial support, training of operators, monitoring of dissemination with long-term support for project extension.

The public authorities, particularly in non-petroleum producing LDCs, are keen on developing regional programmes for the promotion of renewable energies. Coaching measures are crucial so that industry channels set up to get energy value from agricultural waste materials can develop and become competitive on the domestic fuels market. Furthermore, public policies are putting emphasis on the need to preserve natural spaces by using them in a sustainable way and by diversifying activities. Briquette making from agricultural residues to produce fuel to replace wood charcoal is an initiative that meets both of these objectives.

DEVELOPING A PROJECT APPROACH

Feasibility study

Residue pools and competition for use

Step one is to take stock of and quantify residue pools in the region and the use currently being made of them. This means making a correct assessment of the actual availability of residues and determining what people are doing with them in the area under consideration. Indeed, agricultural residues have other uses, including soil fertilisation, mulching, and wind protection (forming windbreaks), in order to promote soil fixation and regeneration of the forest cover. Millet and sorghum stems have a strong potential: one hectare of millet can produce 1 to 3 tonnes of stem. This is also true of the cotton plant, which has a yield of 4 to 5 tonnes of stem per hectare. However, millet stems are also used as an ingredient in animal food or as soil fertilizer, as well as for basket making. Where no fuelwood exists because of deforestation, they are used as a backup fuel. So while studying availability of the residue materials, attention must be given to the risk of competition among the different uses that are made of them.

Economic feasibility

An economic study will be needed to determine the cost price and marketing cost of briquettes, in other words ensuring the economic viability of the production. It will focus on the following expense items:

- Cost for collection, transportation, and storage of the raw material (including seasonality of harvest cycles) and any pre-processing that the residues may require (drying, grinding, etc.).
- Capital cost to purchase and operate the equipment needed for briquette making: energy, labour, transportation, maintenance, cost of binder for agglomeration, etc.
- Marketing costs.

A further study will be needed to get a picture of how the local fuel market is organised (degree of shortage and prices, potential customer base). The study should highlight any actual shortage of fuelwood in the region and confirm whether it is as scarce and costly as claimed. The study would also assess the acceptability of briquettes as a new form of fuel with potential users, given the fact that many people do not like it as much as wood charcoal. The findings of the study will provide a basis to develop a marketing strategy.

Size and design of the production unit

The contemplated production volume and desired quality level of the fuel output will be the major determining factors in the choice of equipment. Once the initial choice is made, further decisions can be made regarding such things as the amount of capital investment, level of expertise required, and needs as far as outside training and support are concerned. The final choice of equipment will also depend on the degree of technological maturity looked for, commercial availability, locally verified references and performance records, O&M costs.

Supporting a briquette-making industry

Project scale and targets

The local energy context and scale of the project will determine the different contexts and potential targets, which will include:

- Rural households involved in local industry at the level of a rural community.
- Women's groups or agricultural organisations that can be involved in a complementary activity project with a commercial orientation.
- Small- and medium-size enterprises (SMEs) or co-op associations that can be tapped in the framework of a project to establish a business or co-op structure for briquette production focusing on marketing the briquettes in an urban context.

Technological maturity

Equipment used for the densification process has been tested and the results can serve as a reference. This is not so of the carbonisation equipment. Homemade apparatuses are very simple (based on local building skills) and serve the purpose, but semi-industrial level applications for higher production levels are still basically in the experimental stage. There has not been enough long-term use to see clearly the prospects for a long-term operation. Many failures have been experienced because the technology of such equipment has not been fine-tuned (selection of dependable material and training of operators).

Performance

The heating value of briquettes varies greatly depending on their carbon content and amount of binding (combustible or not). It is generally lower than that of wood charcoal, which is around 27.2 to 33.4 MJ/kg. A greater quantity of briquettes has to be used to do the same amount of cooking, at a rate of 20 to 50 percent. Moreover, the fuel supply line is touchier (briquettes are harder to ignite in the first place, fumes are emitted, and the ash yield is higher). These disadvantages must be outweighed by the selling price. For briquettes to be attractive, they must cost less than wood charcoal. For large consumers that may be interested, such as public amenities, restaurants, handicraft workshops, or small industries, it is imperative to have a steady supply.

Essential aspects of project guidance

- Organising the agricultural waste collection channel

This component is of great importance. The entire project rationale is based on the idea that access to residues is basically cost-free and they are available in sufficient quantities to feed a production chain. Collecting the refuse must not have a heavy time or money requirement, and it is important that there be a continuous supply. Organising and securing the collection channel are therefore paramount considerations.

Various ways of keeping collection costs down can be contemplated:

- Limit the collection range or set up a pre-collection system in a few villages.
- Reduce the volume to be collected by the use of grinding, faggoting and / or bailing machines. An alternative would be to carbonise refuse right in the villages. The resultant fines would then be collected by an operator who would be in charge of agglomerating them.

The channel can be secured by making long-term agreements with farmers in which residue prices and volumes to be supplied are spelled out.

- Support for setting up, operating, and maintaining a unit

After choosing a suitable equipment format, the next thing is to set up the equipment and go through different experimental phases in the briquette manufacturing process. This allows a test to be made of the raw ingredient, the unit itself, and the usual settings required by the manufacturing process. The project must also have in mind to train a team that will be put in charge of running and maintaining the equipment. It can be expected that the service life of the unit will be longer if a local small- or medium-size business is established to look after briquette production and marketing.

- Marketing
Dissemination of the briquettes produced must be based to the extent possible on an existing distribution network. If that is not feasible, a marketing and extension strategy will have to be developed using advertising, media campaigns, user awareness raising (households, private sector, etc.). Marketing must make room for a balanced distribution among large potential customers (handicraft workshops, restaurants, public amenities) on the basis of a regular supply as well as dissemination in traditional distribution networks.

- Monitoring
Monitoring is of crucial importance, firstly on the technical level to get the equipment up and running and properly maintained, but also on the socio-economic level in phase with marketing the briquettes.

Project duration

The project will vary in length depending on the technical level and hoped-for production volume. The minimum length of a project would be one or two years for a decentralised homemade production in a village and from two to four years if a cottage industry type workshop is going to be set up along with a distribution network.

Skills required

Cottage industry or semi-industrial manufacturing processes as the case may be, quality control, rural development, social mobilisation, marketing.

Positive and negative impacts, risks

Economic

- ⬆ Getting value from unused residues is a way of generating income and creating jobs.
- ⬆ Possibility of covering the costs of waste recycling or disposing of invasive plants (such as typha [cattail or reedmace]) by producing and selling briquettes.
- ⬆ ⬇ Competitiveness in the briquette-making industry is often a stubborn issue. In rural communities, wood energy may be an abundant resource and therefore available free or at a low cost. There is currently a greater incentive to buy briquettes in urban areas where wood charcoal always costs something. The scarcity of biomass recently observable in countries suffering from desertification or deforestation could make briquettes more attractive.
- ⬇ Up till now, commercial failures have been commonplace and most briquette-making workshops still in operation can only hold their own with grant assistance from the public authorities or development projects.

Social

- ⬆ In areas where wood is scarce, a replacement fuel can lighten the burden of gathering wood that falls upon women.
- ⬆ When associations of women take charge of or at least coach the operation, this is one of several activities that can strengthen their position in the community.
- ⬇ Risk of encountering problems in product acceptability, given that it comes with a number of drawbacks.

Environmental

- ⬆ When briquettes are used in place of wood charcoal, the forest cover is saved, which is a factor in climate change mitigation.
- ⬆ ⬇Risk of competition between briquette production and traditional use of waste materials for soil protection, etc.

CONTRIBUTING TO CLIMATE CHANGE MITIGATION

Issues

Extracting energy value from waste materials / biomass residues is one way of reducing climatic warming. When switching from fossil fuels (oil, coal, gas, etc.) or from *non-renewable biomass* (wood sourced from forest destruction), fuel made from waste materials / biomass residues referred to as "renewable" will only release upon combustion the quantity of CO_2 stored in them, which is reabsorbed by the still-standing, growing resources.

Moreover, all waste materials / organic residues in decomposition generate emissions of methane (CH4). This gas has a climate warming potential 23 times higher than that of CO_2. In other words, if the decomposition process takes place in an uncontrolled environment, it will have a negative impact on climatic warming. However, various technologies are available that allow CH4 to be turned to account (see Fact Sheet 4.3 - Family biogas systems).

Illustration: Green charcoal in Senegal

Operator: Pro-Natura International
Project status: *Voluntary exchange market*
Type of carbon credit: *VER* (*gold standard* type)
Source of information: www.pronatura.org, www.actioncarbone.org
Methodology: AMS-I.E "Switch from Non-Renewable Biomass for Thermal Applications by the User"

Context and principle of emissions reduction

The purpose of this project is the production of charcoal briquettes that will be used instead of a CO_2 emitting fuel sourced from the non-renewable biomass.

The process used is that of carbonising residues continuously fed into a Pyro-6F apparatus that recycles the carbon dioxide (CO_2) and burns off the toxic gases resulting from pyrolysis, using them as a source of energy. The production and use of green charcoal is therefore neutral in terms of green house gas emissions.

ER estimates

The annual reductions obtainable amount is 3,7 t CO_2 equivalent per tonne of briquettes. This is based on the assumption that 80 % of the biomass energy is non renewable.

CASE STUDY

GREEN CHARCOAL IN SENEGAL

Project funded by: ADEME, European Union, Conseil Régional Île de France
Scope: Medium-size project with a yearly budget between € 50,000 and € 200,000
Operator: Pro Natura International, www.pronatura.org
Partner: Société Nationale d'Aménagement et d'Exploitation des terres du Delta du Fleuve Sénégal et des vallées du fleuve Sénégal et de la Faleme (SAED – National Development Corporation of the Senegal River Delta and Valleys of the Senegal and Faleme) Fédération des Femmes Productrices du Delta (Delta Federation of Women Producers - FEPRODES)
Implementation date: Since 1995
Beneficiaries: People living in the Senegal River Delta

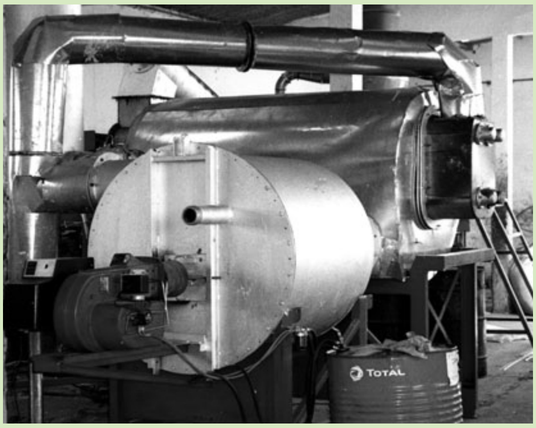
Context

Massive use of wood is a major cause of deforestation in Sahalian Africa, the result being drought and desertification. In Senegal, wood charcoal production alone is causing the loss of forest cover at a rate of 30,000 hectares a year. The distances covered and time spent gathering wood are factors that place many women at a disadvantage as far as development is concerned. The purchase of wood charcoal is becoming an increasing expense burden for households. Diversifying the biomass energy source is one alternative to reducing the human and environmental impact from wood collection. The main economic activity of the region is rice growing. A rice hulling plant is located in Ross Béthio.

Project activities - outcomes

This project involves the salvage of agricultural residues (rice chaff) as well as material from the renewable biomass (invasive plant species such as typha). These resources that would otherwise be lost are converted into green charcoal briquettes and used in the same manner as wood charcoal.

The carbonising equipment developed by Pro-Natura and tested in Senegal makes it possible to carbonise the rice chaff and crushed reedmace (typha) in a continuous feed operation, at a rate of 100 to 150 kg/hour depending on the residue. A binder is added prior to the briquetting phase, which is a manual operation, although plans call for it to be mechanised with the use of small motors to speed it up. The weight of charcoal compared to the weight of the raw biomass is over 30 percent, while the ratio stands at 15 to 20 percent for wood charcoal.



Pyro-6 F carbonising machine (©Roland Louvel)

Rice chaff briquettes (©Roland Louvel)

The cost to purchase a Pyro-6 F carbonising machine is about € 200,000. Rice chaff is free for the time being, while typha bales delivered to the workshop cost € 0.01/kg. The cost price is € 0.08/kg for briquettes made from rice chaff and € 0.12/kg for those made from typha. The ex-works selling price is expected to be € 0.16/kg, which means that the briquettes are a competitive option in the St. Louis du Sénégal region where wood charcoal goes for € 0.30 to € 0.38/kg.

A women's group is in charge of running the factory and will market the briquettes throughout its network of members. At this stage, it is still difficult to assess the actual managing skills of this NGO in the long term or to predict how sales will turn out in the market.

For more information

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Composting organic waste

> **Related fact sheet:** *Fact sheet 4.3 - Family biogas systems*

Biodegradable organic wastes are the vegetable or animal solid residues which can be decomposed through natural processes (mainly through microorganisms). They include: vegetable wastes, agriculture and food-processing by-products, putrescible wastes (peelings, out-of-date food, meals residues), papers and cardboards, and wastewater sanitation residues (purification mud, pit curetting). They are opposed to non organic wastes such as plastic, glass, metals, textile, etc.

Among the different organic waste valorisation sectors, composting appears as one of the operations enabling to limit wastes sanitary and environmental risks and to create jobs on the local scale. Its small-scale implementation, with simple and spreadable methods in a necessarily decentralised composting scheme, enables to valorise organic wastes, which can represent up to 70 % of garbage. Finally, composting enables to reuse organic matter, hence to reproduce a natural cycle which is neutral regarding greenhouse gases.

ORGANIC WASTE VALORISATION

An answer to different challenges

3 cases are particularly favourable to introduce composting operations:

In urban contexts, the question of wastes management – from collection to process – is essential. Indeed, most of the time, public authorities don't have the means to properly manage this service, especially in the poorest neighbourhoods. 60 to 70 % of urban solid wastes are fermentescible wastes, hence composting is perfectly appropriate to reduce sanitary and environmental risks (air, water and soil pollution through emanations of methane, ammonia, sulphur oxide, nitrates, ..).

For the private sector (in particular food-processing industry), composting economic activities vegetable by-products enables to both avoid waste-related pollution and to potentially constitute an additional source of income through compost sale.

In a rural or peri-urban context, agricultural areas benefits from compost supply which enables to improve soil fertility while reducing the use of mineral fertilizers which are expensive and polluting.

Composting scales and principles

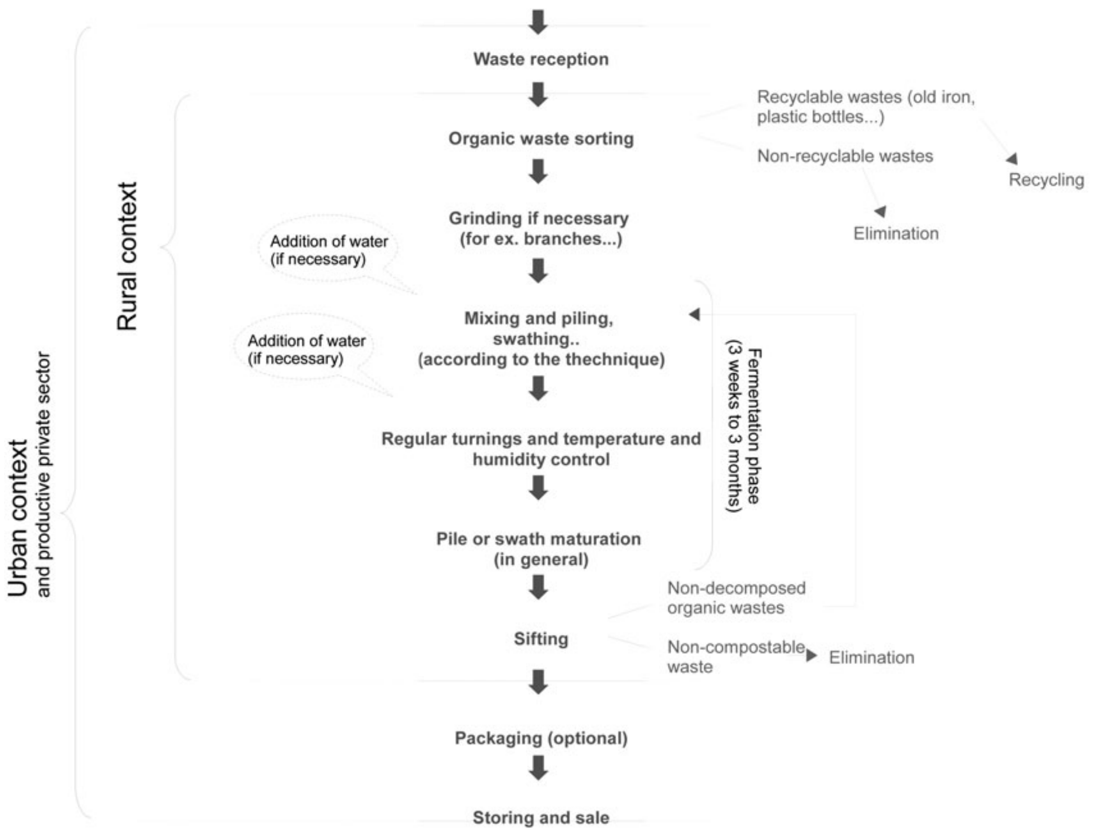
Composting can be performed at the household scale, in pile or in a "composter", or at the scale a company or a city. For a city, large-scale composting treatment of wastes presupposes important investment in sophisticated equipments. There have been many economic and technical failures among these plants implemented in the 1970s and 80s which proves that this approach is not a relevant solution. The focus will be made only on decentralised scale in urban or rural areas.

In urban context, composting operation management can be either directly implemented by the population, or by the informal sector through the implementation of small composting facilities within neighbourhoods. It is based on cheap "country" techniques:

- On not very high windrow sometimes laid on wooden frames which improve aeration. Windrows are generally covered with a cloth or branches to avoid drying. This technique is mainly used in dry regions.
- In aerated static pile, mainly in humid regions. It's not uncommon that part of the process is performed through vermicomposting. This technique is based on the introduction of worms (earthworms' cousins) which accelerates decomposition.

In rural context, composting is performed in addition to agricultural activity. The composted wastes are often made up of animal and/or human excrements laid in pile or in a tank requiring very little to do (returning, sifting). It's very important to make the difference between compost and manure. Manure is made up of faeces and straw (if some is available); it's used on the soils as crops' fertilizer while compost brings organic matter for the soils.

A composting cycle is a full process, at the end of which compost is considered as "ready". It means that it is stable and that decomposition and fermentation processes are complete. The cycle duration varies according to the climate; indeed, matter decomposition is quicker in warm and humid areas. For information only, a composting cycle lasts at least from 3 to 6 months.



Scheme of compost production chain

Challenges for development stakeholders

Development stakeholders (Public authorities, sponsors, NGOs, local authorities, etc.) are in charge of:
- Launching and financial support (for sponsors) since local authorities generally don't have the means to cover costs related to this kind of operation; they take part during the pilot phase.
- The projects' technical guidance in particular for the operation assessment, the works' follow-up, training on processes and sanitary aspects.
- Management of the sector with different stakeholders through awareness-raising and involvement of local authorities, users' information, etc.

In any case, NGOs have an important role of awareness-raising, knowledge transmission (training) and of link between the different stakeholders.

DEVELOPING A PROJECT APPROACH

Feasibility study

The feasibility study includes the identification of stakeholders and their involvement, the market research and technical and economic relevance.

It should define:

- The waste context: quantity, composition, current management, stakeholders involved, economic aspects, collection organisation, etc. Thus, the market research will define the sorting level, indeed pre-sorting (performed by the population, companies and farmers), sifting and final product packaging, in order to ensure compost good marketing.
- The existing and potential markets: existing competitive products, quantity and quality users' needs and purchase capacity.
- The project's organisational, technical and economic criteria: quantity of waste to be composted, collection modes, sorting, selected technique, technical follow-up, compost packaging, instructions for use, collect of possible financial receipts (waste management financial contributions collected by the institutional representative or directly by collectors, to be created or generalised when it already exists)

Supporting operations of local composting

Targets:

- Urban context / city wastes: population, waste management-related stakeholders, local authorities;
- Private sector context: companies producing organic waste;
- Rural context: farmers.

Functionality, performances:

Some figures can be given for information only:
Decentralised composting is performed in Indian and Asian cities and concerns less than 3,000 families; they

process about 3 to 5 tons per day on a surface of between 800 m^2 (windrow composting) and 760 m^2 (forced aeration pile composting, which is quicker). The team is made up of 7 to 11 full-time persons for the operational part (excluding the human means needed to collect wastes, the analysis lab and marketing).
In cold Himalaya regions, farmers make composting in 2m^3-pits which are filed once per cycle, and if the process is optimised, 2 cycles per year can be performed.

Essential aspects of project guidance:

- Awareness
In the event of operations in urban context, populations' awareness should be raised on the operation benefits so as to respect new waste collection rules and to accept to participate in the service financing. Awareness can be based on demonstration sites.

- **Research and Development**
When composting is a means to valorise organic by-products from one or several companies, R&D part is almost indispensable since each activity wastes are very specific and their characteristics are barely studied in developing countries. It is then necessary to start an experimental phase to measure all composting parameters.

- **Knowledge transfer**
It's necessary to make information sessions with the production different stakeholders: populations, local authorities, users. A compost not enough decomposed can have negative effects on crops: "burns", nitrogen hunger (deficiencies), etc. The product will then be left aside. Furthermore, to reach a sufficient product quality level, collection and composting teams have to be trained, especially to composting indicators' control (temperature, humidity, compost chemical composition…).

- **Stakeholders' organisation**
All the stakeholders concerned by waste management should get involved in the operation. To do so, it's important that relations between stakeholders are formalised through a waste supply agreement (volumes and frequency to be determined) from farmers or companies according to the context, as well as through the availability of a composting space. It's necessary to create a steering committee and project follow-up in which are involved all the stakeholders.

Project duration:

A composting project requires a medium-term implementation (3 years). Guidance is crucial during the starting phase (first year): diagnosis, operation technical and economic conception, composting facility construction and equipment purchase, launching.

Required skills:

Composting technical expertise, production management, stakeholders' organisation.

On the long term:

The definition of quality criteria especially regarding pollutant content (heavy metals) and undesirable rate (plastic and glass pieces) should enable to avoid a bad image for the product which could jeopardize the whole production with future users.

Positive, negative impacts and risks

Economic

- ⬆ Creation of jobs suited to the local population qualification level
- ⬆ Better financial viability for companies which can thus valorise their organic by-products. For instance, reduction of costs for farmers who buy fertilizers and improvement of crops' yields.
- ⬇ Weakness of the production economy which is mainly based on the sale of compost and on waste management tax collect when it exists.

Social and sanitary

- ⬆ By reducing insalubrity linked to waste illegal dumping, and by optimising long-term urban waste management, a composting project enables to limit impacts on urban population's health.
- ⬆ In the framework of an agricultural activity, compost can lighten soils and reduce work hardness.
- ⬇ Waste manipulation represents risks for workers' health: sanitary risks (dust, cuts, etc.) and accident risks linked to collection machines' movement; they should be contained through wearing adequate clothes and respecting strict instructions. It is recommended to wear closed shoes, gloves and masks, as well as to have a facility to change and shower.
- ⬇ Furthermore, excrement mix-based compost should not be used on products eaten fresh since there are contamination risks.

Environmental

- ⬆ Composting reduces nuisances linked to organic waste uncontrolled dumping: water, soil and air pollution…
- ⬆ Compost use improves soils' fertility and biodiversity and enables to fight against desertification.
- ⬆ Composting process is neutral regarding *greenhouse gases' (GHG)* emissions since it reproduces the organic waste natural decomposition through matter's biological, geological and chemical cycle. Furthermore, composting operations enable to reduce GHG by avoiding organic waste anaerobic fermentation (methane emissions) in uncontrolled dumping sites and by reducing the use of chemical fertilisers whose production generates a lot of GHG.
- ⬇ Not mastered composting process can lead to anaerobic decomposition conditions generating methane (highly powerful GHG).
- ⬇ When conceiving the composting area: there are environment pollution risks through *leachate*, or

through waste fly ash. The composting area should then be equipped with a roof, a waterproof surface with a juice and rainwater collection system, boxes to receive wastes and covers.

CONTRIBUTE TO THE FIGHT AGAINST CLIMATE CHANGE

Challenges and valorisation of emission reductionss

When organic residues are being decomposed, in anaerobic conditions (i.e. without oxygen), they are in a fermentation process and generate biogas, which is a gas effluent containing mostly methane (CH_4). Methane has a *global warming potential (GWP)* 23 times more important than that of CO_2. Thus, a developing country large city's open air landfill, if it is not subject to specific treatment, emits a lot of methane. Composting enables to process wastes in anaerobic conditions (windrow spreading, aerated piles) and avoids the methanisation phenomenon.

Composting projects are eligible to the *Clean Development Mechanism (CDM)*, in the framework of small-scale projects. AMS III.F methodology "Avoidance of methane production from biomass decay through composting" gives emission reduction calculation methods.

Illustration: Composting of urban wastes in Indonesia

Project status: CDM
Operator: Rotary Club Bali Ubud and GUS Foundation
Information source: www.unfccc.org.
Carbon credit: CER according to the Gold Standard
Methodology: AMS III.F "Avoidance of methane production from biomass decay through composting"
Crediting period: 2008-2017

Emission reduction context and principle

Gianyar regency in Bali generates about 200 tons of wastes per day. Most of it is brought to Temesi facility where anaerobic conditions linked to waste landfill generate important methane emanations. The project enables to process about half of the waste brought to the site, mostly organic waste, and to transform them in compost which is then reused as fertilizer.

ER estimates

The project manages the processing of about 15,000 tons of organic waste per year. It enables to reduce methane (CH4) emissions by 333 tons per year, which represents 7,600 t equivalent CO_2.

A small part of the credit carbon sale enabled to make up the project budget bringing the missing 7 %, since the project is mostly funded by donations. The credit remaining part funds the equipment maintenance and the project extension.

CASE STUDY

CITY WASTE COMPOSTING IN TEMESI VILLAGE IN BALI, INDONESIA

Project funded by: IDRC Canada (International Development Research Centre), Rotary Club Bali Ubud
Scope: Medium scope project (budget from € 50,000 to 200,000 per year)
Execution date: 2 steps: 2004-2005 and 2006-2008
Operators: Rotary Club Bali Ubud, GUS Foundation and BALIFOKUS
Partners: Local Government of Gianyar Regency, Environmental Agency of Gianyar
Beneficiaries: Temesi farmers and communities, Gianyar households

Context

Gianyar Regency is one of the wealthiest regencies in Bali Province. The regency is well known as artisans' regency, wooden sculptors, silver and gold smiths, agriculture, handicrafts and tourism are the main economic activities of Gianyar. Located approximately 70 km East of Denpasar, the population of Gianyar is of 416,728 inhabitants. About 200 tons of wastes are generated every day but only half of it is brought to the landfill. The rest is thrown away in different illegal dumping sites.

Temesi landfill operates as a conventional open air dumping site, which creates foul smell and pollutes rice fields. To avoid methane release generated by the landfill, the project processes about 50 % of wastes brought to the landfill which are mostly organic wastes, and turns them into compost to be used as soil fertilisers. Run by local communities and supervised by GUS Foundation and Rotary Club Ubud, the project has been implemented in coordination with the local government of Gianyar Regency

Illegal dumping site (©BALIFOKUS)

Temesi landfill in February 2004 (©BALIFOKUS)

Project activities and outcomes

In February 2004, a 400 m^2 Material Recovery Facility (MRF) was built on the Temesi landfill. The facility, which is designed to manage up to 80 m3/day, i.e. the equivalent of 20 trucks, was inaugurated in June 2004. It is now run by the Village Waste Management Council under the supervision of Rotary Club Ubud and BALIFOKUS. IDRC also supports the development of an Environmental Theme Park on the landfill site.

The activities implemented are:

- Detailed engineering design (DED) development,
- Construction of the facility,
- Waste sorting,
- Composting using forced aerobic technique,
- Employees' training,
- Environmental education for children, students and public in general.

After the project's second phase, the composting facility implementation enabled to create 60 jobs. About 50 tons of compost are produced and marketed each month with Gianyar farmers.

New composting facility designed for capacity to handle waste about 100 ton/day (©BALIFOKUS)

Composting process using forced aeration technique (©BALIFOKUS)

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Family biogas systems

> **Related Fact Sheet:** *Fact Sheet 4.2 - Composting organic waste*

Biogas is produced from the fermentation of organic matter (animal or plant) in the absence of oxygen (anaerobic digestion). Its main component is methane (CH4), which can be burned for the production of heat or electricity. The large volumes of either agriculture or urban waste in countries of the South mean that there is an adequate supply of the resources needed for methane gas production. These countries will find therein a decentralised energy production source that can be used, for instance, to service families living far from any electricity grid. In a context of spiralling energy costs and energy consumption, developing biogas is a genuine option. Moreover, methane is a greenhouse gas with a global warming potential (GWP) 23 times higher than that of CO2. Its production in nature is therefore highly pollutant, but when produced in a reservoir and totally captured, GHG emission is reduced. Projects for the production and utilisation of biogas from waste are ways of contributing meaningfully to climate change mitigation.

This fact sheet will develop the application of biogas for families and small communities in a rural context.

USING A BIOGAS SYSTEM TO GET VALUE FROM WASTE

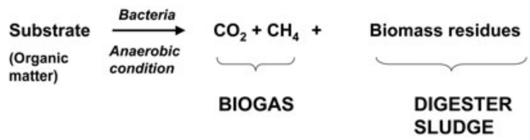
General principle of biogas

The principle of biogas production was discovered in the 18th century and mastered a hundred years ago, but has only recently been disseminated on a worldwide scale. This process is natural in landfill sites, wetlands, manure, and even in the stomach of ruminants where bacteria digest organic matter to ensure their metabolism. The bacteria give off what is called biogas, a mixture of methane (CH_4, typically from 50 to 70 %) and carbon dioxide (CO_2), with variable quantities of water and hydrogen sulphide (H_2S). But these bacteria can survive only in an oxygen-free environment (anaerobic condition).

Methane production can also be stimulated in a closed environment from the fermentation of organic matter (animal or vegetal), called substrate, and the biogas can be easily captured.

The biomass residues (digester sludge) are stable and can no longer undergo fermentation.

Animal excreta, agriculture residues, the organic part of household refuse, discarded food, and sludge from treatment plants are all sources from which biogas can be produced.



Methane gas is produced in three successive steps:
- Hydrolysis and acidogenesis enable the formation of alcohols and organic acids as well as hydrogen and carbon dioxide.
- Acetogenesis, at which stage the aforementioned compounds are converted into precursor products contributing to the formation of methane: acetate, carbon dioxide and hydrogen.
- Methanogenesis, which results in the production of methane from the above elements.

Each phase is brought on by the activity of very specific bacteria, each one crucial to the proper performance of the methane producing operation. The natural conditions conducive to methane-producing bacteria need to be replicated so that they can thrive and "digest" the organic waste.

Depending on the local demand, gas produced by fermentation can be used for several different purposes:
- Food cooking
- Lighting
- Heating
- Refrigeration
- Electricity production
- Vehicle fuel

The last two items on the list require a conversion of the biogas, which causes it to lose some of its energy yield.

Digester sludge, composed essentially of mineral matter, is odourless; virtually all of the things that could cause health problems in the waste materials in their raw state have now been removed (viruses, bacteria, maggots, etc.). Farmers can use it to improve soil fertility as it has soil amending properties in addition to compound fertilizers.

Application of biogas in countries of the South

Methane production technology can be used locally. Small family-scale units can be set up, but an extension is possible for community amenities or even industrial level production units such as treatment plants, waste disposal centres, or large farming operations.

In a developing country, a decentralised application of biogas technology seems to be the most relevant approach. Biogas systems are especially suitable in rural farming communities, given the large volume of material utilisable for methane production (animal excreta) and the working space available for infrastructure construction.

Moreover, biogas can enable a switch from wood or coal, the traditional energy source used in rural communities in developing countries. A further plus is the reduction in time spent gathering wood or expenses incurred for the purchase and transport of coal, not to mention elimination of air pollution caused when cooking is done on traditional appliances fired by biomass fuel.

When biogas is produced from excreta, it contributes to space sanitation, hence to better hygiene and health; risks of water pollution are also reduced. Families using biogas systems thus reap economic, health, hygienic, and environmental benefits.

This fact sheet will deal exclusively with biogas systems on a local scale in developing countries. We will outline the principle on which a digester functions, i.e. the tank used for fermentation of organic matter. From the smallest system that a family can use for its energy needs to very large ones that can meet the needs of a small town, digesters come in many different models.

Different types of biodigesters

A digester is composed of at least a tank (in which fermentation of organic matter takes place) with an inlet and outlet that allow anaerobic conditions to be maintained, along with a gas outlet pipe.

Digesters come in different models. For family use in a developing country, the three main types are as follows:
- Gasholder bell digester, or Indian model
- Fixed dome digester, or Chinese model
- Double feed digester, often made of a plastic tube; can also be made from metal or plastic drums.

Double feeding means that once the organic matter has been put into the digester, no more is added during the methanisation process. The Indian and Chinese models feature continuous feeding; matter is regularly fed into the digester.

The gasholder bell digester is made of a buried tank and has a moveable gas reservoir generally in the form of a metal bell cap (although a plastic bag may also be used). Fermentation takes place in the tank and the resulting gas is collected in the reservoir situated on top, which moves up or down depending on the quantity of gas in it. Gas pressure remains constant, affected only by the weight of the bell cap.

The fixed dome or "Chinese" digester has a semispherical tank, usually of brick, although new materials are coming on the scene such as composites—mixtures of cement and textile fibre. The gas is stored directly in the upper part of the digester. In this system, gas pressure depends only on the quantity of gas stored. The cost of this equipment in China is about € 400 to € 500 including construction, training, and setting up the kitchen recess, latrines, and pigpen.

Fixed dome biodigester (©Initiative Développement)

Dual feed digesters are generally less sophisticated than continuous feed digesters. They can be made from PVC plastic bags, metal barrels or plastic drums; they are easy to design due to the simplicity of installation and cheapness of the materials (plastic bag), which can even be free of charge (salvaged gas barrels or plastic tanks). A single feeding of organic matter is done. The digester can be used as both a fermentation tank and gas reservoir. But it is also possible to add an outside reservoir to serve as a storage tank. Simpler approaches that are equally effective involve the use of plastic bags or even vehicle inner tubes. But dual feeding means that a series of several digesters is needed for constant gas production, as well as storage for the organic matter to be used for fermentation.

Operating a biodigester

Choice of the digester type must be based firstly on an analysis of the regional climate. It must also be compatible with local construction know-how and techniques, gas needs, etc. The materials required for digester construction are generally available locally, which is a way of contributing to the economic development of the area in which they are set up.

From a scientific viewpoint, a good methane production operation requires compliance with the following parameters:
- Absence of oxygen.
- Temperature (37°C is optimum). Most digesters are put underground in order to maintain a constant temperature inside the tank, which enables better conservation of the bacteria required for the fermentation process.
- pH (ideally between 7 and 8); a favourable pH can be maintained simply by refraining from adding acids, chemicals, or soap.
- Carbon-nitrogen (C/N) ratio of the organic matter put into the digester. A reading close to 25 to 30 is ideal

because the bacteria consume about 30 times more carbon than nitrogen.
- Retention time, of particular importance in dual feed systems (may run from 10 to 60 days depending on the above factors).

However, it does not seem to be possible to observe all of these parameters in small-scale biogas systems used by families. In the case of the Chinese digester, it may suffice to take a tank pressure gauge reading to troubleshoot a problem such as a leak or poor digester feeding, formation of a crust inhibiting the methane production process, etc.

Issues for development stakeholders

The public powers need to be involved in biogas development both by promoting it through equipment subsidies and training rural development supervisory staff in this technology.

NGOs can support the dissemination of biodigesters by teaching local craftsmen how to build them, conducting public awareness-raising campaigns in biogas use, etc.

The main difficulty for large-scale dissemination is coaching the poorest of the poor, who often do not have a sufficient number of animals and whose investment capacity is weak. An effort will then be needed to link with agriculture support programmes for add-ins. This is being done in Asia for family-scale hog raising. Another possibility is associating micro-credit organisations with the dissemination operation in order to get funding for part of the installation.

DEVELOPING A PROJECT APPROACH

Feasibility study

Familiarity with the technology and energy context

Firstly, an assessment must be made of the volume of organic resources available and what is currently being done to get value from them. It may be that such resources are being used for animal feed, organic soil amending, aerobic decomposition and heat capturing, direct combustion, etc.
Secondly, a characterisation of current energy infrastructure is needed (gas, diesel, oil, wood/biomass, solar power, hydraulic power, etc.), including a review of how this energy is being accessed and what savings are realisable from biogas. A parallel identification of the main uses of energy is in order (cooking, lighting, refrigeration, equipment or machinery such as pumps, automotive vehicles, etc.).
Thirdly, a review of what has been done countrywide with regard to biogas technology will ferret out past experiences, the technologies used, and the approaches taken, thereby enabling analysis of any potential causes of failure.

Socio-economic and cultural characteristics of the target communities

The main economic activities of the target communities require characterisation. In this way, a structuring of their expenditure can be made (with special focus on the share taken by energy), as well as their investment capacity. Another point is to study the distribution of domestic tasks among men and women. Who gathers the wood? Who buys the coal and transports it? The reason is that dissemination of biodigesters may bring about changes for those who typically carry out such tasks. In some cultures too, handling of excreta can be a problem, as well as use of the gas made from it. An effort must be made to make sure that this practice is culturally acceptable.

Project size and design

The most important step seems to be to start with an experimental and demonstration phase for biogas technology. This will enable the technology to be perfected locally, raise people's awareness, and gauge their expectations; the tool used would mainly be household surveys to determine their level of interest and fears, the size of their herds, income, etc.
Once this first approach has been brought to a successful conclusion, then attention can be given to dissemination, which should be done incrementally based on geographical considerations.
Depending on the size of the project, a determination should be made of the number of technical teams that will be needed to put in the digesters. A technical team should have at least one mason, one technician or mechanic and one person in charge of training and survey-taking. The local community can share in the construction operation (such as digging the pit or hauling in some of the materials needed).

Supporting biodigester dissemination

Target:

Family units

Functionality, performance:

In normal operating conditions, a rather high temperature—never lower than 15°C—, a regular excrement feedstock: 50 kg per jour; a family of four with two pigs can operate a digester of 8 m^3 connected to the pigpen and latrine. It will produce enough gas to cook three meals a day (about 1 m3 of gas per day).

Technological maturity:

Biodigesters have been around for over 25 years. A standard, perfectly operational version has been developed. Currently a number of companies are developing improved technologies: new materials that make construction easier, recyclable construction materials, and the like.

The main difficulty lies in training builders (masons) and quality control of the worksites so that the systems will perform properly and can be operated in the long run.
Sideline equipment channels can also be set up for rice cookers, water heaters, etc.

Essential aspects of project guidance:

The following activities are generally necessary project components:
- Technology transfer to the communities. Coaching is necessary to ensure sustainable management of the biogas reservoir to maximize its service life.
- Training in the construction, use, and maintenance of biodigesters, as well as training in sanitation and hygiene.
- Establishing associations of users is a way of promoting interchange and speeding up equipment dissemination. Within such an association, some members can be given more extensive training and thus be in a position to assist other users.
- Assistance with the capital cost: The initial investment is often too great for poor families to get in on the technology.
- Project monitoring, notably the performance of the digesters, troubleshooting (setting up a database). Coaching is necessary to ensure long-term management of the biogas reservoir. If the system performs poorly at the outset, people may lose interest in it.

Project duration:

The length of the project depends on the level of ownership demonstrated by the technology target group. If all goes well (front-end builders get a good handle on the technology; users get a good grasp of the technology; some investment capacity exists), the adaptation stage will be short as the advantages of this technology catch on (an extension phase can be undertaken in a couple of years).

Skills required:

Development project management, engineering (construction, materials, etc.), rural development, agronomy, renewable energy.

Project monitoring and sustainability:

A monitoring system is a must to keep digesters working well over a long period of time.

First-level surveillance and basic maintenance can be cared for by the user association. A technician should be on call in the event a problem arises (stoppage of gas production, leakage, breakdown of one of the components, underproduction, etc.).

Putting the dissemination programme under the carbon credit arrangement will help keep the digesters running because the income from selling carbon is conditional upon using the full volume of gas produced and maintaining production at top level.

The project will function even better if it is linked to the activities and needs of the local farmers: support for animal husbandry (building pens flocks or herds, forage growing), production of quality fertilizer, and so on. Other perks such as latrines or kitchen counters will bring a measure of comfort to the family as well.

Positive and negative impacts, risks

Economic

- ⬆ Reduced energy bill (less coal or electricity purchased).
- ⬆ Fertilizer production => improved agriculture productivity when soil is fertilised with digester sludge.
- ⬆ Income generation (jobs, use of local materials, etc.).
- ⬇ Cost of the digester out of reach for poor communities, requires investment subsidy.

Social

- ⬆ Improved living conditions: latrines, pigpens to keep the animals from running loose.
- ⬆ Comfort and convenience: lighting, cleaner kitchen area, less noxious smoke.
- ⬆ Latrines are nicer (less odour) and more hygienic.
- ⬆ Time saved due to less time spent gathering wood.
- ⬆ Cooking with biogas is more efficient and faster compared to wood or coal.
- ⬇ Some people are reticent to use gas produced from excreta; however, the cultural resistance to handling excreta is often broken down by highlighting the improved sanitation made possible by the equipment (the place is clean, odour-free, no flies, etc.).

Environmental

- ⬆ Improved drainage.
- ⬆ Clean renewable energy.
- ⬆ Environment protection (control of forest destruction, less soil erosion).
- ⬆ Reduction in indoor household pollution.
- ⬆ Reduction of greenhouse gas emissions (provided the biogas energy is a switch from a fossil fuel such as natural gas or kerosene or one taken from the non-renewable biomass and any excess biogas is not released into the atmosphere).
- ⬇ A methane leak causes more pollution than CO_2, so it is important that digesters and their appendages be sealed. Dome models frequently have a problem with gas escaping at night, and measures must be taken with this model to prevent any methane release.
- ⬇ Although the biogas is under less pressure than "town" gas, it is still dangerous. The pipe assembly requires careful maintenance.

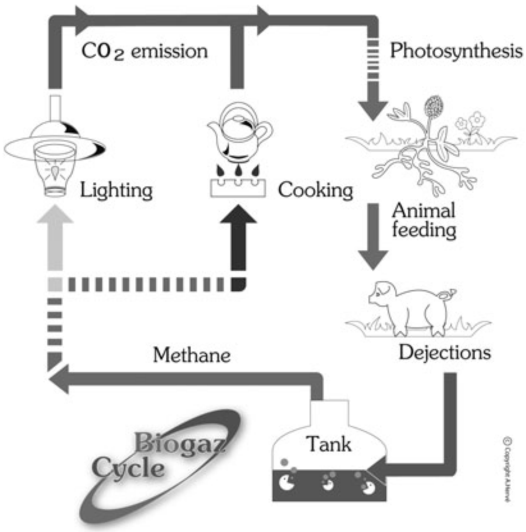
CONTRIBUTING TO CLIMATE CHANGE MITIGATION

Issues

Producing and using biogas is a means of mitigating climatic warming at two levels:

- Reduction of direct emissions (in all cases).
Methane has a *global warming potential (GWP)* 23 times higher than that of CO_2. When methane is produced under controlled conditions from waste (refuse dumps, liquid manure, etc.) and burned to convert it into CO_2, the result is an overall reduction in greenhouse gas emission.

- Avoided emissions (in some cases).
When biogas, a form of renewable energy, replaces a fossil fuel (coal, natural gas) or fuel taken from the non-renewable biomass, emissions are avoided. On the other hand, if the biogas system is operated at the household level, allowing a family to replace wood gathered in a regularly regenerated forest (in which case the energy source is being renewed), the impact is zero.



Turning emissions reductions to account

Projects for the dissemination of family-scale biogas systems are eligible under the *Clean Development Mechanism (CDM)* in the framework of type-I., small-scale renewable energy projects. The AMS I.E "Switch from Non-Renewable Biomass for Thermal Applications by the User"[1] methodology provides formulae for calculating emissions reduction. The reductions are only credited if it is proven that the fuel for which consumption is reduced is sourced from a *non-renewable biomass*, i.e. one that emits carbon dioxide.

Illustration: Biodigesters dissemination in China

Project status: Voluntary exchange market
Operator: Initiative Développement
Carbon credit: VER, under the Gold standard
Information source: www.id-ong.org
Crediting period: 2007-2016
Methodology used: AMS-I.E "Switch from Non-Renewable Biomass for Thermal Applications by the User"

Background and principle of emissions reduction

The project is being carried out in an area where the inhabitants are using non-renewable biomass for cooking. The focus of the project is to disseminate biodigesters among rural users. Biogas is used for food cooking and lighting. If the project had not been implemented, the families would have continued using local traditional cookstoves, most of which are wood fired. Part of the firewood comes from a non-regenerated forest, which is therefore considered to be non-renewable biomass and a source of carbon dioxide (CO_2) emission.

ER estimates

Depending on where the project is operating and local conditions, CO_2 savings realised from a family-scale reservoir may reach 4 to 5 t CO_2 equivalent. A database has been set up for long-term monitoring of the equipment base and calculating the emissions reduction credit entitlement.

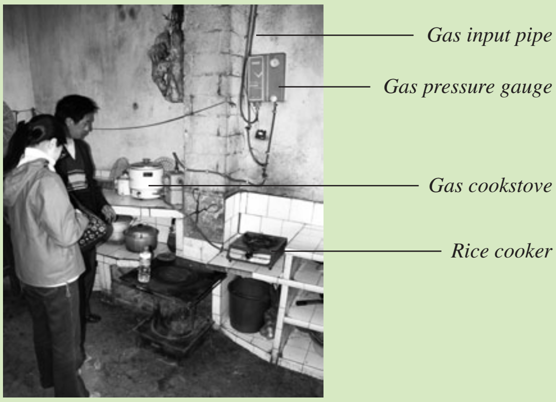
1. Available on the UNFCCC website: www.unfccc.org.

CASE STUDY

DISSEMINATION OF BIOGAS RESERVOIRS IN GUIZHOU PROVINCE, CHINA

Project funded by: Goodplanet, Ensemble Foundation, Michelham foundation, Chinese authorities, input from local communities
Scope: Pilot project with an annual budget under € 50,000
Operator: Initiative Développement (ID), www.id-ong.org
Partners: Chinese authorities and local Chinese NGO
Implementation date: Since 2005
Beneficiaries: 1,600 families

View of a system under construction, including latrines (©Initiative Développement)



Household uses of biogas in Guizhou (©Initiative Développement)

Context

Guizhou province, in southern China, is one of the 30 poorest provinces in the country. Its population includes many ethnic minorities (80), including Miao, Buyi, Dong and Zhuang. Guizhou (174,000 km^2) is disadvantaged because of the mountainous terrain that cuts it off from neighbouring provinces. A rail line was only recently put in, connecting it to Yunnan, Sichuan, and Guangxi, so its coal and phosphate mines remain undeveloped. Agriculture is therefore the leading economic activity. Access to basic utilities and energy is limited. The annual per capita income is about € 260.
China is pushing biogas development in the country, with a national dissemination plan and several million digesters already in operation. The reason behind this is the value of biogas in terms of space cleanup and curbing deforestation.

Project activities

ID began testing digester construction in 2005 in Weining, Guizhou. Then, between 2006 and 2008, biogas activity leaped forward with over a thousand digesters being installed during this period. The technology used was improved with the construction of new digesters made of composite materials that are easy to build and enable a higher yield of biogas.
The total cost of an 8-m3 reservoir linked to the latrine and pigpen is € 470, including the value of materials and village labour, as well as a kick-in of government subsidy money.
No one in the local communities can afford such a sum. The people therefore contribute to digester construction by digging the pits and bringing in some of the building materials. The remainder of the cost is covered by the government and the NGO, which receives support from funding agencies.

Outcomes

Biogas is proving to be a real boon for families, in economic terms where biogas is a switchover from coal, and in terms of time saved because of reduced wood gathering and faster food cooking. Biogas production is a success story in China as it is driven by a heavy demand and strong government support. This has led to an extension of the project to the neighbouring province of Yunnan.

For more information

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SECTION 5

SUSTAINABLE AGRICULTURE AND FORESTRY

ISSUES FACING DEVELOPING COUNTRIES

A common denominator among developing countries is the preponderant role of the agriculture sector. According to the *FAO*, this sector accounts for a large share of the gross domestic product (GDP) (from 30 to 60 % in two thirds of Least Developed Countries). It employs a significant proportion of the working population (from 40 to 90 % in most cases). Most basic foodstuffs are sourced from agricultural production, and farming is the only means of subsistence income for over half of the people living in these countries.

Natural resources such as soil, water, and the forest are essential production factors for agriculture. These natural resources are collective goods but are being subjected to processes of degradation that are already in an advanced stage, notably with regard to the expansion of agriculture surfaces.

The forest plays a vital role in biodiversity protection, as well as regulation of the water budget and local microclimates. Forest ecosystems are also a crucial factor in the living conditions of poorest rural communities: over 800 million people live in or in proximity to zones of tropical forest and depend on them to satisfy their needs for fuelwood, utility wood and lumber, food products and income sources.

Agriculture and forestry are therefore two areas of strong interaction. They weigh heavily in the issues of food security, access to energy, poverty alleviation, and biodiversity conservation in developing countries.

AGRICULTURE, FORESTS, AND CLIMATE

What impacts on climate change on the global scale?

According to the Fourth Report of the Intergovernmental Panel on Climate Change (*IPCC*) published in 2007, agriculture's contribution worldwide to greenhouse gas emissions is 13.5 %. The emissions are mainly due to animal husbandry, especially ruminants (effluents, enteric fermentation resulting in the emission of methane gas), use of inputs (that emit nitrous oxide N_2O), soil use change due to the expansion of arable surfaces (clearing of forests to obtain farmland), energy consumption (transportation, irrigation).

What is referred to as non-mechanised or peasant farming—the predominant form in developing countries—contributes little to these emissions. It is carried out on small tracts of land (1-3 hectares) or families simply produce the food they need (rice, maize, manioc, etc.) and sell any surplus on the local market. The technology used is low pollution (little use of nitrogen fertilizer, small-scale animal husbandry with no consequential production of emissions). The general approach is diversified, combining agricultural crops, tree crops, and forest plants and/or animals simultaneously or sequentially (agroforestry).

Forests theoretically are carbon sinks and thus contribute to climate change mitigation. However, the net appraisal of the forestry sector impact on climate is now proving to be negative and in 2007, according to the IPCC, it is contributing as much as 17.5 % to world greenhouse gas emissions, which makes it the third greatest producer of GHGs in the world after the energy and industry sectors.

Forest destruction in developing countries

According to the 2005 world forestry reserves estimate made by the FAO, there was an annual net loss of 7.3 million ha of forests from 2000 to 2005. South America is the leading continent suffering from this phenomenon, with a rate of 4.3 million ha a year (3.1 million for Brazil), followed by Africa, where 4 million ha are disappearing every year. In terms of forest destruction, the most affected regions are Central America and Southeast Asia (2 % a year for Indonesia). However, a major reforestation effort is taking place in some Asian countries (China, India). And some exceptions to the deforestation pattern are currently noted in certain regions, notably certain areas of Central Africa.

Deforestation is implicated in the direct emission of CO_2 via combustion and decomposition of the biomass contained in trees and the loss of organic carbon in the soil. Loss of tree cover is also implicated in the emission of other greenhouse gases, namely CH_4 and N_2O, along with indirect emissions due to the soil use activities that follow it. When fertilizers are used for crop growing, N_2O is emitted. Animal husbandry is accompanied by CH_4 emissions, while fossil fuel use in vehicles spews out CO_2 emissions.

Vulnerability of agriculture

Non-mechanised farming is noted for its low greenhouse gas emissions. Nevertheless, it is also characterized by limited access to quality seeds, poor irrigation water management, and lack of equipment for conversion or processing, and these are all areas that put developing countries into a vulnerable situation in the face of climate change, in particular where drastic variations in weather or climate patterns are occurring.

When precipitation levels and temperature patterns vary, this puts additional pressure on already fragile agriculture systems, with inevitable unfavourable consequences on crop yields (prolonged drought, soil erosion and degradation, desertification). Some regions of the world are particularly affected by such variability, including the Sahel, northwestern Brazil, central Asia and Mexico. As climatic and agro-ecologic zones shift, farmers are called on to adapt.

Although extreme climate conditions such as flooding, drought and storms are more dramatic in nature, they have an overall less serious impact on agricultural production than do chronic climate anomalies.

Global warming can also have positive effects as far as farmers are concerned, for where there is more carbon dioxide, a number of crops tend to flourish, thus enabling increased yields and more efficient use of water. Yet, many questions remain regarding the various possible scenarios.

ISSUES FOR DEVELOPMENT STAKEHOLDERS

The book you are reading is promoting the link between energy, climate, and development.

The operations that will be outlined here are classified under two key approaches:

- Developing agriculture practices in which GHG emissions are reduced, but more importantly allow resilience, i.e. enable farmers to better cope with climate variability and build their capacity to adapt to the change in the long term.

  Fact Sheet 5.1 - Solar greenhouse farming and rearing
  Fact Sheet 5.2 - Direct seeding mulch-based cropping systems

- Contributing to sustainable forest management in a way that takes into account all the different roles played by the forest (biodiversity, soil maintenance, supply of fuelwood for communities, etc.)

  Fact Sheet 5.3 - Forestry plantations
  Fact Sheet 5.4 - Fighting against deforestation
  Fact Sheet 5.5 - Sustainable charcoal production

Solar greenhouses farming and rearing

> Related fact sheet: *Fact sheet 2.1 Bioclimatic architecture in cold regions*

Agricultural activities of populations living in extreme life condition places (height, cold, and desert) are often subject to many constraints (lack of water in desert areas, low temperatures). This agriculture is reduced regarding crops' yields, livestock size, and activities' diversity. It ensures part of these areas' food safety but doesn't satisfy the local market demand in food products.

This fact sheet proposes to present the principle of solar energy through quite simple devices to develop farming and rearing activities. These techniques are developed in small-scale local development projects. They enable to improve food safety and to generate incomes in areas where they are introduced. They have social effects such as the strengthening of women's position and the improvement of populations' health through a more diversified diet. Solar greenhouse farming and rearing enable to fight against climate change reducing CO2 emission linked to traditional greenhouses' heating in winter.

AGRICULTURE AND SOLAR ENERGY

Agriculture in extreme conditions: challenges

The Himalayan chain spreads over many Asian countries; part of its population lives in valleys located at average heights around 2,500 m, especially in Afghanistan, India, Tibet, Mongolia, China or Nepal. In the same way, the Andes cordillera is the highest in Peru and Bolivia. These areas of high plains or mountains mean particularly difficult life conditions due to long and hard winters.

Farming (wheat and barley culture) and rearing (goats, sheep and yaks, poultry..) are the main resources for these populations and guarantee food safety for the poorest and extra incomes for the well-offs (health, education expenses, etc.). Agricultural practices strongly depend on the climate context. Main cultures are then done during summer (cereals, vegetables) while during the 6-month winter, temperatures can go down to 30 degrees below zero and thus no vegetable culture is possible. The mortality rate in poultry farms is also high due to the cold. Farmers who can afford it sometimes heat their poultry farms thanks to a kerosene or wood stove. Thus, agricultural activities are much reduced during winters and supply has to come from outside. Fresh products' supply, and especially in fruits and vegetables is done through the road or air if communication roads are cut. Food products' prices are then much higher.

In parallel, these extreme life conditions' areas generally benefit from high sunlight (more than 300 sunny days per year in Ladakh in North-West India for instance) which is favourable to solar energy use. This energy can also be used to enable agriculture in winter. In rural areas, these technologies bring an answer to rural needs regarding food safety and health improvement. They also enable women's empowerment, who are the main farmers. Given the easy marketing and high demand, the main objective in peri-urban areas is to generate income for beneficiaries. In this context, greenhouse culture technologies could represent full-time economic activities.

General presentation

Concept of passive solar

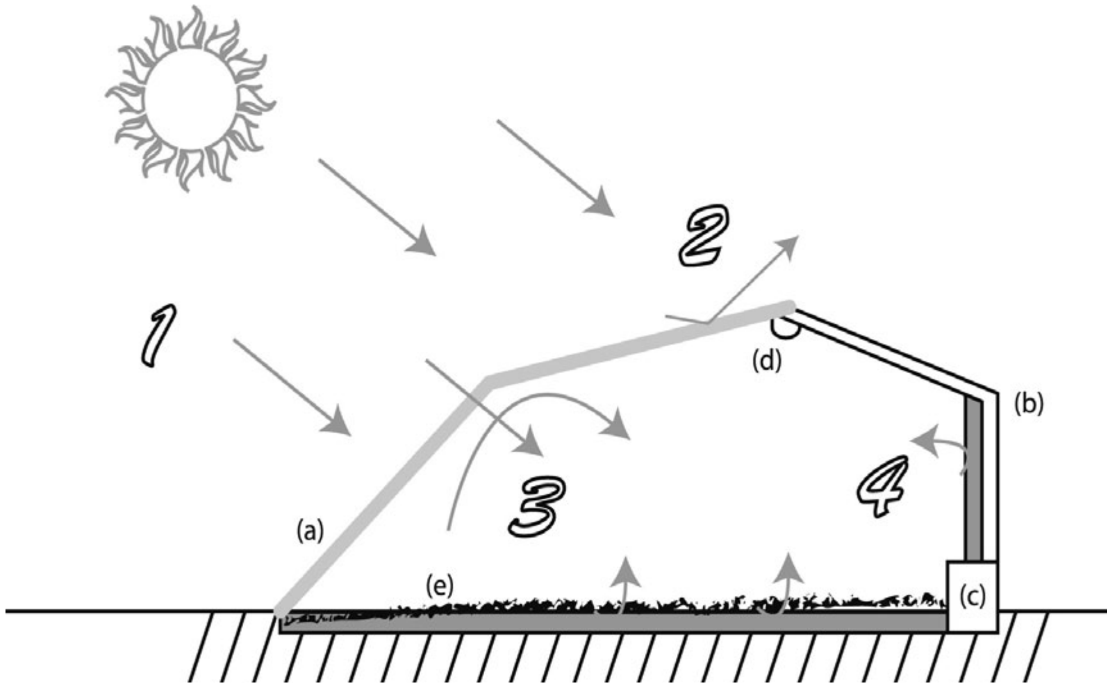
Greenhouse agriculture, in general, is based on the simple principle of "passive solar" use. The principle is to store sun heat during the day and to release it during the night thanks to a proper thermal mass and insulation. Thus the building should be oriented toward the south. Wall insulation is done through bricks or earth and straw for the roof. Two applications will be presented in this fact sheet: solar greenhouse for farming and solar poultry farms.

Farming greenhouses

They are many systems depending on the use, and they have varying cost and efficiency: trench, tunnel, simple wall, double wall with insulation, etc. Thus, a 35 m^2 double-wall greenhouse in Ladakh enable to produce 300 to 400 kg of vegetables from November to March. It also enables to cultivate patches in nursery to prepare outdoor summer crops.

Solar poultry farms

Poultry farm technology uses sun effect through a greenhouse placed next to a building, and large windows, so as to heat 1, 2 or 3 rearing rooms. The trombe wall solar passive technology can also be used; it's a wall covered with a black coat with double glaze and an intermediary space in which the room inner cold air is heated. The building and use of a solar poultry



a) Polythène sheet
b) Opaque Wall
c) Foundation
d) Roof strucutre, main beam
e) Farming area

1. Solar insulation
2. Loss by reflection on the transparent sheet
3. Solar insulation getting into the green house
4. Heat given back by the ground

farm can represent important costs and require some investment and economic activity management capacity. There are small installations for poultry farms of about 50 head and large for 200 to 1,000 head.

Materials and costs

The materials used to build greenhouses are mainly locally available (bricks, stones, cement, mud, sawdust, straw, glass, wood, paint, etc.). Only the polythene, polycarbonate or glass sheets are hard to find in isolated areas and are available in more developed urban centres. Farming greenhouses' costs are lower than solar poultry farms'.

Thus, according to the prices in use in Leh in 2007 (Ladakh, India):
- a small-size farming greenhouse (8.5 m x 4.3 m) costs about € 500,
- a poultry farm between € 1.500 and 3.000 depending on the rearing rooms' number (from 1 to 3). A solar poultry farm can be more expensive than a traditional one by 15 % but is easily made profitable thanks to energy savings.

Thanks to incomes generated through farming activities or fuel savings for a poultry farm, equipments can be made profitable in a few years.

Challenges for development stakeholders

NGOs have to:
- Support the building and use of solar greenhouses for farming and livestock rearing to demonstrate these technologies' efficiency to local communities and institutions, to encourage them to recreate and distribute them by themselves,
- Train private sector to the building of these greenhouse culture technologies,
- Offer pre-financing services through micro-credit.

DEVELOPING A PROJECT APPROACH

Feasibility study

Social and economic context

In order to propose adequate devices, the study should take into account the rural or peri-urban context, the community needs (food safety or income generation), its food habits (type and level of vegetable consumption) and its investment capacity.
For instance, in peri-urban areas, big size greenhouses (27.5 m x 5.5 m) are best suited to produce vegetables, and market-scale solar poultry farms.
In rural areas, where it is essential to guarantee food safety and where investment capacities can be lower, small-scale poultry farms and farming greenhouses (8.5 m x 4.3 m) are best suited.
Finally, it's better to cultivate vegetable which can not be stored during winter (leafy vegetables rather than carrots for instance).

Technical study

The study seeks to assess that the following criteria are met:
- Necessary orientation toward south (between 20° SE and 20° SW),
- Sunlight of at least 6 hours per day in the middle of winter,
- Few or no shadows,
- Good quality soil and available water,
- Closely available building materials.

Selection of beneficiaries

It assesses:
- Motivation,
- Investment capacity (especially for solar poultry farms),

- Command of poultry rearing techniques,
- Visibility of the agricultural products' possible marketing.

Supporting the dissemination of passive solar systems

Farming targets:

Farmers, women's groups

Rearing targets:

Small companies, women's groups

Technological maturity:

Techniques used to build greenhouses are based on simple principles that can be mastered by local craftsmen. Materials are mostly locally available except for the polythene, polycarbonate or glass sheets.

Project guidance parts:

- R&D part (design, agronomy, local food, methodologies, etc.),
- NGOs and local staff training to the greenhouses' building and use part,
- Beneficiaries' training part, especially in agronomy,
- Social mobilisation part, to introduce solar greenhouses,
- Impacts' follow-up and project assessment part.

Project duration:

A pilot project should last at least 2 years. Nevertheless, about 4 years are required in order to perpetuate the project and to disseminate the technologies.

Required skills:

R&D, social activities, rural development, insulation and passive solar skills, agronomy.

Positive and negative impacts, risks

Economic and social

- ⬆ Income generation/increase of purchasing power
- ⬆ Diet diversification (thanks to fresh vegetables, eggs and meet consumption in winter)
- ⬆ Strengthening of women's positions in communities through their involvement in the project
- ⬆ ⬇ Solar greenhouses' initial cost sometimes high but that can be supported through micro-credit and quickly paid back through the sale of agricultural products.

Environmental

- ⬆ In the case of rearing installations, fossil or non-renewable fuel savings if they were heated before
- ⬇ The polythene sheets pollutes and it is then necessary to implement recycling.

CONTRIBUTING TO CLIMATE CHANGE MITIGATION

Challenges

Passive solar greenhouses can contribute to a better adaptation to extreme climatic events and to an increased climatic variableness. Furthermore, since these greenhouses require less water than outdoor fields, they can contribute to a better water management, hence to adapt to possible water shortages due to the melting of glaciers.

The impact of passive solar greenhouses on the climate change mitigation is two-fold:

- in the case of passive solar greenhouses substituting traditional greenhouses which are highly heated thanks to fossil fuels or non-renewable biomass,

- if it enables to avoid importing fresh vegetables, there is a reduction of the emissions stemming from transportation.

Only the case of substitution of highly heated greenhouses will be dealt with in this section since the emission reduction can be calculated quite accurately. In the other case, this calculation depends on hypotheses specific to each context (transportation modes, distance, etc.).

Valorisation of emission reductions

Projects including the implementation of energy efficiency measures to isolated buildings or group of buildings are eligible to the *Clean Development Mechanism (CDM)* and enable to valorise emission reductions. In a broader sense, passive solar greenhouses as well as poultry farms can be considered as buildings. AMS II.E methodology "Energy efficiency and fuel switching for buildings"[1] can be applied. Thanks to passive solar energy, fuel consumption (fossil or non-renewable biomass) can be significantly reduced indeed completely avoided.

Passive solar greenhouse farming and rearing is eligible to CDM only if it can be demonstrated that the reference level is represented by the building's important heating with fossil energies or non-renewable fuel wood. Nevertheless, given the limited level of greenhouse gases' reduction for poultry farms and the limited replication potential, participating in the voluntary market seems more appropriate given the high cost of a CDM project.

1. Available on www.unfccc.org

Illustration: dissemination of solar poultry farms in Ladakh

Project status: Voluntary exchange market
Operator: GERES India
Information source: www.india.geres.eu
Carbon credit: VER
Credit posting: 2006-2015
Methodology: AMS-II.E. "Energy efficiency and fuel switching for buildings"[1]

Emission reduction principle

In Ladakh (Trans-Himalayan region, India), poultry farms are generally heated 4 months per year. A 14 m^2 rearing building's heating need is of about 15 kWh per day. With a 50 % -efficiency kerosene stove, yearly emissions amount to about 1.1 t CO_2 equivalent. The experience shows that thanks to passive solar measures, poultry farms can work perfectly without extra heating during the whole winter and avoid CO_2 emissions.

ER estimates

A solar poultry farm avoids 1.1 t CO_2 equivaleny per year. With a calculation, it is shown that the valorisation and sale of the emission reductions on the voluntary market enables to pay the solar poultry farm investment back over 10 years. Thus, in this case, carbon finance plays a minor financial role in the project execution.

CASE STUDY

LEARNING INCOME GENERATION IN HIMALAYA TOGETHER (LIGHT)

Project financial partners: European Commission and Foundations Ensemble and Michelham
Operators: *GERES* India, www.india.geres.eu
Local partners: *LEHO, LEDEG, LNP, SKARCHEN, STAG*
Implementation date: 2005 – 2009 (4 years)
Scope: Average-scale project (yearly budget between € 50,000 and 200,000)
Beneficiaries: 600 families as direct beneficiaries; more than 50,000 people as indirect beneficiaries. The latter don't directly benefit from the technologies, but from the production

Context and activities implemented

Remote in the Himalayan hills of the Jammu, Kashmir and Himachal Pradesh states, the valleys of these desert areas are located at more than 3,000 meters high. During the harsh and long winters, the temperature frequently falls below -20°C. Villages are then isolated for more than six months per year, the access passes being closed because of the snow. But they benefit from an exceptional sunlight, of more than 300 days per year. Traditionally, families essentially rely on agriculture and livestock rearing. The project target populations are poor villagers who live with less than € 0.7 per day (35 rupees per day). The project aims at improving the rural population livelihood in the cold desert areas of the Indian Western Himalayas in the on-going transition period from an isolated subsistence agricultural system toward the integration into a monetary economy, respecting the local specificities. Part of these activities aimed at introducing improved solar greenhouse farming, solar lambing sheds and solar poultry farms.

Solar poultry farms under construction

Vegetables cultivation under a greenhouse

Outcomes

Since 2005, 500 improved solar farming greenhouses, 80 solar lambing sheds and 15 solar poultry farms have been built. More than a 100 local staff have been trained to build them. The project's impacts' follow-up shows that a small-size solar farming greenhouse can increase the beneficiary's incomes by at least 15 %; that, in average, the beneficiaries eat 8 times more fresh vegetables in winter than before; and that a 40m² greenhouse can provide fresh vegetables in winter to about 10 families. Finally, the empowerment of women in charge of running more than 300 farming greenhouses has been noticed.

Thanks to solar lambing sheds, lambs' mortality has been reduced by 50 % in winter. Fresh eggs and meat are more available in winter which enables to diversify the diet. Some lambing sheds owners use them as multi-use sheds, for the production of handicraft, vegetable farming and passive solar heating in winter (which also enables fuel savings). Education and health expenses are generally increased thanks to extra incomes generated through the products' sale.

For more information

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Direct seeding mulch-based cropping systems

Agriculture as practised in various forms in developing countries is vulnerable to the vagaries of weather. This is even more so of non-mechanised farming wherein there is often limited access to inputs, quality seeds, and machinery. Compounding the problem is the hit-and-miss nature of water management for irrigation.

Direct seeding mulch-based cropping systems (DMC) is an innovative crop-growing technology based on a combination of zero cultivation, permanent plant cover, and crop rotation. Once this approach is mastered and applied in the long term, it results in better yields while ensuring soil protection and promoting the resistance of crops to drought and aggressions of insect pests and weeds.

This technology has been developed more or less extensively in many geographical zones. The purpose of this fact sheet is to outline how DMC can be applied in developing countries, based on research work led by the International Centre for Cooperation in Agriculture Research for Development (Centre de coopération internationale en recherche agronomique pour le développement - CIRAD).

AGRICULTURE IN DEVELOPING COUNTRIES

Overview

What is referred to as "non-mechanised" farming or "peasant" agriculture is the most common production model in developing countries. It involves small plots (between 1 and 3 hectares) on which families produce the food they need for their own consumption (rice, corn, manioc, etc.), with surpluses sold at the local market. The technologies used cause little pollution (low use of nitrogen-based fertilizers, small-scale animal husbandry with no consequential emissions), and is generally diversified.

Agriculture at this level encounters numerous constraints and can have an impact on surrounding natural environments:

- Soil tilling is an arduous task where power equipment is not available, and often remains a totally manual operation for the poorest of the poor. Where tilling or cultivation is used for *weed* elimination, this also contributes to soil erosion because the soil is uncovered and exposed to violent downpours at the start of the rainy season. In this situation, the land is subject to a runoff process that causes soil disaggregation and erosion, resulting in a major loss of organic compounds and nutrients (mainly phosphorous, potassium, and nitrogen) that are needed for plant growth.

- The problem of soil degradation is aggravated by frequent and long periods of drought, characteristic of Sudan and the Sahel, and this wreaks havoc with the anticipated harvest. Where irrigation systems are inadequately developed, it is not possible to make up for the shortage of water.

Direct seeding mulch-based cropping systems (DMC) have been developed to offer alternatives that allow some of these constraints to be addressed and enable farmers to cope with various climatic phenomena.

DMC—Innovative crop-growing practices

General principles

DMC is a system that associates a "permanent plant cover" with a main crop.

The permanent cover of the soil may be a plant mulch, either living or dead (straw). The idea is to maintain residues from the previous crop grown on the soil or to grow cover plants (intercropping). In order to preclude any competition with the main crop, the cover is later dried (after mowing or crushing it, or by spraying it with an herbicide). It may also be kept alive and simply controlled under the crop by a low-dose application of herbicides.

The main crop is sown directly in the plant cover after simply making a hole or furrow. Different types of seeding implements can be used, such as animal drawn seed drills, seeding wheels, or planting dibbles. A variety of crops can be seeded in this way: corn, rice, sorghum, cotton, peanuts, manioc, millet, etc.

Cover plants have long, powerful root systems and are capable of picking up nutrients and recycling them to the surface where they can be used by the main crop. They are also a major biomass source and can grow even in difficult or marginal conditions, such as during dry or cool weather, on compacted soil, and even where there is extensive weed growth. Cover plants can be various types of grasses that have a heavy biomass output (brachiaria [signal grass]) or legumes (stylosanthes [pencil flower]; mucuna) that contribute to atmospheric nitrogen fixation by eventually returning nitrogen to the soil. In addition to their role as a cover, such plants may also be used for animal forage.

These systems are therefore based on zero cultivation (time gain) and using cover plants that are locally available. The key point is to use a cover plant that does not compete with the main plant for water and nutrients. This requires controlling growth of the cover plant by application of an herbicide (such as glyphosate). The most critical phase of the process comes in here, as a correct dosage of the product is important. Any overdose will cause harm both to the environment and to human health.

Rotating crops is promoted, which includes grass and legumes that have the special property of fixing atmospheric nitrogen.

What are the pros?

When farmers learn to apply them properly, DMC systems offer the following advantages:

- Soil protection and improved soil structure.
Plant cover is a factor that diminishes the mechanical effect of raindrops on the soil and improves water infiltration, thus slowing down the drain off and loss of soil. When living organisms in the soil decompose the plant, humus is formed. Humus stabilises the top layer and limits the drying process.

- Improved water management.
In dry climates, cover plants can tap moisture deep down in the soil with their roots, thus improving the water budget. In wet climates, the soil infiltration and drainage are improved, so water is more quickly absorbed in the field. The water retained in the soil helps the main plant to perform well.

- The tilling workload is reduced; the farmer has less pressure from pests and disease to contend with.
Zero cultivation is a means of cutting down on time spent on the land and the arduous work of tilling. Labour-intensive periods can be managed more easily (preparation of fields, crop maintenance). In the long run, attacks by plant and animal pests are also lessened when crop rotation is practiced.

These advantages are often particularly strategic where measures must be taken to fight desertification. The United Nations defines desertification as "land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities." It is affecting developing countries severely due to their particular vulnerability to it, with a subsequent reduction of tillable surfaces and biodiversity. Soil protection and improved water management are both offered by DMC systems, making them a means of limiting desertification and its consequences.

Experimental DMC systems in developing countries

DMC systems were first developed in the United States and improved considerably in Brazil. From there they were moved into Latin America, Australia, Asia and Europe and finally reached Africa. Today, some 95 million hectares worldwide are under direct seeding mulch-based cropping systems.

However, programmes to introduce this technology in developing countries require a special approach due to the innovative and complex nature of DMC systems (zero cultivation, control of the permanent cover with the use of herbicides). This approach is a combination of agricultural research and the need for farmers to get a good handle on it. CIRAD got the approach going in Brazil (the results were successful and are available on www.cirad.fr), in Madagascar, Laos, Cambodia, Tunisia, and Cameroon. Each of these countries has different agro-ecological features and socio-economic contexts that require long-term, targeted approaches.

Some examples of experiments conducted in developing countries:

Country	Region	Main crop	Cover plants
Madagascar	High plateaus	Corn	Clover (live grown)
Madagascar	Alaotra Lake	Rice	"Bozaka" (a grass mulching material)
Cameroun	Northeast, a low-rainfall region	Corn or sorghum	Brachiaria (a grass)

Rain-fed rice grown on a cover of pencil flower (stylosanthes guianensis) in Madagascar (©CIRAD)

Issues for development stakeholders

Institutional coaching for dissemination of these innovative practices requires that research programmes and agriculture extension services be set up to make cover plant seeds available or provide technical advice.

Governments, donor agencies, and NGOs can contemplate incentive measures in the form of micro-credit and insurance for farmers interested in trying out direct seeding mulch-based cropping systems and thereby limit financial risks on the one hand and encourage dissemination of the techniques on the other.

DEVELOPING A PROJECT APPROACH

Pre-selection of intervention contexts

A project for the introduction of direct seeding mulch-based cropping system technology is generally implemented at the level of the landscape unit and would focus on a village area. The village area is defined as all the farms found within a landscape unit. The landscape unit is made up of a group of agro-ecological tiers (that may be upper, central or lower in relation to the typographical level considered) and represent the different soil types and water patterns of fields under cultivation. Initial DMC experiments would be participatory and take place on different types of land, with planting done by the farmers identified in the framework of the "village area – farm" survey conducted at the outset of the project.

The development operator would undertake a study of the relevance of introducing a direct seeding mulch-based cropping system with a number of scenarios in mind:

- Fertile zones, recently cleared land, humid or sub-humid land, but subject to strong erosion. This might involve mountain areas where steep slopes facilitate water runoff or zones subject to frequent precipitation. Farmers often consider erosion as the cause of their problems of poor crop rooting and low productivity in general. The direct seeding mulch-based cropping system is a way of maintaining soil productivity and promoting soil conservation.
- Areas that have been degraded due to several years of continuous slash-and-burn episodes or intensive monoculture (in which only chemical fertilizers have been used). These are frequently encountered in the sub-humid and humid regions of developing countries. Direct seeding mulch-based cropping systems are helpful in rehabilitating such land that has often been abandoned.
- Semi-arid zones. These zones suffer from water shortages from time to time during the growing season and lend themselves to the introduction of a direct seeding mulch-based cropping system. The moisture status is good compared to traditional agricultural practices (reduction of runoff and evaporation due to the soil being covered, improved infiltration, better soil porosity, deep crop rooting).

The pre-selection process of the zone will identify the context based on these guidelines and allow an assessment of the relevance of implementing a direct seeding mulch-based cropping system.

Supporting dissemination of DMC technology

Targets:

Farmers, technicians (in government agriculture departments, local technical support organisations for famers)

Functionality, performance:

Direct seeding mulch-based cropping systems can be assessed by the short-term effect they have on agriculture performance, their mid-term effect on the socio-economic status of the farm family, and their long-term effect on the local, regional, and global environment.

A case in point is Cameroon where, since 2001, over 200 farmers have been experimenting with direct seeding mulch-based cropping systems in cooperation with CIRAD and Sodecoton[1] on the basis of a cotton/grain crop rotation. The following results were observed: (i) over half of the land lots had a higher cotton yield (over 20 % on the average) and sorghum yield (over 15 % on the average) compared to the control lots; (ii) better water infiltration into the soil; (iii) less time spent on tilling; (iv) higher net income (cotton and sorghum).

On the other hand, higher expenses for herbicides and nitrogen were reported for the first three years (in cases where the cover plant was not a legume).

	DMC	Traditional farming
Net income (€/ha)	301	225
Days of work per ha	101	109
Value added (€/day worked)	3,53	2,28

Data for this table taken from a CIRAD study in Cameroon (Naudin and Balarabe, 2005, 2006)

Skills required:

Agronomy, pedology, sociology and rural economics, project management, training, communication.

1. Cotton company in Cameroon.

Project steps:

Direct seeding mulch-based cropping systems are a long-term venture that requires a participatory approach with an initial experimental phase (3 years on the average), followed by a dissemination phase (5 years on the average). In this way, farmers gradually assume ownership of the new crop-growing technologies.

Step 1: Participatory experiments

The first objective for development operators and agriculture researchers associated with them is to open a window on each representative portion of the ecosystem (see landscape unit) and determine the potential for direct seeding mulch-based cropping systems. The experimental phase will last at least a couple of years, given that crop rotation is paramount in the DMC approach. Training will enable farmers to understand the agriculture mechanisms in play and get a handle on them, then make their own choices as to the types of plants and learn how to get enough of the plant material needed for these systems. Coaching is needed in each village area and would focus on the formation of village community organisations: credit, product marketing, supply of inputs and agricultural equipment, community rules, etc.

This initial phase is a means of:
- Putting direct seeding mulch-based cropping systems to the test in real life.
- Having the farmers assess the systems and guiding research on priority themes.
- Training the various players in development research (village areas provide an excellent forum for interchange).
- Identifying and promoting motivated farmers who have assimilated DMC practices and getting them to take on the role of farmer advisers for direct dissemination of this technology in other village communities.
- Providing a benchmark for the more extensive farming areas in the focus region or country.

Step 2: Dissemination of the practices

The dissemination phase requires work with the famers on a one-to-one basis over a timeframe long enough to coach them in this totally new approach to their vocation. To successfully have the new agro-ecological technology accepted, emphasis must be put on improvement of the agriculture environment, and this requires:

- A competent staff base that has been given appropriate training, mastery of DMC techniques, tools to adapt them, as well as principles for their dissemination at the level of the village area that is consistent with farmer strategies.

- Concentration of the means of dissemination on just a few sites so as to provide ongoing proximity support.

- Coaching the changeover.

- Promoting a concentric spread from trained farmers to interested farmers, thus gradually working toward wide-scale dissemination.

Essential aspects of project guidance:

- Technical coaching for farmers.

One of the project objectives is the provision of seed and fertilizer inputs services. It will have a farmer capacity-building focus with ongoing training for technicians (government agriculture department staff, local partner organisation) in order to provide farmer coaching.

- Anticipating possible conflicts.

In Africa, developing these systems raises the issue of integration and competition with animal husbandry for biomass, which has become a coveted resource. Alternatives are now being studied (for instance in northern Cameroon where support is being given to small-scale cotton producers) which involve awareness raising and promoting dialogue with all the people involved in the target area. Negotiation among players and decision makers to come up with a set of management rules for the space and sharing of productions has proven to be necessary, in particular in regions that have been won back due to this innovation.

- Monitoring and assessment.

A monitoring and assessment mechanism is needed for farms that go for the new technology and those that do not, and compare the results. The project's agriculture research component is there to intervene to anticipate, upgrade, adapt, and simplify the direct seeding mulch-based cropping system technical offer. Indicators are designed to identify the number of farmers that use the biomass produced and recycled in the form of ground litter, how much is accomplished in a workday, etc. Attention will also be given to soil quality monitoring (analyses) or to farm economics. The individual and collective analysis will highlight success stories as well as failures.

Positive and negative impacts, risks

Environmental

- ⬆ Soil protection due to soil cover, runoff control, conservation of water resources and biodiversity.
- ⬆ Sequestering of carbon in the soil, thus cutting down on the concentration of CO2 in the atmosphere, hence contributing to climate change mitigation.
- ⬆ Reduced use of chemical fertilizers.
- ⬇ Use of herbicides to control the permanent cover.

Economic and social

- ⬆ Improvement of farmer incomes due to savings on input access costs.
- ⬆ Increased productivity of the workday due to less time spent on tilling or irrigation activities.

- Improved food security due to better productivity and crop diversification.
- Need for financial support for experimental plots during the early years of the project, notably for access to herbicides for cover plant control.
- Health risk in the event herbicides are used improperly (respiratory tract and skin problems).
- Risk of conflicts over use of the biomass (produced by cover plants) with livestock raisers (between using the plant as a cover crop and for forage).
- Introduction of the innovation in rural communities using a participatory approach and knowledge transfer to farmers. The experimentation and learning phase required to successfully implement a state-of-the-art technology is relatively long (as much as 3 years) and this could promote elitism.

CONTRIBUTING TO CLIMATE CHANGE MITIGATION

Direct seeding mulch-based cropping systems contribute to *adaptation* given the soil renewal and conservation aspects, as well as control of erosion. Furthermore, the systems increase the *resilience* of agricultural activities in the face of climatic variability by improving management of water on the individual land plots (better resistance to periods of drought or flooding).

Direct seeding mulch-based cropping systems contribute to *mitigation* through the reduction of *greenhouse gas* concentrations in the atmosphere. The technology enables a saving of fossil fuel expenses (no tilling of the soil, less treatment, hence less use of chemical fertilizers and molecules). Furthermore, they promote carbon fixation in organic matter accumulated in the soil from harvest residues and cover plants. The quantity of carbon that can be sequestered is therefore essentially tied in with the increase of plant biomass and its specific nature (the richer the lignin content of recycled harvest residues, the more they contribute to humus stock reconstitution).

In order to calculate reductions, a soil analysis must be made during year 1, with a soil carbon content statement being made in year 5. In the hinterland of Brazil, studies (*CIRAD*, 2005) compared conventional agriculture with DMCs and revealed that emissions were from 0.2 to 1.4 t CO_2 equivalent/ha/year in conventional agriculture in the soil at the “surface” or “average depths” (0 à 20 cm). But using DMC technology, the rate of carbon in the soil jumped from 0.83 to 2.4 t CO_2 equivalent/ha/year, depending on the precise location, type of system, and cover plants used.

CASE STUDY

RICE GROWING USING THE DMC SYSTEM IN CAMBODIA

Project funded by: *AFD*, government of Cambodia, and CIRAD. 2008-2012
Scope: Large-scale project with a yearly budget over € 500,000 / year
Operator: *CIRAD*
Main partner: Ministry of Agriculture, Forestry, and Fisheries; Cambodia Rubber Research Institute
Implementation date: 2 phases: 2004-2007 and 2008-2012
Beneficiaries: Farmers in Kampong Cham province

Context

Cambodia has a land area of 181,035 km^2 and a population of 13.2 million inhabitants (2004), 85 to 90 % of whom live in rural communities. Some 36 % of these farmers live under the poverty line. Agriculture is a major economic sector in Cambodia, accounting for 37 % of the GDP and 85 % of jobs. The Mekong and Tonle Sap flood plains are the main agricultural and socio-economic activity zones. The climate is tropical monsoon, with a dry season from November to April and a rainy season from May to October.

The low performance of irrigation in Cambodia is due to:
- Irrigation infrastructure deficiency and mainly "back-up" irrigation used to secure production.
- Financial precariousness of farmers and their inability to invest in off-season crop growing.

Rice is the staple food of Cambodia and it is grown on approximately 50 % of cultivated surfaces. The total yield is 4.17 million tonnes a year; exports total 416,118 t / year. Local consumption is 143 kg of rice per person per year. The growing system is based on control of the rainwater level by land reshaping operations that include removing high spots and ridges, filling depressions and gullies, grading, levelling, smoothing, forming ditches, establishing terraces, and throwing up levees. Rice growing is associated with a few other cash crops, some annual such as soybean, sesame, and manioc, others perennial, including cashew, rubber, banana and mango. Family-scale cattle raising and fish farming are also practised.

Project activities and outcomes

The initial phase of the project concentrated on improvement of both rain-fed and irrigated rice productivity, taking into account various other agriculture activities (rubber tree plantations, animal husbandry, and fish farming). Work was done on the red and black earth plateaus as well as on the sandy uplands of Kampong Cham province. A system of trial and demonstration plots was set up that focused on the key annual cash crops in the province (manioc, soybean, corn, and rice). Phase 1 yielded the following results: (i) development of direct seeding mulch-based cropping systems for rain-fed agriculture; (ii) implementation of the first components of a seed multiplication system; and (iii) getting a nucleus of DMC experts together in Cambodia.

Soy plant grown on a cover of Brachiaria in Cambodia (©CIRAD)

Phase 2 (2008-2012) includes further experimentation with direct seeding mulch-based cropping systems for manioc, corn, soybean, and rice (on plateau land and hills); as well as rice growing (sandy soil terraces and hydromorphic plains).
The total surface of the pilot plots is anticipated to be about 10 ha in 2008. By 2012, this figure is anticipated to reach over 400 ha and involve approximately 350 family-scale farms. The pilot dissemination network will be set up in Kampong Cham province in 2008 and extended to Pailin and Battambang provinces starting in 2009.

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Forestry plantations

Afforestation and reforestation

> **Related Fact Sheets:** *Fact Sheet 1.1 - Fuel-efficient cooking; Fact Sheet 3.1 - Local production of agrofuels; Fact Sheet 5.4 - Fighting against deforestation*

In 2005, forests covered 3.95 billion hectares of land, locking in 53 % of the aggregate carbon reservoir of the earth's ecosystems, a truly phenomenal quantity. Looked at from the standpoint of the entire planet, forests play a most significant role in the *greenhouse gas* (GHG) swap, sequestering approximately 0.7 Gt of carbon per year, or about 9 % of global GHG emissions. In this capacity, they are referred to as "carbon sinks."

There has been a 2.38 % annual increase in forested surfaces due to plantations from 1990 to 2005. Plantations now account for 4.6 % of forest cover worldwide, and total over 18 million hectares. Forest planting has been carried on for centuries by man to meet food, energy, or economic needs. Afforestation and reforestation projects serve many purposes, and the socio-economic benefits they bring to local communities make them a particularly worthwhile undertaking.

In the context of climate change mitigation, it is obvious that such projects can fulfil a further purpose with regard to the environment: an increase of wooded surfaces and maintenance of growing stands of trees contribute to carbon sequestration ("sink" effect) and therefore to reduced concentrations of GHGs in the atmosphere.

MANY PURPOSES SERVED BY FORESTRY PLANTATIONS

Background...

Forestry planting is a very ancient practice. Early evidence of fruit tree domestication is found with the fig tree, going back some 11,400 years.

There are a number of historical reasons why people started planting trees. Among these can be mentioned man's transition from a nomadic to a sedentary way of life, development of new tools enabling tree growing and most importantly, a depletion of resources that were formerly scavenged or picked (fruit, lumber, etc.).

Forestry plantations have evolved with the needs of human societies and today they play many different roles. Among these are: a response to the need for food security (fruit picking, animal forage), fuelwood supplies, medicinal products (tree bark, leaves, sap), production of building materials, erosion control, a means of maintaining the quality of water resources, etc.

Overall, though, forestry plantations play a role in the storage of carbon dioxide (CO_2) from the atmosphere, as will be developed further on, and this function has only recently been recognized since climate change and the need to combat it have come to the fore.

Depending on what role is looked for, tree types and plantation management practices vary, as we shall see.

Typology of forestry plantations

How a forestry plantation will be put in depends on the type of end product wanted. Each project must then be adapted to the social, economic, and environmental targets identified, as well as to the human, technical, and financial resources that it is reasonably possible to mobilise.

From a technical point of view, a typology can be highlighted in relation to the main intended purpose. A plantation will generally have a number of the functions described below:

Energy plantations

The purpose here is to optimise production of the energy quantity represented by "quantity of such-and-such a wood tree X calorific power of wood harvested from that tree species." Conformation of the wood is not an important consideration at this point. In this case, the plantation will be dense and start with a sprout forest. Harvesting will be done on a short-term rotation basis (depending on the species). Fertilisation is commonly necessary. Fast-growing tree species such as acacia (Acacia auriculiformis), leucaena (Leucaena leucocephala), cassia (Cassia siamensis), gliricidia (quickstick) or sesbania are obvious choices. (See Fact Sheet 1.1 - Fuel-efficient cooking and biomass energy).

Timber plantations

The objective of such a plantation is to produce wood that is easily sawed, of standardised mechanical properties, and no doubt possessing some aesthetic value.

1. FAO, 2006

The trees must be of a species that grows straight and is knot-free. The plantation will be dense to start with, then gradually thinned down. Branch cutting operations will be necessary. Trees grown for this purpose can only be harvested when they reach maturity. The stand can be regenerated naturally or assisted by replanting. A considerable variety of trees can be grown for sawn lumber, such as teak in Asia, rosewood in Brazil, or okoumé and limba in Africa.

Fruit and forage plantations

In this case, the purpose is to harvest the edible part of the tree (fruit, leaves, bark), and tree types are chosen according to their ability to meet this need. Based on the time of harvest and technique used (ripe fruit still on the tree, ripe fruit that has dropped to the ground, hand picking, tree beating, etc.), a regular trimming or pruning operation may be required. The trees would only be cut down after they have passed their fruit or forage production peak. Some of the types of trees used for this purpose are the coffee plant, vanilla orchid, cinnamomum verum (of which the inner bark is harvested to make cinnamon), pistachio, breadfruit tree, cashew nut tree, Brazil nut tree, and shea butter tree. .

Agroforestry plantations

Agroforestry plantations are plantations that include the different purposes described above.

According to the World Agroforestry Centre (ICRAF), agroforestry is a dynamic system of managing natural resources based on ecological foundations that make trees part of farming operations and the rural landscape, thereby diversifying and maintaining production in such a way as to improve social, economic, and environmental conditions for all users of the earth.

We will here take a look at agroforestry systems that associate both tree and crop growing on the same piece of land. These plantation techniques are especially relevant for local development initiatives. They have the advantage of generating more diversified incomes for rural or forest-based communities and better spreading out of the income over time.

Crops such as manioc, sorghum, corn, coffee, and cacao can be grown under stands of rubber, teak, cashew nut trees, and the like. This approach allows value to be extracted from both the fruit and wood within the agroforestry system.

Furthermore, soil fertility can be improved by associations of trees with legume crops (peanuts, peas, lentils, soybeans), as these plants enable atmospheric nitrogen fixation in their roots. In order to protect the soil and keep invasive plants from taking over, a grass cover crop can be planted between rows of trees.

Issues for development stakeholders

Forestry plantation projects are worthy of the greatest interest on the part of public authorities in developing countries, given the many social, economic, and environmental roles just mentioned. At the social level, these projects enable the putting in place of innovative approaches to governance and decentralised forestry management. At the same time, the local communities directly affected by the projects can be involved in them and thereby receive training.

NGOs can play a canvassing role to garner support for development of a national, regional, or local policy framework for the setting up of forestry plantation projects. They can also play a role in the dissemination of information and/or technology implementation on potential project sites such as local communities or *forest-based communities*.

DEVELOPING A PROJECT APPROACH

Feasibility study

The feasibility study will have a number of headings:

- Analysis of the environmental parameters of the zone.

A study of the climate, geological, pedological, and hydrological features is required to determine which types of trees are appropriate and the tree-growing techniques that must be applied. An assessment of the ecosystem where the plantation is to be put in is necessary to determine if it is rare and/or vulnerable and what level of biodiversity is found in it. Possible threats to the plantation need to be anticipated (forest destruction, fire, phytosanitary attacks, etc.).

- Technical feasibility study.

An overview of what has been done in terms of forestry plantation in the region or country will highlight examples of successful experiences to build upon or errors committed that must not be repeated. On the basis of an analysis of the environmental parameters, a selection of tree species can be proposed, with priority given to those that are available locally. The study would also confirm the availability of the water resource (pluviometry, identification of the *watershed*).

- Land use security situation and financial capacity.

Plantation projects are long-term ventures that involve many hectares of land. The land under consideration may be classified as community, private, or public. In any case, land use security is a paramount issue. Handling it will require prior knowledge of the law and how any disputes can be arbitrated. Stock must be taken of available land use and legal guarantees. As for the financial environment (price of lumber, possible export tax, etc.), an analysis will make it possible to assess the attractiveness of such an investment for the project implementer.

Support for setting up forestry plantations

Targets:

Farmers, *forest-based communities*, local and/or regional authorities.

Functionality, performance:

A few months to several years may be required to set up a plantation depending on the surface area involved and the human and technical resources available. Coordination between the different phases (preparation of the land, nursery, development of seedlings, etc.) and compliance with the critical phases for transplanting (among which season is a decisive factor) will have a major influence on the mortality rate in the first few months of the plantation. Anticipated yields vary greatly depending on environmental conditions (soil fertility, pluviometry), the tree types themselves, and the technological itineraries. The harvest can vary from only a few cubic meters per hectare per year for some to several dozen for others.

Essential aspects of project guidance:

The type of coaching will vary considerably according to the purpose of the plantation. The following information is provided as a rule of thumb:

- Research and Development: Development of technical itineraries, testing possible associations within the agroforestry system, improving productivity of a plantation for sawn lumber, etc.
- Technical coaching and training: Setting up nurseries, transplanting, managing the stands (thinning, trimming or pruning, etc.).
- Stakeholder organisation: Required to mobilise the labour force, obtain land use security, distribute the proceeds from the plantation (fruit, charcoal, carbon credits, etc.).
- Monitoring: A necessary means of assessing the socio-economic spin-offs of the plantation. For projects seeking eligibility under the *Clean Development Mechanism* arrangement, monitoring is a must in order to collect reliable information enabling evaluation of actual carbon sequestration

Project duration:

Setting up forestry plantations is a long-term undertaking, but in a local setting especially there must be some short- or mid-term benefits, such as fruit production, inasmuch as income and capital mobilisation from the project will only kick in quite some time down the line.

Skills required:

Forestry and agroforestry: Planting operations and plantation monitoring, development of the carbon budget, and implementation of sequestered carbon monitoring on the basis of approved methodologies.

Financing: Project financing package with possible input from buyers of carbon credits.

Economic assessment in order to calculate the project's internal profitability rates (with and without sale of carbon credits in the framework of a CDM project).

Industry organisation: Provide an umbrella for and facilitate the involvement of small-scale farmers.

Sustainability:

The sustainability of a project depends primarily on two points: Land use security for the piece of land on which the plantation will be put and capacity of the project operator to mobilise capital several years in a row. For long-term project viability, it may be necessary to intervene at a very early upstream stage, i.e. at the level of national forestry policy and/or national land management policy. Moreover, in a CDM-type project, it may be advisable to design innovative financing tools, such as obtaining loans for the plantations against advance payment for carbon credits.

Positive and negative impacts, risks

Economic

General

- ⬆ Job creation (tree planting and care), income (proceeds from the plantation).

A plantation on primarily agricultural land

- ⬆⬇ Short-term drop in income from agriculture due to the long plantation cycle, although a mid- and long-term increase will be felt once soil fertility has been restored, fruit and charcoal are harvested from the trees, and carbon credits are sold.
- ⬇ Farmland set aside and switching of productions.

Energy plantation

- ⬆ Reduction of expenses for charcoal, fuelwood.
- ⬆ Long-term reduction of time spent collecting fuel.

Social and health

General

- ⬆ Improvement of water quality due to water regulation made possible with healthy tree cover.

Fruit tree plantation

- ⬆ Improved food security for communities.

Environmental

General

- ⬆ Protection of water resources.
- ⬆ Restoration of degraded land, soil quality renewal.
- ⬆ Carbon sequestration (explained below) in the trees and soil, lower GHG concentration in the atmosphere.

Energy plantation

- ⬆ Less pressure on fuelwood and charcoal producing resources.

CONTRIBUTING TO CLIMATE CHANGE MITIGATION

Issues

Forest ecosystems are a critical element in the carbon cycle. Photosynthesis enables trees to capture atmospheric CO_2 and convert it to organic molecules with energy from the sun. The resultant carbon is stored in the roots, trunk, and crown of the trees. Forest soil generally contains at least as much carbon as the tree biomass standing on it.

Reference is made to the sequestration capacity of the forest ecosystem (trees and soil). To illustrate, a thriving forest can store from 3 to 10 t CO_2/ha/year, while old forests would basically have reached a steady state[2]. Depending on the geographic region and the tree variety planted, a forestry plantation has the potential, according to *IPCC* data, to sequester between 8 and 20 t CO_2/ha/year.

Eligibility of a forestry plantation as a CDM

Afforestation/reforestation

A forestry plantation project is eligible under the *Clean Development Mechanism (CDM)* arrangement for afforestation and reforestation projects. The definition of these two terms given in the *United Nations Framework Convention on Climate Change (UNFCCC)* is based on the length of time the forest has been absent. A tree planting project on a piece of land that has had no forest on it for at least 50 years would be considered as afforestation. Any other project would be defined as reforestation.

On the other hand, forest conservation or management activities are not eligible for the first commitment period from 2008 to 2012. These initiatives have been put together under the programme known as Reducing Emissions from Deforestation and Degradation (REDD) and are at the core of the debate in ongoing post-Kyoto negotiation cycles (2012). They will be explained in Fact Sheet 5.4 - Deforestation control and avoided deforestation.

Afforestation/reforestation CDMs

As any other CDM, the project must prove its additionality, i.e. show that its net real GHG absorptions would not have taken place in the absence of the project.

The most specific characteristics of afforestation/reforestation projects are as follows:

- **Date the afforestation took place and definition of the forest**

The afforestation/reforestation project must involve a piece of land that did not have forest on it as of December 31, 1989, which status must have prevailed at the time the project was started. Each country is to set the parameters for forest definition. A "forest" is considered to be a system on an area of land of at least 0.05 to 1 hectare, with tree crowns covering over 10 to 30 % of the surface, with the potential of reaching a minimum height of 2 to 5 meters at maturity.

- **Temporary carbon credits**

GHG emissions reductions brought about by afforestation/reforestation projects are temporary in nature. The carbon stored in a plantation will not remain there indefinitely. For reasons that are human-induced (usage conflicts, fragility of land use security, etc.) or natural (fire, insect attacks), the stand of trees can disappear and the carbon stored in it heretofore can be freed into the atmosphere. So while emissions reductions under CDM projects focusing on energy efficiency or the use of renewable energies are eligible for ongoing credits, the absorption made possible by forestry projects are temporary, for a five-year period, because of the inherent risk that the afforestation/reforestation will not be permanent. For projects that have been developed for the voluntary exchange market, other systems of guarantee are available, such as the one developed by the Voluntary Carbon Standard. It works like insurance. Standing credits are delivered, while a number of them are put on hold and can be used if the afforestation is undone.

At time of writing, forest credits are not accepted under the European Union Emissions Trading Scheme (see Box 2), and this is a deterrent for forestry CDMs. However, they are traded on other markets at a price of approximately US$2 to 3/t$CO_2$e.

Advanced planning for a forestry CDM project

Assessing the sequestration potential of the plantation will require answers to the following questions and data[3] on storage, emissions, and emissions induced by the project.

Storage data

- Surface area of the land undergoing afforestation.
- Woody species used.
- Plantation density.
- Association pattern of woody species.
- Annual growth rates by species.
- Expansion factors by species that allow the standing biomass to be calculated.
- Ratio of aerial biomass to root biomass by species.
- Wood density by species.
- Carbon content of the wood by species.
- Technical itinerary (phases of planting, thinning, trimming, harvest, etc.).

Project emissions data

- Technical operations and how they are implemented (mechanical or manual? type of machinery? consumption of fossil fuel per hour of work?).
- Necessity of putting a fence up around the plantation.

2. Kowalski et al, 2004.

3. If some of this data is not provided, the IPCC provides default values.

Data on project monitoring

Additionally, the project must be designed in such a way as to factor in measurement of atmospheric carbon sequestration throughout the life of the plantation. An effective monitoring protocol must be developed (a minimum requirement being the measure of tree diameter). Some technical interventions are to be avoided, given that they have an impact on the net carbon budget (e.g. power machinery causes GHG emissions due to fossil fuel use; tilling the soil very frequently results in a reduction of carbon stored in it; irrigation too has an impact on the carbon balance).

Illustration: agroforestry reforestation in Haiti

Project status: *Voluntary exchange market*
Carbon credit: VER (standard still to be determined)
Information source: www.onfinternational.org
Crediting period: Not yet determined
Methodology: AR-AMS0001 small-scale methodology

Context and principle of emissions reduction

The project involves the planting of 100 ha of both fruit and lumber trees in a watershed area on which the land has undergone considerable degradation. The thrust is to regain soil fertility and enable subsistence agriculture to be resumed, erosion to be controlled, and institute protection for the watershed and water resources. The trees will be a source of fruit and wood will be harvested for charcoal making. Without the project, the condition of this degraded land would continue to worsen because of erosion. The natural conditions would not be conducive to restoration of the tree growth. Reduction of CO_2 concentration in the atmosphere is therefore possible because of sequestration.

ER estimates

Sequestration is initially evaluated at about 24,000 tCO_2 equivalent throughout the duration of the project (30 years), or from 6 to 8 tCO_2equivalent/ha/year. Some 300 to 400 small-scale farmers stand to reap benefits from the project. This project is purposely being kept small at the outset, as many plantation programmes in Haiti have failed. A second more extensive phase will be planned based on the results of this initial phase.

CASE STUDY

SUSTAINABLE MANAGEMENT OF NATURAL RESOURCES IN MAPUCHE COMMUNITIES, CHILE (PROMACIN)

Project funded by: FFEM, AFD
Scope: Large-scale project (yearly budget of € 200,000 to 1,000,000)
Operator: CONAF (Chilean forestry administration)
Partner: ONF Conosur (affiliate of ONF International) - www.onfinternational.org
Implementation date: 2003-2008
Bénéficiaries: 57 Mapuche communities in Lumaco commune and 8 Mapuche communities in Curarrehue commune

The PROMACIN project was designed to promote sustainable natural resources management with the involvement of the local indigenous Mapuche communities, most of whom are poor. The project is seeking to conserve biodiversity, improve the quality of life of the communities, and promote sequestration of atmospheric carbon through forestry plantations that have been established in Lumaco commune, north of Temuco.

Context

Since 1974, the government of Chile has put in place a grant system allowing 75 to 90 % of the costs of plantations to be picked up, the purpose being to promote forestry plantation and wood production activities. Remittance of the grants is a two-step process, one and three years after completion of the work and subsequent to field audits by CONAF. Small-scale owners very frequently do not have the funds necessary to pre-finance the work, so the idea was born of putting in place a rotating fund to have the pre-financing money available, with the fund topped up by the later remittance of grant assistance. The PROMACIN project was instrumental in having this fund set up back in 2003. The plantation component is only one part of the overall project.

Meanwhile, a system similar to the rotating fund was contemplated as an interface between the small-scale owners and purchasers of the future carbon credits generated by the plantations.

In this way, the Mapuche communities will receive in the mid-term (after 12 years) and in the long-term (30 years) income sourced from the sale of lumber. In the short-term (2008), they will receive income from the sale of lumber (2008) and in the mid-term money from the sale of carbon credits.

Project activities

The rotating fund made it possible to plant 850 hectares between 2003 and 2006. Half of the plantations are of fast-growing tree types on degraded land with no plant cover.

The gradual transfer of the rotating fund to the Mapuche communities, represented by the Lumaco League of Mapuche Communities (UCML), was initiated in 2007. A Mapuche NGO, Lonko Kilapang, is handling the fund because it has more extensive administrative and technical skills than the UCML. At the present time, the Lonko Kilapang organisation is making contracts with small-scale owners, acting on behalf of the Social Affairs Department of the Temuco bishopric.

More specifically with regard to the carbon component of the PROMACIN project, the sale of credits will take place on the voluntary market. The project is not eligible as a CDM because international funding packages have been obtained for its implementation. Furthermore, the modest size of the project has the risk of generating proportionately higher transaction costs if it is run as a CDM.

Nevertheless, given that the project complies with all other CDM eligibility criteria, a small-scale methodology validated under this arrangement will be used. It will ensure project transparency and quality in the eyes of voluntary purchasers of carbon credits and result in better pay for the owners.

Land plot being prepared for plantation (foreground) (©ONF International)

The lumber will have commercial value after 12 and 30 years have elapsed, so it was decided to take advantage of a temporary type of carbon credits (valid for 5 years). Initial calculations show that the 850 ha of plantation will generate a value of 224,000 VER (verified emission reductions) in 2028. Sale of the credits will be centralised. Each owner is to enter into a contract with the fund operator who will take care of the transactions necessary for the production of certified credits: monitoring measures, audit by a certifier, purchaser search, etc. The owner will receive payment from the proceeds of the sale of credits, although the operator will deduct service charges from that sum. For the time being, the carbon fund will be managed by the Social Affairs Department and gradually be turned over to the UCML, in a manner similar to the rotating fund. Currently, although the price of temporary credits on the markets is subject to considerable fluctuation, it will be at least US$ 2-3 for a credit valid for five years.

Plantation after a few months (©ONF International)

Outlook

Assessment of the project is scheduled for the near future, but an initial balance sheet can already be presented. The PROMACIN project has enabled the establishment of an innovative funding system for small-scale owners. It is anticipated that economic spin-offs will be enjoyed by the largely poor local communities, both from the sale of lumber and collection of carbon credits. The rotating fund and carbon fund are being gradually turned over to the local communities, and it is expected that this will ensure the long-term viability of the project, place greater responsibility on the shoulders of the local communities, and give them a greater measure of self-management.

For more information

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CIFOR - Centre for International Forestry Research): www.cifor.cgiar.org
ICRAF - World Agroforestry

Fighting against deforestation

Avoided deforestation

> **Related Fact Sheets:** *Fact Sheet 1.1 - Fuel-efficient cooking and biomass energy; Fact Sheet 5.3 - Forestry plantations; Fact Sheet 5.5 - Sustainable charcoal production*

Forests play a critical role in protecting biodiversity, as well as in regulating the water budget and local microclimates. Forest ecosystems are also vital for the living conditions of the poorest rural communities who depend on them to meet their needs for fuelwood, utilitarian and construction wood, food products, and sources of income.

According to the Global Forest Resources Assessment 2005 made by the FAO, forested surfaces today come to less than 4 billion hectares, or about 30 % of the land surface. The FAO points out that between 2000 and 2005 deforestation took place at an accelerated pace, although it had slowed down compared the figure for the 1990-2000 period. It is currently responsible for 17.5 % of *greenhouse gas (GES)* emissions.

The purpose of this fact sheet is to highlight the socio-economic and environmental impacts of deforestation. It will then focus on the special attention that this phenomenon is receiving at the institutional level of climate change mitigation, under the name "avoided deforestation."

ALARMING STATE OF FORESTS IN DEVELOPING COUNTRIES

The many roles of the forest

Forests play an essential ecological role. They are reservoirs of biodiversity and habitat. They impact on the water budget and local microclimate regulation (evapotranspiration, canopy with the capacity to lessen thermal shocks). If not overtaxed, forests can contribute to soil restoration and effective erosion control.

Furthermore, forest ecosystems play a vital socio-economic role for communities that neighbour them. Thus, in most of these countries, firewood is the main energy source and accounts for up to 95 % of domestic energy consumption.

Non-wood forest products (NWFPs) also are of major importance, mainly in terms of food security and local economics. The designation NWFP includes biological forest products other than lumber, in other words products used for food (nuts, fungi, wild fruit, herbs, spices, aromatic plants), plant materials (fibres, liana, flowers) and their derivatives (raffia, bamboo, rattan, cork, essential oils), as well as forest fauna and products taken from it (game, honeybees, honey, silk). Some 80 %[1] of the people living in developing countries use NWFPs as health aids and nutritional supplements. The sawn lumber and wood industry are also an important source of income and are a significant factor in the economies of countries that have an extensive forest cover.

Forests are also a key factor in the carbon cycle. Photosynthesis enables trees to use energy from the sun to capture atmospheric CO2 and convert it into organic molecules. The carbon is stored in the roots, trunk, and foliage head of trees. Forest soil generally contains at least as much carbon as the tree biomass it sustains. Put another way, this refers to the sequestration capacity of the forest ecosystem (trees and soil).

Over 800 million people live in or near tropical forest zones and depend on them to meet their needs for fuelwood, utilitarian and construction wood, food products, and sources of income.

Deforestation and what it means

According to the Global Forest Resources Assessment 2005 of the FAO, there was an annual net loss of 7.3 million ha of forests from 2000 to 2005. South America is the leading continent suffering from this phenomenon, with a rate of 4.3 million ha a year (3.1 million for Brazil), followed by Africa, where 4 million ha are disappearing every year. In terms of forest destruction, the most affected regions are Central America and Southeast Asia (2 % a year for Indonesia). However, a major reforestation effort is taking place in some Asian countries (China, India). And exceptions to the deforestation pattern are currently noted in some regions, notably in Central Africa.

1. FAO, 2001

Studies on the subject reveal that deforestation and forest degradation result from a number of factors that interact in a complex way. The main direct causes of deforestation are agricultural expansion (agro-industries, animal husbandry, and slash-and-burn agriculture), extraction of wood products (sawn lumber, pulp, firewood) and infrastructure development (roads) that may be prompted by various agents or factors: industrial enterprises, small-scale producers, etc.

Loss of forest cover has many consequences, among which are the upset of the water balance, aggravation of erosion, loss of biodiversity, as well as social and economic impacts for communities that directly depend on the products and services of the forest.

Furthermore, deforestation is implicated in the direct emission of CO_2 via combustion and decomposition of the biomass contained in trees and the loss of organic carbon in the soil. Depletion of the tree cover is also responsible for the emission of other greenhouse gases, namely methane (CH4) and nitrous oxide (N_2O), when biomass is burned.

In this context of deforestation, the net assessment of the forest sector on climate is therefore negative. According to the *IPCC*,[2] the contribution of deforestation to world greenhouse gas (GHG) emissions was 17.5 % in 2005. The "forestry" sector is the third largest contributor to GHGs in the world, behind the energy and industry sectors but ahead of transportation and agriculture. Most of these emissions result from deforestation and forest degradation in developing countries, particularly in tropical regions.

Issues for development stakeholders

Reducing forest destruction and degradation therefore requires a comprehensive, countrywide strategy, developed and implemented by competent institutions in consultation and partnership with all persons and entities directly involved: local communities, NGOs, private sector, research institutions, donors, etc. An institutional framework must be set up in conjunction with local initiatives.

Institutional framework

Many of the potential measures to control forest destruction and degradation are in the hands of institutions in charge of the major policy orientations of the country or area of operation (economic and financial instruments, legal measures, promotion of good governance). Policies designed to reduce deforestation and forest degradation include economic and financial instruments (grant aid, certification schemes, public and private investments, payments for environmental services), adopting and enforcing laws and regulations, strengthening of governance mechanisms and institutions (landholding system, integrity and transparency of decision-making, institutional capacities).

Local initiatives

Development operators can support concrete projects in the field that deal with replacement of firewood with other sources of energy, dissemination of agricultural technologies as alternatives to slash-and-burn agriculture, multi-purpose reforestation programmes, energy, and utilitarian wood (see Fact Sheet 5.3 - Forestry plantations, afforestation and reforestation). Other approaches may include the establishment of private protected areas, commune and community forestry management, etc. NGOs will have a major role to play in implementing such projects.

UNDERSTANDING THE NOTION OF "AVOIDED DEFORESTATION"

Despite the controversy and challenges spawned by the suggestion that forests be included in the Kyoto Protocol, deforestation has become a key point in current international negotiations on climate change mitigation. Thus, "avoided deforestation" emerged as a theme at the October 2006 Summit on the World Agenda when the Stern report came out. This report, sponsored by the government of the United Kingdom, was most influential. It proposed that "avoided deforestation" be listed in the post-2012 negotiations and that pilot project and methodology testing be implemented as quickly as possible.

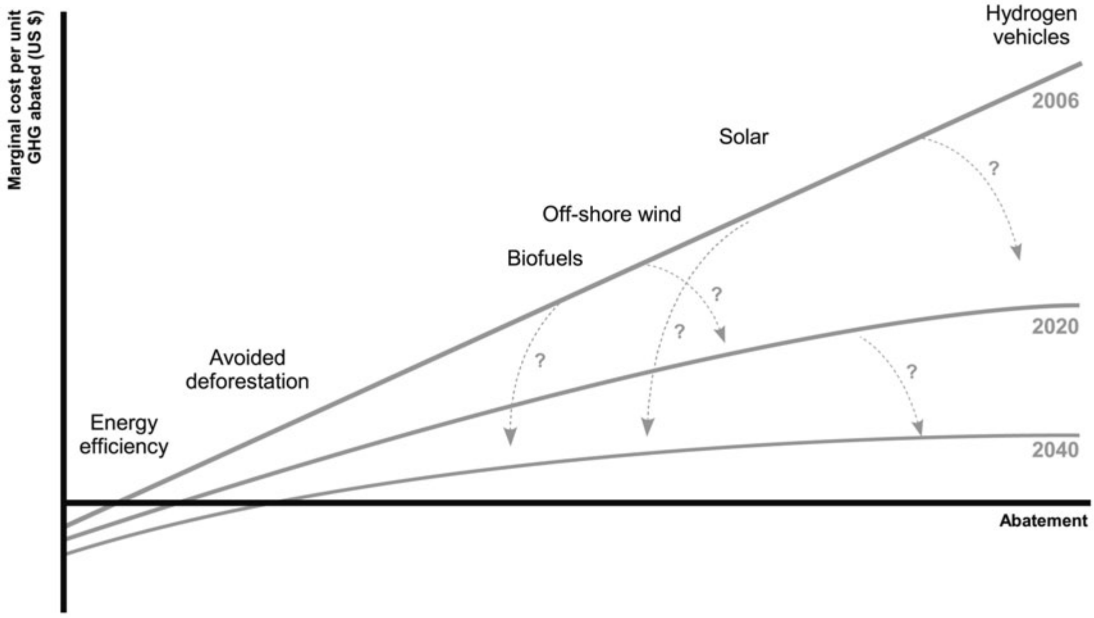
Role of the forest in climate change mitigation

The forest, due to its ecological role mentioned previously (climate, soil maintenance, water drainage, etc.), provides protection against a number of natural risks such as floods, drought, and desertification. These events are bound to increase in frequency and/or scale as a result of climate change. Developing countries that have extensive stands of forest will find that this resource will strengthen their *capacity of adaptation* in coping with the changes.

Furthermore, as explained earlier, deforestation and forest degradation come out as one of the key sources of total anthropogenic GHG emissions on the planet. Reduction of this type of GHG emissions is therefore an essential part of climate change *mitigation*.

The Stern report stated in 2006 that this solution would prove to be the most economical after energy efficiency (agrofuels, photovoltaic kits, and wind powered generators are more costly options).

1. 2007 IPCC Report



Link between the marginal cost of different measures for GHG emissions reduction and the scale of the reduction (Source: Stern's Review of the Economics of Climate Change, 2006)

Eligibility of REDD under the Kyoto Protocol

Background

At this point, the United Nations Framework Convention on Climate Change does not provide for any type of instrument or incentive to institute deforestation control measures in developing countries.

At the 11th Conference of the Parties to the Convention (COP11) in Montreal (2005), Papua New Guinea and Costa Rica proposed that incentives to reduce deforestation be included in the negotiation framework. The idea underpinning that suggestion is to put in place a funding mechanism to reduce emissions caused by tree clearing in developing countries. This request opened up a negotiation process that has gone on for two years now and that has been characterised by very active participation on the part of all countries of both the North and South.

In December 2007, the countries meeting in Bali, Indonesia (at COP13) reached an important agreement on the issue of avoided deforestation. An action plan was set up that provided for the implementation of a number of pilot initiatives for the 2008-2009 period, aiming to come up with a mechanism known as "Reducing Emissions from Deforestation and Degradation" (REDD) by late 2009.

Methodological issues

No official methodology exists in the UNFCCC or Kyoto Protocol to assess the impact of avoided deforestation measures. A number of questions are still on the negotiating table:

- How can the baseline scenario be defined—on the basis of historical tendencies, future projections, or a combination of the two?
- How can one be sure that the climatic impact of initiatives to protect the forest carried out on a given project zone will not be cancelled out by the deforestation simply shifting to neighbouring areas?
- Should consideration be restricted to raw deforestation, or to net deforestation, i.e. with reforested surfaces being factored in?
- How can this mechanism be articulated with afforestation/reforestation clean development mechanisms?

Beyond these methodological principles, the success of "avoided deforestation" projects hinges to a considerable extent on the existence of an adequate institutional environment.

Land use security is a fundamental issue: With no guarantee of holding use rights on land on which the initiatives are slated (creation of private protected areas, sustainable productive systems, energy plantations, etc.) the local communities targeted by the project will not commit themselves to mid- or long-term initiatives.

Future of carbon credits

A large share of carbon credits obtained is to be distributed to players who implement initiatives either directly or in the form investment assistance or payments for environmental services. The mechanism for distribution of carbon revenues must therefore be transparent and effective, and be considered in consultation with all of the stakeholders involved.

Avoided deforestation on the voluntary exchange market

All REDD projects that have been launched or that are on the drawing board come under the voluntary market arrangement, since no mechanism has yet been officially approved by the UNFCCC.

Three benchmark methodologies are now available to operators for the development of REDD projects:

- In July 2008, the World Bank's Bio Carbon Fund published an "avoided deforestation" methodology at the project scale.
- The Voluntary Carbon Standard (VCS) published a guidebook on agriculture, forestry, and other land uses (AFOLU) that addresses the issue of "avoided deforestation."
- The CCB (Climate Community Biodiversity) standard is also applicable to REDD projects.

The Climate, Community and Biodiversity Alliance (CCBA) was founded in 2003 by a group of leader NGOs and now includes six private companies and seven international NGOs.

The CCBA is seeking to have policies framed and markets developed in support of forestry projects that will bring significant benefits in the areas of climate, local communities, and biodiversity. With this in mind, the CCBA has come up with its own CCB standard in cooperation with representatives of the communities and the environmental sector, private sector, research institutes, and project developers.

Several buyers have announced that they will deal preferentially with or even offer a superior price or exclusivity to projects bearing the CCB label.

Three REDD projects (located in Indonesia, Brazil, and Costa Rica) have been submitted to the CCBA; one of them was awarded the "silver standard" and two are undergoing evaluation.

CASE STUDY

PROTECTION OF NATURAL RESOURCES IN A COLUMBIAN *BIOLOGICAL CORRIDOR*

Project funded by: Fond Français pour l'Environnement Mondial (FFEM)
Scope: Large-scale project (yearly budget of € 200,000 to € 1,000,000)
Operator: CAM (Corporación Autónoma del Magdalena), agency in charge of natural resources management in the Huila administrative district
Implementation date: 2001-2007
Beneficiaries: 4,000 families

The project has the potential of replication in any priority zone for the conservation and sustainable management of natural resources.

Context

The *biological corridor*, covering 115,202 ha, is located between the Puracé National Park and Cueva de los Guácharos National Park in southern Colombia, between the Western Cordillera and Eastern Cordillera. It is one of the most outstanding sites in South America in terms of biodiversity. It is found at the headwaters of a number of large rivers that flow through Colombia, including the Magdalena and Cauca, as well as some that traverse Amazonia, which makes it a strategic water resource zone. Its importance as a stopover zone for migratory species must also be mentioned. Its forest cover (88,197 ha) enables regulation of the water regime and erosion control.

This biological corridor is nevertheless being put under great pressure from deforestation. The agriculture frontier is moving up against it (coffee, sugarcane, and cool climate fruit growing), along with animal husbandry and gathering of fuelwood and utilitarian wood. Approximately 14,000 people (4,000 families) depend on it for their daily subsistence.

Project activities

The project has developed a participatory land management process at the level of families, villages, and municipalities in the area. This has led to the adoption of a corridor management plan that defines areas for conservation and restoration of natural resources, as well as production zones.

In parallel, the project is assisting producers on an individual basis and/or organised into associations to adopt sustainable production systems so that they can improve their incomes and living conditions while protecting the environment in which they live. This is well illustrated by the two major productions of the zone:

- **Coffee**:
The project has supported dissemination of dryers that enable greater value to be extracted from the production on the market, systems to decontaminate water from coffee processing, and organic production practices (agroforestry, composting to get value from the processing residues).

- **Animal husbandry**:
The rotation of plots of land set aside for pasture and forage production along with the practice of semi-confinement of dairy animals have led to an increase in both the yield and quality of dairy products. Furthermore, a supply of organic fertilizer has been made available for farms. This more finely tuned system of animal husbandry takes less space and relieves deforestation pressure.

Deferred grazing of wetlands and providing livestock watering troughs have proven to be a good way of protecting drinking water sources used by the communities.

Fencing has been put in to facilitate rotation among the plots set aside for pasture and structures for semi-confinement of livestock were built to keep the animals from wandering into wetlands.

Fencing allowing plot rotation for the production of forage (©ONF International)

Waterer allowing the avoidance of drinking water pollution (©ONF International)

Cow house keeping the livestock from wetland degradation (©ONF International)

Protected wetland areas (©ONF International)

Outcomes and prospects

A feasibility study is now underway to estimate the project's potential to be considered as an avoided deforestation project, and has the following main headings:

- Assess the impact of the project in terms of deforestation control by means of an analysis of pressures from deforestation and land use changes during a control period (1989-2001), then during the project (2002-2007).
- Determine the carbon stocks of the forests and therefore GHG emissions due to deforestation.
- Develop the project's institutional framework (project implementer, participants, technical support).
- Develop mechanisms for distribution of the future income from carbon and conditions for funding the planned activities.

For more information

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Websites:

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CIFOR (Centre for International Forestry Research): www.cifor.cgiar.org
ICRAF (World Agroforestry Centre): www.worldagroforestrycentre.org
VCS (Voluntary Carbon Standard): www.v-c-s.org

Sustainable charcoal production

> **Related Fact Sheets:** *Fact Sheet 1.1 - Fuel-efficient cooking and biomass energy; Fact Sheet 4.1 - Charcoal briquettes from agriculture residues; Fact Sheet 5.3 - Forestry plantations; Fact Sheet 5.4 - Fighting against deforestation*

Wood charcoal is widely used as a domestic fuel by urban households in developing countries. It has the triple advantage of slow, easily controlled burning, low smoke production, and energy content twice as high as the wood from which it was made. But for want of efficient technology and sustainable management of the biomass resource, wood charcoal production is contributing to environmental pollution and exacerbating pressure on forests.

The introduction of high-performance carbonisation equipment and putting in energy plantations (see Fact Sheet 1.1 - Fuel-efficient cooking and biomass energy renewal) is a long-term solution to this problem. These new technologies are designed to enhance conversion efficiency and produce charcoal of better quality (fixed carbon content); a co-product can be obtained by condensing the pyrolysis gases into pyroligneous acid (wood vinegar). Capturing the value of this co-product is a means of getting more out of the operation and thus getting a return on the investment required for the kiln. In some cases it can make "sustainable"[1] charcoal competitive with traditional charcoal. This fact sheet will outline a low-cost carbonisation technology along with proposed ways of getting value from wood vinegar.

SUSTAINABLE CHARCOAL AND TRADITIONAL CHARCOAL

Traditional charcoal making

Wood charcoal is obtained by carbonising wood in a controlled way in the absence of oxygen. The process is designed to extract from the wood the moisture held in it as well as any volatile plant matter, leaving only carbon.

Wood charcoal production in developing countries is mostly done in traditional kilns or ovens that may be an earth cover kiln or pit. These conventional approaches give off acid-type gaseous effluents, carbon monoxide (CO), and *greenhouse gases* (carbon dioxide, methane, nitrous oxide) that account for over 80 % of the raw material, and this constitutes a source of environmental pollution. Furthermore, their conversion efficiency, from 10 to 15 %, and the source of the wood used, essentially from primary forest, contribute to deforestation. Some countries have put alternatives in place (grant assistance for gas, prohibition of "non-sustainable" charcoal production, etc.), but these have not proven to be a long-term solution to the problem (lack of economic viability, no forestry management, etc.), and they have generally been written off as failures or do not have a secure future.

Loading a traditional charcoal kiln, deforested zone in the foreground, Cambodia

High-performance carbonising equipment under community management

A long-term solution to this problem that has both an environmental and ecological dimension is the introduction of high-performance carbonisation equipment and smart biomass management.

Carbonisation is the process of obtaining a more or less pure carbon residue due to a pyrolysis reaction or incomplete combustion. It is possible to make low-cost equipment (using local materials and construction skills), which enables the producer to have greater control over the different carbonisation phases, improve conversion efficiency, and shorten processing time. The pyrolysis gases are then collected and condensed in a simple thermal exchanger; pyroligneous acid is obtained; emissions and atmospheric pollution are reduced.

The service life of the equipment can be extended if it is put under the care of a village forest management group, referred to as a forest-based community. The technique of using a sprout or coppice forest (very effective for acacia and eucalyptus), with cuts in a five-year rotation, helps increase the forestry value of the land parcels. The community quickly begins receiving regular income from them. The product of these operations alone is used to fuel the carbonisation kilns. Strict rules governing the operation of the village group guarantee growth of the forest cover.

1. Sustainable: This notion refers to management of the biomass resource to ensure long-term production.

Improved charcoal kiln system, bigger and better, Cambodia.

For the same mass of wood, the better conversion efficiency and higher calorific value of the charcoal produced translate into an energy gain of 35 % compared to the traditional process. However, in some cases, even this is not economically sufficient to make "sustainable" charcoal competitive with traditional charcoal. The income generated by marketing wood vinegar needs to be added in for sustainable charcoal production units to be profit-making ventures.

Getting value from wood vinegar

Wood vinegar is a concoction of wood tars that are soluble and insoluble in water, acetic acid, formic acid, methanol, acetone, furfurals, phenols, guaiacol, and smidgens of many other chemical compounds. The liquid therefore possesses all the properties of smoke: the odour and colour, as well as the antioxidant, antiseptic, bacteriostatic, and preservative effect of smoke.

A simple decantation process enables a separation of the insoluble tars from the aqueous phase. Wood vinegar is obtained in this way, with a pH in the neighbourhood of 3. Further distillation can then be done to separate the methanol, acetone, and acetic acid from the soluble tars, which yields a more acidic product.

Wood vinegar is used mainly in agriculture, firstly as an insect repellent. When combined with fertilizer, it increases the nutrient absorption of plants, thus promoting plant growth in general and reducing the consumption of chemical fertilizers and pesticides. When applied to compost, wood vinegar neutralises odours by limiting the release of ammonia, accelerates fermentation, and enriches the product. It keeps fruits and vegetables fresh and increases the life of cut flowers. It is also used as an antiseptic in animal husbandry; it protects wood from termites due to its repellent effect. The tar component can be used as a waterproofing smear on boats.

This product therefore can be used in many ways, and this potential can be developed both nationally and internationally.

Issues for development stakeholders

Overall, the public authorities would be responsible for putting in place a national strategy for biomass energy, given that it is the leading energy source for the poorest of the poor. The strategy would provide for better management of the biomass energy resource by controlling deforestation, setting up forest-based communities, disseminating fuel-efficient cooking equipment for household and public amenity use, etc.
A specific support initiative for more sustainable charcoal production would be to set up a charcoal certification system designed to differentiate sustainable charcoal from traditional (often referred to as illegal) charcoal. Tax abatement might also be an incentive for sustainable charcoal to hold its own against illegal charcoal, the production of which is a cause of forest destruction.

DEVELOPING A PROJECT APPROACH

Feasibility study

Relevance

A study of the relevance of introducing improved carbonisation kilns would begin with an analysis of the charcoal supply and demand. A look would be taken at how it is produced and where the biomass is sourced. A list of production and consumption sites would be made and transportation costs determined. Existing zones would be identified, along with potential sites for the setting up of a forest-based community and a viable charcoal production centre.
Following that, a pilot phase would be set up to test the technical feasibility, determine the associated costs, and identify the position occupied by wood alcohol. In this way, the profitability of the process can be appraised, given that it will have to compete with traditional charcoal that entails no investment or management of the biomass.

Size and design of the kiln and plantations

The first step would be to determine the type of kiln to be set up, in keeping with local skills and materials. Then it will be necessary to estimate the plantation surface required to meet the needs for renewable charcoal, identify the type of tree best suited to the plantation, and go through the steps necessary to secure land use.

Pre-selection of sites

Potential intervention sites are deforested zones close to urban centres, buffer zones between villages in which charcoal is produced and the primary forest on which considerable pressure is being put and where the distance covered to gather wood is increasingly long.

Supporting the production of sustainable charcoal

Targets:

Forest-based community, charcoal producing village

Functionality, performance:

The technical features will depend upon the kiln, of which there are two types. One involves partial combustion and the other external heating. The difference is that in the first type, part of the mass of wood is burned to supply the energy necessary for carbonisation, while in the other, this energy is supplied by heating the outer shell of the kiln with no direct contact with the mass undergoing carbonisation.

Most of the construction materials are available locally (bricks, clay, etc.), although some kilns have metal components. The conversion efficiency is from 20 to 25 % for partial combustion technologies. These technologies are more readily transferred to developing countries, since they work in a way similar to those used in traditional processes and they are more affordable. The second type mentioned above is more frequently used in industry.

In a traditional kiln, about 6.5 kg of wood are needed to produce 1 kg of charcoal, with a lower calorific value in the neighbourhood of 26 kJ/kg. Using an improved kiln, the quantity of wood is reduced to 4.5 kg to yield 1 kg of charcoal with a calorific value approaching 31 kJ/kg.

Technological maturity:

Partial combustion kiln technologies are relatively well understood and applied. Improvements can be made in the condensation system and use of the inflammable pyrolysis gases at the condenser exit (reinjection into the kiln, drying out the wood prior to carbonisation). These improvements have been implemented at the industrial level where large size kilns are used. Applying them to smaller kilns in developing countries would result in an additional reduction of the pollution caused by charcoal making.

Essential aspects of project guidance:

- R&D: Possible avenues of optimisation (volume and fractioning of the condensation, ensuring the consistent quality of the charcoal produced).
- Technology transfer: Training personnel to operate and maintain the kilns.
- Monitoring: Control of sustainable management of biomass resources, quality of the charcoal produced.
- Marketing support: Sale of quality charcoal (part of the production can target a more financially sound market than the traditional market such as restaurant operators) and of wood vinegar.

Project duration:

Two years to ensure the technology transfer for improved wood charcoal production. Ten years for capacity building in sustainable biomass management.

Skills required:

Materials and construction, carbonisation processes, high added value product marketing

Sustainability:

The financial profitability of the charcoal making operation is a must for its sustainability. Another condition is decentralisation of management of the energy biomass to rural communities under the guidance of the Forestry Department. To the extent that each party's interests are met (maintenance of natural forests, maintenance of an economic activity), the operation will keep itself going in the long run.

As for any economic activity, a sustainable operation also requires technical support, quality control, and control over the conditions needed for viability.

Positive and negative impacts, risks

Economic

- ⬆ Forest-based communities, producer groups, and businesses are established (building of corporate management capacity).
- ⬆ Long-term survival of an economic activity that would disappear without sustainable management of the associated biomass.
- ⬆ Stabilisation of an energy product for urban households that are suffering from the sharp rise in petroleum-based fuels.
- ⬆ Putting out a high added value product with benefits to the local economy.
- ⬇ Investment for acquisition of kilns may be very heavy.

Social

- ⬆ Job creation in rural communities based on charcoal/wood vinegar production.
- ⬆ Building local technical capacity.

Environment

- ⬆ Deforestation control/preservation of primary forest.
- ⬆ More limited use of chemical fertilizers and pesticides with efficient use of wood vinegar.
- ⬆⬇ Reduction of greenhouse gas (GHG) emissions provided that plans are included for condensation of the pyrolysis gases.

CONTRIBUTING TO CLIMATE CHANGE MITIGATION

Producing wood charcoal from renewable biomass residues is an initiative that promotes the reduction of climatic warming provided that the fuel is replacing fossil fuels (oil, coal, gas) or *non-renewable biomass* (wood sourced from deforestation).

Sustainable charcoal production is comparable to making charcoal briquettes from biomass residue. We therefore invite the reader to refer to the section "Contribution to climate change reduction" in Fact Sheet 4.1 - Charcoal briquettes from agricultural residues.

CASE STUDY

SUSTAINABLE CHARCOAL PRODUCTION IN CAMBODIA

Project funded by: GERES (own source funds)
Scope: Average size project (yearly budget of € 50,000 to € 200,000)
Operator: GERES
Partnership: CIRAD, Ministry of Industry, Mines and Energy
Implementation date: Since 2003
Number of beneficiaries: Takeo forest-based community

Context

Some 40 % of households in Phnom Penh use wood charcoal as their main fuel, generating an annual demand estimated at 90,000 tonnes. Preliminary studies and current projections show that this demand is tending to fall in the capital, but is undergoing exponential growth in other urban centres and middle-class rural communities. Charcoal making is a survival activity, but it is a direct cause of deforestation in the outskirts of urban centres (Kampong Speu, Battambang, Siem Reap) and a factor contributing to the switchover from forested surfaces to cultivatable land or plantations. The illegality of producing and selling charcoal has not stopped the activity for want of acceptable alternatives. This illegality has only changed the structure of the industry and how the added value is shared. It has made the producers more vulnerable and is jeopardising any sustainable charcoal production initiative.

Project activities

Since 2003, GERES has been implementing a pilot project for sustainable charcoal production in association with the forest-based community in Takeo province, which is touted as a benchmark community in terms of forestry management in Cambodia. The biomass supply is being replenished, based on a sustainable management plan for the forest area.
Two carbonisation technologies have been introduced: the Yoshimura kiln and the Iwate kiln. These technologies enable a larger amount of charcoal to be produced from the same mass of wood, and the quality of the charcoal is better than the traditionally made product. The combined gain in process enhancement and calorific value is about 35 %. Each kiln requires a team of 5 masons trained in its construction; the completed kiln will need at least two full-time operators.

Acacia energy plantation

Filling an improved Yoshimura-type charcoal kiln

The charcoal production technologies implemented by GERES include production of a high added value co-product: pyroligneous acid. This acid has many uses, depending on the amount of processing it is put through.

It was used experimentally as a phytosanitary product on annual crops and has been shown to have properties that allow crop protection with no ill effect on the environment. Pryoligneous acid has a potential use as a switchover from most pesticides used by Cambodian farmers, and experiments will be continued.

A potential market has already been identified in countries of Eastern Asia: Japan, China, and Korea. The domestic market is being surveyed for agricultural applications. A look at the regional market is needed regarding applications in agriculture, cosmetics, and the agri-food industry.

Prospects

The results of the Takeo pilot project show the value of developing a sustainable charcoal industry with the following outcomes:
- Deforestation control.
- Energy saving.
- Job creation and local technical skills development.
- Production of a high added value product: pyroligneous acid has a strong export potential.

This project is furthermore based on a successful partnership with a forest-based community.

However:

- There is no national policy and suitable legal framework to legalise this form of charcoal production and develop it at the national scale while guaranteeing the quality of the conversion process.
- The value of co-products such as pyroligneous acid is not yet sufficiently recognized in Cambodia and on the export market. The ability to market pyroligneous acid now appears as a prerequisite to develop and ensure the long-term survival of the sustainable charcoal production industry as a whole.

The government (MIME and Council of Ministers) are committed to working up a policy in these areas at the national level. All of the persons directly concerned feel that it is now imperative to support the sustainable charcoal industry, with priority given to marketing its co-products.

For more information

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GERES Cambodia: www.geres-cambodia.org

Adaptation : Adaptation to climate change refers to the adjustment of natural or human systems in answer to current or future climate stimuli or to their effects, in order to mitigate negative effects or to take advantage of favourable opportunities. Adaptation includes a wide range of measures. In agriculture, developing new practices or vegetable varieties is an option as well as improving water management. Protecting forest and biodiversity or creating protected areas or biological corridors can help eco-systems adapt and migrate. In health, climate change impact on the emergence or extension of diseases will imply specific measures.

Adaptation capacity: Capacity of a system to adapt to climate change (including climate variability and extremes) and to moderated possible damages, to take advantage of opportunities and to face consequences.

Adventives: In agronomy, it refers to herbaceous or ligneous plants which are undesirable where they are. It's also used as a synonym for "weed".

Biological corridor: The expression "biological corridor" (or bio corridor) refers to one or several environments functionally linking different habitats vital to a species or group of species (habitats, breeding, feeding, resting, migration sites, etc.). These corridors enable to connect or reconnect different underpopulations. They enable the migration of individuals and the circulation of genes (animal, vegetable or fungus) from one underpopulation to the other. Restoring a network of biological corridors (ecological gridding or network) enable to conserve many species threatened by their habitat fragmentation.

Biomass: All organic matter stemming from living organisms in different eco-systems and all the derived products such as wood, straw, bagasse (sugar cane residues), old wood.

Canopy: Uppermost level of the forest, in direct contact with free atmosphere. It is sometimes considered as a habitat or eco-system as such, especially in tropical forests where it is particularly rich regarding biodiversity and biological productivity.

Carbonization: Forming of a more or less pure carbon residue through pyrolisis reaction or during an incomplete combustion.

Catchment basin (or river basin): Part of land delimited by water divides, whose water flows into a common water body: a river or a lake. Adjacent basins are separated by a drainage divide. Each catchment basin breaks into smaller ones corresponding to the supply area of affluents flowing into the main water stream.

Clean Development Mechanism (CDM): Mechanism authorising developed countries (who have emission reduction quantified objectives) to invest in greenhouse gas reduction projects in developing countries. Initiated by public and private investors, they set gas emission reductions (Verified Emission Reductions, VER) in relation with a reference situation.

Compost: Composting is defined as a controlled biological process to convert and valorise organic materials (biomass by-products, biological organic wastes…) in compost which is a stabilised, hygienic product, similar to vegetable mould, and rich in humic components.

Executive Committee: Governance body of the Clean Development Mechanism (CDM) which controls the latter's implementation, registers CDM projects and gives verified emission reduction units (VER). Finally, it accredits Designated Operational Entities (DOE).

Forest-based community: Forest communities are local communities who have an agreement with the State in relation with forest national regulations. They obtain a several-year concession (about 15 years) on a given forest area depending on the countries. Forest communities have a precise mission statement to manage the land which implies, in particular, to plant only forest species. It's a forest management decentralised process.

Fuel wood (or bioenergy): Energy made available from non-fossil organic matter such as wood, straw, oils and vegetable wastes from forest, agricultural and industrial sectors. Bioenergy comes from solar energy stored in plants through photosynthesis. If the source it properly managed, it's renewable and can be used continuously, as opposed to fossil energies. There's a difference between "traditional fuel-wood" such as wood and agricultural and forest residues aimed at household cooking and heating, and modern fuel-wood, i.e. biomass created with conversion capacities superior to that of traditional biomass, for the production of electricity or liquid bio fuel, both enabling to use resources more efficiently.

Geographic Information System (GIS): A GIS aims at giving the geography of a given location. It is then based on the geographic data it integrates, manages, analyses and displays as maps.

Global Warming Potential (GWP): Measure unit of GHG effect on climate warming in relation with CO2's (CO_2 PRG =1) on a 100-year period.

Gold Standard: Non-profit foundation created in 2003 by public and private donors (WWF, SSN and Hélio International) and based in Switzerland. This association is empowered to offer a quality label to Clean Development Mechanism (CDM), Joint Implementation (JI) and voluntary offset projects. Gold Standard label is aimed at renewable energy dissemination projects or those seeking energy efficiency and presenting a strong sustainable development character on economic, social and environmental impacts.

Greenhouse gases (GHG): The radiation flow sent back to Earth is naturally caused by clouds and greenhouse gases (GHG) which are present in the atmosphere, i.e. water vapour, carbon dioxide (CO_2), methane (CH_4) and nitrogen protoxide (N2O). Furthermore, new industrial gases have appeared, such as chlorofluorocarbons (CFCs) and HCFC-22 such as Freon, perfluoromethan (CF_4), sulphur hexafluoride (SF6) and contribute too to the greenhouse effect.

Intergovernmental Panel on Climate Change (IPCC): Its role is to assess the state of scientific, technical and economic knowledge on climate change, its ecological and socio-economic impacts as well as answer strategies.

Leachate: Residue liquid draining from water percolation through a material.

Liquefied propane gas (LPG): It refers to gases such as butane and propane which come from oil or natural gas refining (also called "gasoline extraction"). In the common language, LPGs became LPG in the singular, even if it refers to several gases.

Mitigation: Mitigation measures include all human interventions aimed at reducing sources or strengthening greenhouse gas sinks. Two mitigation main options are generally considered: The first one consists in reducing emissions by limiting energy consumption, looking for renewable alternative energies, transforming transportation or waste treatment systems and by reducing deforestation. The second one, often called carbon sequestration, aims at capturing part of atmosphere carbon and storing it in biosphere.

Non-renewable biomass: Biomass combustion emits carbon dioxide (CO_2). It is considered to be reabsorbed by photosynthesis during biomass source renewal (forest, thickets, savannah, plantation, etc.) on the short term. It is then called renewable biomass. Nevertheless, when the source is not regenerated and that collect is more important than renewal, the carbon cycle is broken and an excess of carbon dioxide is released in the atmosphere. It is then a non-renewable biomass which contributes, just as fossil energies, to greenhouse gas emissions hence to climate change.

Pyrolisis: i.e. organic matter thermic decomposition without oxygen or in an atmosphere with little oxygen. It's the first thermic transformation phase after dehydration. It enables to get a carbonated solid, oil or gas. It begins at a relatively low temperature (from 200°C) and goes on until about 1,000°C. Depending on the temperature, the proportion of the 3 resulting components is different.

Resilience: Capacity of a system to resist climate change negative impacts without loosing its core functions.

United Nations Framework Convention on Climate Change (UNFCCC): Convention adopted on 9th May 1992 in New York and signed by over 150 countries and by the European Community in Rio de Janeiro in 1992. Its final objective is "to stabilise greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous human interference with the climate system". The Convention entered into force in March 1994. The UNFCCC is one of the authorities involved in the implementation of flexible mechanisms, among which the CDM. All information regarding project decisions and CDM methodologies are to be found on the website, www.unfccc.org.

Voluntary exchange market: Carbon credit exchange mechanism which is not related to international regulations. On these markets, individual or organisations buy "carbon credits" to projects of greenhouse gas emission reduction or carbon capture. These credits are used to compensate the buyers' emissions.

Voluntary Carbon Standard (VCS): It was developed by Climate Group, International Emissions Trading Association (IETA) and the World Economic Forum Global Greenhouse Register (WEF). It was first published in March 2006. The standard specifically aims at standardising and quantifying emission reductions stemming from carbon compensation voluntary projects. In order to be accredited as VCS, projects have to demonstrate that offsets are real, measurable, permanent and additional.

Windrows: Waste long and high piling in order to improve returning (control of water and air supply) hence their decomposition in a composting process.

Wood stere: Measures the quantity of wood under the form of piled trees, and equals one cubic meter. This unit is mostly used in firewood trade.

Acronyms

ADEME	Agence De l'Environnement et de la Maîtrise de l'Energie (France)
AEP	Ansary Engineering Products and Services
AFD	Agence Française de Développement
AMEDD	Association Malienne d'Eveil au Développement Durable
BMZ	German Ministry of Cooperation and Economic development
CER	Certified Emission Reduction
CIFOR	Center for International Forestry Research
CIRAD	Centre de coopération internationale en Recherche Agronomique pour le Développement
DATe	Developement of Appropriate Technology
DED	German Development Services
EDF	Electricité de France
FACT	Fuel from Agriculture in Communal Technology
FAO	Food Agriculture Organisation
FFEM	Fond Français pour l'Environnement Mondial
FONDEM	FONDation Energie pour le Monde
GERERE	Groupe d'Etudes et de Recherche sur les Energies Renouvelables et l'Environnement
GERES	Groupe Energies Renouvelables, Environnement et Solidarités
GTZ	German technical cooperation
IEPF	Institut de l'Energie et de l'Environnement de la Francophonie
IETA	International Emissions Trading Association
IPCC	Intergovernemental Panel on Climate Change
LEHO	Ladakh Environment and Health Organisation
MAE	Ministère des Affaires Etrangères (France)
NEPA	National Environmental Protection Agency
OCDE	Organisation for Economic Cooperation and Development
OMI	Office des Migrations Internationales
RIAED	Réseau International d'Accès aux Energies Durables
SCET - Maroc	Société centrale pour l'Equipement du Territoire
TMF	Turquoise Mountain Foundation
UNDP	United Nation Development Programme
UNEP	United Nation Environment Programme
USAID	United State Agency for International Development
VER	Verified Emission Reduction
WBCSD	World Business Council for Sustainable Development
WWF	World Wide Fund for Nature

FINANCIAL PARTNERS

The French Ministry of Foreign and European Affairs (MAEE)

The Directorate General for International Cooperation and Development represents France with European bodies, in particular in the framework of the European initiative on energy (EUEI) and with work groups on climate change and development. The MAEE follows-up questions related to developing countries in negotiations on climate change. It takes part in the main international aid to development programs and networks on energy and climate change. It supports regional initiatives for the implementation of energy policies, for the adaptation or strengthening of the negotiators' skills on climate change. The MAEE finances cooperation of research for development and is in charge of the French cooperation device on these questions

www.diplomatie.gouv.fr

The French Environment and Energy Management Agency (ADEME)

ADEME is a public body under supervision of the French Ministry of Ecology and Sustainable Development and of the French Ministry of Education and Research. It takes part in public policies' implementation regarding environment, energy and sustainable development. The agency puts its expertise and advice capacities at the disposal of companies, local authorities, authorities and the public at large and helps them finance projects in 5 areas (waste management, soil preservation, energy efficiency and renewable energies, air quality and fight against noise pollution) and make progress in their sustainable development approaches.

www.ademe.fr

La Fondation Nicolas Hulot pour la Nature et l'Homme

Since its creation in 1990, Fondation Nicolas Hulot pour la Nature et l'Homme has set as a mission to change individual and collective behaviours to preserve the planet. It's the only state-approved French association to be devoted to environmental education; its target audience includes every society's stakeholders to contribute to change behaviours towards a new form of society and culture based on sustainable development.

To address the double energy and climate crisis, Fondation Nicolas Hulot pour la Nature et l'Homme is involved in international negotiations in order to promote the conclusion of an international agreement on climate in 2009. In addition, the Foundation is supporting development projects enabling to address these crisis' consequences. It also wishes to support the different stakeholders concerned – particularly NGOs which are active in the South – in giving birth to proposals and strengthening their position as negotiators.

The Foundation is also present at the international level as a member of the IUCN (International Union for Conservation of Nature) and of the International Organisation of La Francophonie. It's an NGO in a consultative status with the UN Economic and Social Council.

www.fondation-nicolas-hulot.org

Energy
Environment
Solidarity

GERES – Groupe Energies Renouvelables, Environnement et Solidarités

is a French non-profit NGO created in 1976 after the first Oil Shock. Today, 108 staff work on innovative and sustainable development projects in France and in eight African and Asian countries.

Environmental conservation, climate change mitigation and adaptation, reducing energy poverty, and improving livelihood of the poor are the main focus areas for GERES. The GERES team is particularly involved in the implementation of engineering solutions for development and providing specific technical expertise.

Activities include conducting energy efficiency programs, providing decentralized energy services for local economic development, supporting and developing renewable energies and promoting waste management. These activities are implemented in partnership with local stakeholders and communities on the basis of collaborative experience sharing.

GERES programs deal with the following areas :

- Improving conditions for agricultural production and processing to enhance family farms/small-scale agriculture systems and to promote food security in the South – example : GERES implements projects in mountainous areas (in the Himalayas and in Afghanistan) which focus on greenhouse gardens and preserving and stocking agricultural products such as potatoes and fruits.
- Optimising energy use in forest areas to preserve natural resources – example : In Cambodia, with the support of GERES, 250,000 families are now using economic cooking appliances.
- Promoting the development of renewable energy to intensify local production of clean energy linked with the environment – example : In the southeast of France (Région Provence Alpe Cote d'Azur) GERES is facilitating the implementation of micro-hydro-electric projects in partnership with actors involved in protecting wetland areas.
- Promoting waste management good practices to reduce the environmental impact of waste disposal – example : GERES supports awareness campaigns on domestic composting managed by communes in partnership with community gardens in southeast France.
- Fostering energy efficiency and solar energy for sustainable development in mountainous areas – example : GERES is implementing a passive-solar construction program for domestic housing, schools, and hospitals in the Indian Himalaya and Afghanistan.
- Developing local biofuel solutions to meet energy needs of rural populations – example : In West Africa (Benin, Mali, and Niger) GERES assists pilot projects for the local production and use of biofuels.
- Promotion of energy-saving to limit consumption, decrease vulnerability, and mitigate climate change – example : GERES advises and provides information for the public on alleviating energy poverty and fostering the use of renewable energies in southeast France.
- Developing new energy and technical services to improve rural living conditions – example : GERES coordinates a regional-level program in the Zou district of Benin for the installation of multi-functional platforms (MFP) and related services.
- Facilitating the integration of climate change into project development in Southern and Northern NGOs – example : GERES provides training for NGOs in South East Asia to assist them to gain access to carbon financing for their operations in Asia.

In 2004, GERES launched the first French-language worldwide carbon offset website to support climate change solidarity projects. (www.CO2solidaire.org)

GERES has a total budget (2.5 million euros in 2007) which is funded with support from the French government (Ministry of Foreign Affairs, French Development Agency, FFEM, ADEME, and local collectives), international aid donors (European Union, UNDP, the World Bank) and contributions from private donors (foundations, companies, and individuals.)

GERES is a member of various networks including the Comité de Liaison des Energies Renouvelables (CLER), Comité Français de Solidarité Internationale (CFSI), Comité 21, International Network for Sustainable Energy (INFORSE), Global Compact, Asia Regional Cookstove Program (ARECOP), MEDCOOP (a collective for Mediterranean aid), etc.

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BEST PRACTICES GUIDEBOOK
CLIMATE, ENERGY, DEVELOPMENT

Climate changes are upsetting environmental, economic, and social balances. Developing countries, and among them those categorised as least developed, are the first affected by these upsets that are aggravating existing vulnerabilities. The most prominent manifestations of climate variability (droughts, flooding, etc.) predicted by the experts will hit agriculture and forestry the hardest. The result will be a decline in food security and depletion of energy resources. Thus, in developing countries, agricultural activity is the lynchpin of the economy. From 50 to 80 % of the energy used by households is biomass—sourced from the forest.

These harmful effects will be compounded by the spiralling cost of energy—the mainstay of domestic life, economic development, and access to education and health services.

There is a strong interaction between climate, energy, and development.

For human communities to adapt to climate changes they need to have new energy sources available, make better use of existing sources, change agricultural and field husbandry practices, manage better natural resources.

At the present time, information is often inadequate or sadly lacking in the following areas:
- Link between access to energy and adaptation to climate changes.
- Issues involving energy technologies and energy supply chains, in terms of impact on the climate.
- Financing mechanisms provided for under the Kyoto Protocol (CDMs, Adaptation Fund) and carbon finance in general.
- A tiered list of action priorities to reduce greenhouse gases emissions in the countries of the South.

Put together by GERES (*Groupe Énergies Renouvelables, Environnement et Solidarités*) with the contribution of numerous practitioners, this best practices guidebook presents an overview of technologies and exemplary approaches that combine development and climate change mitigation. **It covers areas such as energy efficiency, managing the energy demand, renewable energies, getting value from waste, resilient agriculture practices, and deforestation control**.

This book is intended for all development stakeholders: institutions in developing countries, donor agencies, international solidarity organisations, decentralised cooperation operators, technical cooperation agencies—to name just a few.

Its focus is be of real interest to professionals in their daily grind of project implementation in the field, as well as to persons who would simply like to understand the issues more clearly and see what can be done concretely in the realm of the fight against climate change.

Needless to say, of course, the impact of what is suggested for countries of the South will be limited, if not altogether nil, if strong emissions reductions measures are not undertaken in parallel in countries of the North.

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Energy
Environment
Solidarity