DEVELOPMENT
A MATTER OF ENERGY
PROMOTING RENEWABLE SOLUTIONS
3 major questions are addressed in this brochure:

How to improve access to energy?
What future for renewable energy?
How to design energy efficient buildings?
About BTC

The Belgian development agency, BTC, mobilises its resources and its expertise to eliminate poverty in the world. BTC contributes to the efforts of the international community and works towards a society that provides present and future generations with sufficient resources to build a sustainable and fair world.

Its staff members in Brussels and overseas embody the commitment of the Belgian State and other development partners to international solidarity. They support cooperation projects and programmes in some 20 countries in Africa, Asia and Latin America.

BTC listens, gives advice and puts the experience of its staff to the disposal of its partners. Its staff members look for innovative solutions to the challenges set by a continuously more complex environment. To support the development processes BTC provides services that are characterized by transparency and integrity, which are essential values in a relation of trust.

Acknowledgment

This brochure is the result from a one-week training organised by BTC in April 2011 in Brussels.

It is directly inspired by the course material from consultants of 3 agencies, Aperse, Fondem and 3E, but also by the active involvement of an audience of 50 motivated participants with various backgrounds: BTC representatives coming from the field and headquarters, representatives of other cooperation agencies such as DGD, LuxDev, GIZ and EuropeAid, and NGOs (MSF, ISF, APEFE…). We would like to thank all of them for their input.

Our consideration is going to F. Lorette who scrupulously compiled all the information provided from all sides during the training. Our gratitude is going to all the persons who accepted to directly contribute to this brochure by either writing a small article or providing pictures or charts: Professor J.P van Ypersele, D. Debeer, E. van Malderen, P. Junker, S. Moreno, N. Wilhelm, Frederik van Herzeele, Atelier Lion and Solarpraxis. Finally, special thanks go to Yves Maigne from Fondem, Michel Huart from Aperse and Jérémie de Clerck from 3E, who validated the document.
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FOREWORD

BY PROFESSOR JEAN-PASCAL VAN YPERSELE, IPCC VICE-CHAIR *

There is no development without energy services. But energy use contributes to climate change when it is based on fossil fuels or unsustainable forest usage. And climate change threatens development. More and more people in the world are aware of this double challenge: how to provide energy services to the almost two billion humans who don’t have access to them, while not aggravating the climate change problem which affects many of the same populations.

The answer to climate change is a combination of mitigation (reducing emissions) and adaptation measures. From the point of view of Developing Countries, mitigation conditions the actual exercising of the right to develop. However, in numerous countries, vulnerability to climate change is such that adaptation also conditions development. Therefore, the policies aimed at meeting the challenge of climate change will gain from being conceived and integrated within the framework of development activities. This is essential if the response to climate change is to comply with the objectives of human development, especially the reduction of poverty.

As I discussed in my report on the subject¹, we can distinguish three types of interactions between development and climate change:

- the impact of climate change on development projects;
- the impact of projects on climate change; and
- the impact of projects on the vulnerability of populations and/or ecosystems to climate change

These three types of impact combined are likely to considerably reduce the effectiveness of development aid if they are not addressed. And this is particularly true in the energy area.

But it is one thing to be aware of the challenges; it is another thing to know how to address them in practice. Particularly in developing countries, where so many other challenges have to be addressed as well, often with so little resources.

The quality of this publication is that it provides precisely the kind of information that is useful to understand:

- the context in which energy, development, and climate change interact;
- the challenge of energy access in developing countries, particularly for electricity;
- the importance of energy efficiency (particularly in buildings) as the cleanest energy is the one that is not used and wasted;
- the assets (and limits) of renewable energy; and
- how to practically implement measures and techniques which promote access to clean energy.

I hope it will be widely read and used, as every additional human who has access to energy and every kilogramme of carbon that is not burnt both contribute to a more sustainable future for all on this small planet. The only one we have.

* Co-chair of the Master in Science and Management of the Environment at the Université catholique de Louvain (UCL)
Professor of climatology and environmental sciences at UCL

¹ van Ypersele, J.P. (2008) “Climate change and the Belgian development cooperation policy: Challenges and opportunities”, Report established at the request of Mr. Charles Michel, Belgian Minister for Development Cooperation. Université catholique de Louvain and DGD (Belgian Development Cooperation), 66 pages. This report can be downloaded from www.dgdc.be and www.climate.be/vanyp
INTRODUCTION

BY BENÔIT LEGRAND, BTC INFRASTRUCTURE ADVISOR
AND CLAUDE CROIZER, BTC ENVIRONMENT ADVISOR

In April 2011, BTC organised a training session on energy issues. Two themes were at the core of the debates: What access do countries in the South have to renewable energy? How to improve energy efficiency of buildings built in tropical or sub-tropical countries? Some forty people met with energy experts to think, to discuss and to share their experiences, successes and challenges.

The original idea was to reach an audience of development professionals who are dealing with energy issues when implementing their infrastructure projects. This could be in designing a healthcare centre or a school, in treating or distributing water, in researching energy solutions in a rural environment... while meanwhile paying attention to ecological parameters of energy production or transport.

Three specialized organisations helped BTC in preparing this training session: Fondem (Fondation Energie pour le Monde), which is active in promoting access to energy in countries in the South; APERE (Association pour la promotion des Energies Renouvelables), which is specialised in raising awareness, communication and training on renewable energy, and the study office 3E, which designs 'sustainable' energy systems and solutions.

This brochure is the output of the training session. It aims at summarizing the content of the training and of the rich discussions that involved the audience. The idea was to start from the experiences presented and questions raised by people attending the training session to provide the reader with practical tools to go further in his or her own research and possibly to make decision-making easier. At the end of the publication, we list references and a selected bibliography.

Chapter 2 goes more directly into the issue of accessing energy in countries in the South, more in particular in remote areas. Several strategies that could lead to electrification of the countryside are presented here. At the same time the chapter highlights the importance of researching the capacity and the willingness of the local populations to pay the price for electrification. Also lessons learned from past experiences of electrification projects in Africa are dealt with.

Chapter 3 explains the concept of a low-carbon economy, a development path that is also viable for countries in the South. It is actually considered the only possible alternative to allow our societies to develop without however disrupting the climate.

Chapter 4 provides an inventory of the various types of so-called sustainable energy production. This chapter focuses especially on technologies that are directly applicable in the partner countries of BTC. In Chapter 5 we identify the financial, technical, legal or social and cultural constraints that inhibit the implementation of such technologies. And yet, it is not only a matter of producing green energy. First and foremost, energy must be used advertently and no energy should be wasted. To do so, in the countries of the North building energy-efficient constructions has become evident. But this does also count for countries of the South, as we explain in Chapter 6. It gives various techniques to do so, which have to be combined in a coherent way though. This chapter also reminds us that we still have to learn a lot from vernacular architecture and traditional building techniques by reinterpreting them with today’s technical know-how. The recycling of materials used in construction is also dealt with through the “cradle to cradle” concept.

Finally, this brochure highlights the case study of a vocational training centre for renewable energy and lists recommendations for development actors, so they become aware of the importance of the energy issue for the countries of the South and the challenges involved. It is now up to them to integrate the discussion topics in their interventions.
BTC RWANDA

Renewable energy provides rural populations with electricity.
ENERGY: AN ISSUE FOR DEVELOPMENT

Energy is at the very centre of our lives and of our concerns. Nowadays, numerous energy-related crises illustrate very well how the stakes involved are becoming critical. These crises are either geo-political, with a drastic increase of energy prices, or environmental, taking the form of oil spills or a major nuclear incident.

In fact, risk is inherent to all type of energy production. Waterworks could also represent a potential risk such as dam breaches in hydroelectric power plants resulting in intense and quick flooding destroying entire villages. However, a major difference with nuclear threats is that we know how to deal with the consequences of these risks and the amplitude of the impact both in spatial and temporal terms.

These crises are impacting our daily lives and are directly linked with the supply uncertainty and with the resource depletion, which is a no return tendency. This reminds us of the un-sustainability of the current energy scheme.

ENERGY AND DEVELOPMENT

Today, developed countries focus on mitigation and energy savings to balance the over-consumption induced by our way of life, while populations in developing countries struggle to get access to energy. Energy is an important factor to improve access to basic services, such as water supply, lighting in public buildings and schools, efficiency of health centres, communication, etc.

Energy is also crucial to facilitate economic development by supporting handicraft activities or business opportunities. This can only come true with a good and stable energy supply.

Energy – and especially electricity – is a key factor to reach the Millennium Development Goals (MDGs) by 2015. Electricity facilitates economical development and can contributes to improve maternal and child health, ensures education, water supply, leisure, culture, communication...

Though inherent to most MDGs, energy is not explicitly mentioned as one of the key success factors for their achievement and until recently, international donor agencies did recognize energy as such. The absence of a straightforward link between development and energy had a negative impact on funding, which was slowed down and became even more complex. However, this tendency has changed since the Copenhagen Summit (2009), where the link between development and energy has been institutionalised.
DEVELOPMENT, A MATTER OF ENERGY

THE ‘DARK SIDE' OF ENERGY

Energy is deeply linked to two global debates, namely the climate debate and the environmental debate.

In the growth model of industrialized countries, energy production is mainly based on stock fuels. This production type requires low investment at starting phase and insures a constant energy supply on the short-term. But this “easy choice” has too many side impacts.

The resource depletion of fossil fuels is a fact. We only have a few decennia left to find alternatives. So-called peak oil, which is the point in time when the maximum rate of global petroleum extraction is reached, occurred in 2006 (WEO). After peak oil, the rate of oil production will enter a terminal and irreversible decline. The world is not running out of oil itself, but the effort, expenditure and risk needed to extract it will gradually increase, as high-quality, cheap and economically extractable oil will be exhausted.

Depending on the speed of exhaustion and on the alternatives we will find in the meanwhile, fossil fuel rarefaction might have far-reaching consequences. As oil has been one of the most important stimuli of economic growth and prosperity since the industrial revolution, oil scarcity will probably lead to economic recession. Moreover, resource scarcity leads to price increase, and this upward trend will not only affect oil, but also numerous derivative products. Food is expected to become more and more expensive, for example.

Resource depletion will not exclusively affect oil. It is also inherent to nuclear energy, as uranium is not a renewable energy source. Various forecasts wager on 44 to 200 years of uranium availability.

Besides energy scarcity, the combustion of stock fuels for energy production also leads to environmental problems. Harmful substances are emitted during the process, leading to air and water pollution, health threats, respiratory troubles, etc. Peak oil leads to the extraction of more ‘non-conventional’ oil, which is damaging the environment faster, such as the recent extraction of shale oil in France or Canada².

Last but not least, fossil fuels combustion contributes to climate change. Greenhouse gases (GHG) emissions released by fossil fuel combustion speed up the natural process of greenhouse effect, which could become a major threat for life on earth in the future. Climate change, with sea level rise and the increase of extreme events such as droughts, floods, storms, and their consequences such as saline intrusion, landslides... represents a crucial challenge that has to be tackled at a global scale.

CLIMATE CHANGE IN THE NORTH AND IN THE SOUTH

Climate change concerns the entire world population. Yet, a new form of North-South inequality is engendered by climate change, because vulnerable populations who have contributed least to the problem are feeling the most severe impact.

Developing countries are more vulnerable to the impacts of climate change. A country struggling with poverty, political instability, high dependence on agriculture or low access to energy, is not in a good shape to cope with devastating climate impacts. To tackle the vulnerability of these countries and assist them in adapting to the adverse effects of climate change, the United Nations Framework Convention on Climate Change established an Adaptation Fund. This fund aims at facilitating the development and deployment of techniques that can help increase resilience to the impacts of climate change. It is financed from the share of proceeds from the clean development mechanism project activities and other funding sources.

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²
The countries responsible for the majority of polluting emissions for the two last centuries are not the most affected by climate change.

Indeed, the United States, Europe and Japan are responsible for about 60% of the historical carbon emission, whereas the most affected countries are the Asian Mega Deltas, sub-Saharan Africa, the Caribbean and small insular states.³

The latter will support the majority of the costs caused by the effects of global warming, whereas it is the model of growth of the former that is at the root of global warming.

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**Long-term effort and short-term result needs**

Michel Huart, Secretary General of the Belgian Association for Renewable Energy Promotion (APERe), states, “Implementing sustainable energy is a long-term effort. And I speak about ‘effort’ because we need to change a system (based on fossil fuels and nuclear) that currently works in many countries. Therefore, renewable energy is not the easiest choice today, but it is definitely the only long-term option, because one day, it will be the only choice left.”

In the South, this long-term thinking collides with the rapid results needed in the political field, and the urgent need for energy access.

**SUSTAINABLE ENERGY: THE ONLY LONG-TERM SOLUTION**

The strategies applied to curb the effects of climate change are not the same in the North and in the South. Industrialized countries have to reach the emission reduction set in the Kyoto Protocol in 2000. First, a reflection is necessary to completely review the current northern economic development process and way of life, which both heavily rely on abundant and cheap energy. Second, technologies have to be developed, on the one hand, to reduce energy consumption and, on the other hand, to promote types of energy that are more environmentally friendly, that is, renewable energies.

The approach is different in developing countries. Energy production has to be promoted for development purposes, but sustainable choices have to be made so that southern economies go through a low carbon development.

Both the North and the South need to produce and consume energy in a sustainable way, because it is the only long-term solution to solve the energetic, environmental and climatic crises we face today.

**SUSTAINABLE ENERGY: WHAT’S IN A NAME?**

Energy is not the final goal, but it is a way to ensure access to basic services and economic development. Sustainable energy guarantees that you can afford all these services today and tomorrow.

Sustainable energy conception follows a three-step method, known as the trias energetica, which can be summarised as follows: Consume less (through wise behaviour), consume better (efficiency of technology, infrastructure and materials) and produce better (renewable energy).

We may reduce the energy needs with a **behavioural approach**: consuming less by acting wisely. We may consume less by using **more efficient technologies, infrastructures and materials**. For example using energy efficient devices as economical lighting, designing and constructing buildings very carefully to reduce the energy needs for the end-users, choose material with low energy content and long lifespan.

Behaviour and energy efficiency are commonly described as **Rational Energy Use (REU)**. It implies making individual or collective choices for solutions that require the least of energy.

The main element of the third step is the **production of renewable energy (RE)**.

Sustainable energy has four dimensions. Firstly, it has to be a **long-term energy service**. Sustainable energy is based on renewable energy sources, with a **guaranteed supply** on the long run. Why would a country in a tropical climate depend exclusively on imported fuels whereas this country has an enormous potential of solar energy? Import has a higher cost, makes the supply less reliable and the entire country dependent on the goodwill of other countries. It is, therefore, less sustainable.
Secondly, you have to consider the environmental impact of the energy service on a local and a global scale. In Belgium, most people change mobile phone once a year on average. This habit does not only have a local impact concerning the treatment of waste. It also has a global impact, because buying a new mobile phone implies more energy consumption and the related pollution in the country where it is produced, for example China.

Thirdly, the economical sustainability is also important. To implement a new energy service, a detailed financial study is needed to make sure that it will be long lasting and financially sound.

Finally, you have to take the social and economic dimension into account. We know that a lot of money is invested in energy. Investing in fossil fuels means that the investment will be virtually lost once consumed. But an investment in local capacity or activities creates a dynamic based on local anchorage. It fosters local jobs and competence.

Applied to construction, sustainability means, for example, to focus on low-tech using as much passive solutions as possible to achieve comfort, and to use local material and competence.

THE WAY FORWARD
The analysis of the world’s energy situation leads to a very simple conclusion: We need to go for a drastic change and adopt a sustainable growth model, by combining less and better consumption with energy production based on renewable sources.

This conclusion seems straightforward on paper, which does not mean it is easy to put into practice. Sustainability implies a significant change of mindset, lots of technical and technological research and development, individual and collective financial efforts, and above all, a huge work on communication and awareness raising.

Most development agencies acknowledge that today energy issues are not sufficiently taken into consideration either in terms of specific projects to improve access of southern populations to (renewable) energy or in terms of the “energy” components used in infrastructure projects (health centres, schools, etc.).

Implementing sustainable energy in the South is more complicated than just exporting the northern vision of energy efficiency. In the North, energy efficiency is a widely developed concept, but it is not adapted to the southern context and needs. With regard to the cooling needs, which represent an important part of energy consumption in Southern countries, we see that the systems used, i.e. air-conditioning, represent a huge energy squander because most buildings are absolutely not airtight. Other cooling solutions should be considered in this specific context or should be joined with adapted building design.

But the solution is not only technical. Energy efficiency also requires another way of organizing the territory. There are at least two reasons: First, to integrate alternative forms of energy production, such as windmills or hydroelectric plants in the landscape in a harmonious way. Second, to limit energy consumption. In scattered habitats, the infrastructure and mobility needs are high; public transports are less efficient than in densely populated regions. This leads to a more intense use of private transport means. Therefore, scattered habitats are considered energetically less efficient and less sustainable than densely populated areas. This calls for densification and the promotion of efficient public transport. These principles are also valid at the scale of the city, where the zoning principle should also be reconsidered as it increases the mobility needs of goods and people.

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BTC SENEGAL
A windmill and drip-irrigation for market gardening.
ACCESS TO ENERGY IN DEVELOPING COUNTRIES

Figures related to energy access speak for themselves. 1.6 billion people in the world have no access to electricity. The electricity landscape in developing countries is characterized by scarcity, with a general electrification rate of 68%. The most precarious situation is in rural areas, with only 19% access in the African countryside.

**ACCESS TO ELECTRICITY PER REGION**

<table>
<thead>
<tr>
<th>Region</th>
<th>Population</th>
<th>Population having access to electricity</th>
<th>Population having no access to electricity</th>
<th>Electrification rate</th>
<th>Urban electrification rate</th>
<th>Rural electrification rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Million</td>
<td>Million</td>
<td>Million</td>
<td>%</td>
<td>%</td>
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<tr>
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<td>337</td>
<td>554</td>
<td>37,8</td>
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<td>930</td>
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<td>Latin America</td>
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<td>404</td>
<td>45</td>
<td>90</td>
<td>98</td>
<td>65,6</td>
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<tr>
<td>Middle East</td>
<td>186</td>
<td>145</td>
<td>41</td>
<td>78,1</td>
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<td>61,8</td>
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<td>8</td>
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<td>100</td>
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<tr>
<td>&amp; OECD</td>
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<td></td>
<td></td>
<td>75,6</td>
<td>90,4</td>
<td>61,7</td>
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<tr>
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<td>4,875</td>
<td>1,577</td>
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</table>

Source: World Bank

Without energy access, people are cut off from a wide range of services, such as health, water, education, lighting, driving force, communication... Energy also provides power for the industrial processes that are necessary for growing economies. It is also a good support to the informal economy, enabling the development of various craft industries and micro-businesses.

Even though electrification should not be mythicized and considered as the only way to solve problems of poor populations, it is definitely a very powerful lever of development.
ELECTRICITY SECTOR IN DEVELOPING COUNTRIES

The electricity sector in developing countries is characterised by low involvement of the private sector and local micro-finance institutions, especially in the sector of rural electrification. This is due to the high investments needed to install, maintain and develop electricity utilities, combined with the high risks and low (short-term) profitability of this business. Therefore, electricity and grid maintenance are often in the sole hands of national authorities.

In developing countries, especially in Africa, where energy access is utterly problematic, most low and medium towns and big cities are equipped with electrical utilities, but the grid is generally in a bad shape. Huge investments are needed to maintain the grids and to adapt them to the exploding energy demand, but national authorities often defer these investments, which lead to a deterioration of the material and to inadequate electrification infrastructures. Intermittent supply is the norm; end-users experience daily power cuts that last several hours. Extending such a grid would worsen the situation.

The energy situation significantly differs according to the area concerned. In some rural areas there is no grid at all. Grid extension is very costly and return on investment made very difficult by the low density, the low energy demand and also the fact that the main means of subsistence of rural population is agriculture, which offers limited, uncertain and irregular incomes.

Experience shows that political will is a key factor to give the impulse to rural electrification. Morocco and South Africa illustrate this statement. In these countries, vast and ambitious electrification programmes were launched, resulting in high increase of electrification rate in a few years time only.

ELECTRIFICATION STRATEGIES

The gap between North and South with respect to electrification is enormous. This is not only due to the different economic situations, but also to the different population density and reparation. The scattered and mainly rural population in developing countries diverges from the dense and mostly urban population in northern countries. This implies that northern electrification strategies cannot be transferred as such to the South.

In northern countries, the high urban population density is one enabling factor to financing urban electrification and also to bearing the additional costs induced by rural electrification. Here, a kind of ‘solidarity fee’ is applied to everyone – urban and rural customers – to finance grid extension. All customers share the costs to insure return on investment to electricity suppliers and producers.

In the South, financing rural electrification by urban population is not always feasible, because the majority of the population is rural and the urban electricity network is already in deficit. Moreover, the conventional solution of grid extension is not feasible in most developing countries. The authority in charge usually favours the electrification of densely populated areas in the first place, since low electrification rates combined with low and scattered demand is not compatible with the high investment cost of grid extension.

A second conventional electrification strategy is the use of diesel generators connected to micro-grids. This option is more frequently applied in developing countries, but it has a number of limitations: Fuel price fluctuations are unpredictable and fuel supply is not always possible in remote areas. Moreover, the generator lifespan is low, with an average of 3 to 5 years. Last but not least, the environmental impact of this system is significant at local and global scales.

Thus, conventional electrification approaches are not adapted. The development of innovative technological and organisational options is needed. Renewable energy would be a good alternative to conventional electrification strategies, but various barriers such as technical, financial, cultural and legal constraints are slowing their implementation.

ELECTRICITY PRICE: AFFORDABILITY AND WILLINGNESS TO PAY

In developing countries, grid connected areas often benefit from some kind of subsidies. As a consequence, the price of electricity in urban area is not representative of the real production and distribution costs, and this distorts the fair price perception. This perceptive distortion is reinforced by higher cost of energy in rural areas than in cities. Roughly speaking, 50% of the costs is allocated to energy production and
50% to the energy distribution. Moreover, rural electricity does not benefit from subsidies. Hence, one of the difficulties encountered in electrification projects is to make people understand and accept that they have to pay more to get the ‘same’ energy service as their relatives living in cities.

It has to be pointed out that electricity services costs are often more expensive than conventional energy sources (kerosene, batteries, wood). Discussion with the end-user and awareness raising about the assets and limits of access to this type of energy plays an important role. The ability and the willingness to pay is indeed a key factor for the success of a project.

Rural electrification is therefore not only a political, technical and financial matter, but also heavily relies on social mechanisms. The projects have to be accompanied by soft support activities, such as discussions about the ownership of the installation, the payment terms, end-users’ awareness and training.

Rural populations are usually struggling with day-to-day survival. Therefore, they manage their financial means on a short-term basis, daily paying their energy needs, like kerosene, paraffin, candles and batteries. Bringing them a long-term electrification scheme means to change to a longer – for example monthly – payment scheme. This requires education to help people manage money on a longer term. Moreover, micro-credit initiatives could trigger small investments in rural areas.

RURAL ELECTRIFICATION IN THE PAST: ENTHUSIASM AND DISAPPOINTMENT

As rural populations are the first to be impacted by energy shortages, most energy projects are concentrated in rural areas. But what about the end-outcomes of rural electrification projects up to now?

Most electrification projects created great enthusiasm in the development sector and among local populations. Bringing electricity in remote areas provides the nice feeling of ‘changing the life’ of rural populations: school children finally have the possibility to read and study at night thanks to electrical lighting, people open to the world by watching television, health care is improved thanks to properly stored vaccines... However, although being a short-term success, a great part of the electrification projects turned out to be less positive in the long run. Problems arise in the field of maintenance, spare parts supply, correct utilization of electricity systems and low involvement of authorities and users. These elements lead to a “first-breakdown-last use” situation. The high failure rate of electrification projects shows the high complexity of electrification, but also the importance of experience capitalisation.

LESSONS LEARNED

Development agencies gathered the following lessons from their experience in the field:

- The adaptation of policies and statutory texts are necessary for operation of equipment by private parties or users associations and ownership of the electrical infrastructure;
- A good analysis of context and demand is necessary when designing the project;
- The communities of users and institutions must be involved right from the beginning;
- The operation and management mechanisms, price setting, technical and administrative staff training must be defined precisely to ensure continuity of the electricity service;
- The investment must be mostly covered by outside funding, but institutional running costs should be at cost recovery.

As a consequence, a number of specific questions have to be considered before the start of any electrification project.

- Will the electricity service be viable and sustainable in the long term?
- Will the tariff be acceptable for a significant part of the population?
- Will the relations between the contracting authority, the institutions, the operator and the users be clear and precise so that the conditions of use of the systems are respected?
- Can an operation/management structure be easily created? Can it rapidly become professional and sustainable?
- Which methods and mechanisms ensure that the least expensive options are chosen?
- Do financial partners exist to cover the investment costs? Also in the long run?
From small-size projects to larger-scale programmes

Based on their long experience in the field, the organisation Fondation Energies pour le Monde (FONDEM) came to the finding that the electrification of one single village with renewable energy is achievable, but it is difficult to achieve sustainability as, at small scale, running costs are high and professional operators are not interested. Promoting “sustainable” rural electrification implies 3 types of changes.

1 Widen the scale of projects: The local scale involving a few villages needs to be extended to regional-scale programmes, involving at least twenty villages.

2 Involve private and public sectors: Projects have to be implemented within a partnership with professional local entrepreneurs and with all levels of authority.

3 Analyse the local context and plan investments carefully.

Based on these necessary changes, FONDEM developed a planning method called NORIA (New Orientation for the Realisation of Adapted Investments). With this method, projects developers are able to concentrate their action on the poorest of the poor. At the same time, it is easier to limit the risk and insure the sustainability of the rural electrification projects based on the use of available energy sources.

The system contains a set of databases to analyse national, regional and local contexts, cartographical software (Geographical Information System, or GIS)
to visualise the collected information, and calculation software to elaborate and define the decentralised rural electrification programmes. The calculation software covers the technical, financial and organisational options to optimise the durability of the project and insure the stability in the operating phase.

**The method to elaborate a new electrification programme is divided up in three main steps.**

1. **Data collection:** Data are collected at the national, regional and local level in partnership with all levels of authority to make sure that the context and policy are adapted to the implementation of an electrification project. This first step is long (it can last 2 to 3 years) but essential.

2. **Location of priority zones and market study:** The collected data are inserted into the cartographical system to locate priority zones, where the failure risk is minimal and the maximum success conditions are encountered. After validation of the priority zone by the regional authority, a more detailed study of the concerned villages is realized, including demand analysis, resources, payment capacity, etc.

3. **Set up of a large-scale electrification programme:** The Noria calculation software is used to design regional programmes: choice of renewable energy source, profitability analysis, proposed business plan, operational plan and calculation of the positive CO₂ impact of the project.

   The programme is ready for implementation and based on a clear operational scheme, where FONDEM solely acts as facilitator between the different actors. It also has a supportive role on financial aspects.

   **For more info:**
   [http://www.energies-renouvelables.org/proven](http://www.energies-renouvelables.org/proven)
BTC CAMBODIA

Improved school building design contributes to better natural ventilation and solar protection.
Towards a Low-Carbon Economy

Current greenhouse gas emissions in developing countries are low compared to industrialized countries. However, the CO₂ issue in the South should not be overlooked.

Firstly, the high deforestation rate in the South represents a global danger. Deforestation does not just wipe out critical habitat, disrupt ecosystems and lead to the potential extinction of many species, including species that might be essential for cures or treatments. It also contributes to global warming, as forests absorb and store CO₂. Burning these forests releases de carbon back into the atmosphere. Deforestation can thus exacerbate the effects of climate change.

Secondly, the growth of developing and emerging countries is higher than the growth of industrialized countries. They could hence become big greenhouse gas (GHG) producers in the future. As an example, today China is the world’s largest polluter. Its GHG emissions per capita are nowadays higher then the ones of France and Spain and could take the poll position from the United States by 2017 according to the Dutch environmental agency. Considering this, it becomes clear that low carbon development has to be promoted in developing and emerging countries so they ‘get a good start’.

It is time to anticipate the above-mentioned risks and elaborate a development strategy based on low-carbon energy. The northern actions of mitigation, energy efficiency, reorganisation of transport and new buildings norms cannot merely be transferred, as the development of industrialized countries took place centuries ago and was based on fossil fuels. The challenge is to let emerge a new concept of development based on low-carbon growth.

Low-carbon growth and development opting for low-carbon development firstly implies reducing the amount of money spent on importing fuels and decreasing the import dependence of a country, for greater energy supply security and diversity. Renewable energy is a possible option, and in some cases, the only technical option.
There is a risk in linking development too much with other challenges, especially in the discussion about global warming. CO₂, security, immigration... should not be mixed with the core mission of development agencies, namely contribute to building a fair world, eradicate poverty and reach the Millennium Development Goals.

This is how Rob Swart⁴ sees the complex relation between development and climate: “One could [...] wonder what meeting the MDGs and alleviating poverty implies for the climate change challenge. For most developing countries, alleviating poverty is the main goal, and climate change at most a hindrance to achieve it. Also, this coin has two sides. Meeting the MDGs implies a significant improvement in the standards of living for the poor. On the one hand, this will enhance both adaptive and mitigative capacity, but on the other hand, the associated use of natural resources such as fossil fuels may lead to increasing GHG emissions.”

One implication of poverty is the difficult access to energy, which explains why development agencies are also concerned with energy delivery. But their final aim is rarely to build a low-carbon economy. When tackling climate change issues, development agencies are often keen to address adaptation measures rather than mitigation measures, arguing that the latter should be handled by the private sector. Mitigation measures are efforts (policies, programmes, projects...) aiming at reducing the sources of greenhouse gas emissions (from industry, transport, domestic use, deforestation...) or at expanding carbon sinks. Adaptation measures are efforts (policies, programmes, projects...) aiming at adapting to climate change in order to lessen potential damage, to take advantage of opportunities provided and to deal with consequences, (for example, by adapting infrastructure and equipment, to higher flood risks).

Similarly, developing countries tend to concentrate their efforts on short-term adaptation strategies to prevent themselves from climate hazards instead of investing in in-depth policy modifications (energy, transport, urbanization, waste management, land use reforms, agriculture). Yet these may contribute to reducing GHG emissions and will, in the long run, be the only possible way to prevent or limit dangerous modifications of global climate patterns from which developing countries will suffer first and most.

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**DEVELOPMENT FUNDING VERSUS CLIMATE FUNDING**

One of the Copenhagen Conference initiatives was the “fast track” funding which, between 2010 and 2012, should transfer US $30 billion from developed countries to developing ones for adaptation and mitigation of climate change. Developed nations also pledged to raise US $100 billion annually by 2020 and to establish the Copenhagen Green Climate Fund to help nations curb greenhouse gas emissions, chart a low-carbon growth pathway and adjust to climate challenges.

Would this fast-start funding really be “new and additional” to the 0.7 percent of gross domestic product (GDP) development assistance goal that was set already in 1970 by the United Nations? After the recent economic crisis, the “additionality” aspect of climate finance is questioned. Some cash-strapped governments tend to divert some of the money from existing official development assistance (ODA) budgets rather than find new cash.

Meanwhile, poorer nations ask for a distinction between climate funding and other development aid because climate change is adding to the human and financial cost of disasters, and making their social and economic development more expensive. Quamrul Chowdhury, a negotiator for Bangladesh at the U.N. climate talks, argues that using climate finance to fulfill development aid promises will be damaging to his country, which is already struggling to cope with rising sea levels and frequent floods: “If [fast-start funding] is not new and additional, and it is not over and above ODA, our whole development will be paralysed, and how can [we meet] our goals for anti-poverty, education and healthcare programmes?”

However, in certain fields, such as rural electrification, practitioners feel a bit squeezed about the distinction between climate and development financing. As stated by Yves Maigne, Director of Fondation Energie pour le Monde: “Based on my own experience, these subjects are very deeply linked. […] How can you get health centres electrified in remote areas without renewable energy? […] The funds necessary for such actions could be different from ODA, they could be taken by climate change funds, but I really don’t know where the border is. […] And if there is a border, what kind of project will exclusively be considered as development projects or exclusively as climate projects? In my field of activity, they are deeply linked.”

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5 Based on http://ictsd.org/i/news/biores/74825/ and http://www.cseindia.org/userfiles/Fast%20Track%20Funding.pdf
BTC RWANDA

Renewable energy provides rural populations with electricity.
MAIN SOURCES OF RENEWABLE ENERGY

Renewable energies are flux energies, which are regenerating permanently following the rhythm of the sun and its derivatives, along with the tides and the natural heat of the earth. Renewable energies contrast with stock energies such as fossil fuel. Sun, wind, hydropower, and biomass are the main renewable energy sources available on earth.

SOLAR ENERGY

Solar energy is plentifully available on earth. Harnessed in an optimal way, the sun's radiation reaching the earth could cover a great part of our energy needs. The foremost applications today are thermal panels, producing hot sanitary water, photovoltaic or concentrated solar power installations for electricity production with limited operational and maintenance costs. A great potential is still to be explored in the field of cooling systems and desalination. Today, thermal and photovoltaic cells are both mature technologies that could be used in countries of the South.

A significant asset of solar installations is the limited maintenance and operation need. As the system is not composed of running parts, the maintenance is mainly limited to cleaning work and various checks.
Solar thermal heaters

Two main types of solar water heater are widely available on the market: the forced circulation and thermosiphon system.

The **forced circulation heater system** works with a pump, which forces the circulation of a fluid through the pipes when the water is heated by the sun collector. Most of the forced circulation heaters work with a primary and a secondary fluid and a heat exchanger, offering a twofold advantage. In systems solely functioning with a primary fluid, the running water can leave impurities in the system. If the system is placed in a region with a freezing risk, it is better to use anti-freeze fluid as primary fluid rather than water, which could damage the installation by expanding in freezing periods. Anti-freeze fluid is also used to prevent corrosion of the installation.

The **thermosiphon** works on the basis of passive heat exchange driven by natural convection. The liquid circulates without the necessity of a mechanical pump. This system therefore contains less auxiliary components than a forced circulation system. Here, the sun radiation on the collector heats the liquids up that expand and become less dense, and thus more buoyant than the cooler water in the bottom of the loop. Convection moves heated liquid upwards in the system as it is simultaneously replaced by cooler liquid returning by gravity.

The thermosiphon solar heater is easily recognisable with its storage tank located on the top of the sun collector. Its intended purpose is to have a simple design and avoid the cost and complexity of a conventional liquid pump and of all auxiliary components needed in a forced circulation heater system.

The thermosiphon is thus a low-tech solution that works in any country not exposed to frost. It is cheap, easy to manufacture and to install and requires little maintenance. Efficiency is lower than in forced circulation heaters, as more heat is needed to initiate the process. But this does not represent a major problem in countries where solar radiation is very abundant. Conversely, in northern countries, the preference generally goes to highly efficient systems because the solar resource is scarcer.

Regarding the collector’s design, three types are currently used: flat plates, vacuum tubes and non-glazed collectors.

The simplest collectors are **non-glazed collectors**. These are covered with a very simple coating, or even simply painted black. They offer low efficiency but can be useful for low temperature heating.
Flat plates consist of an insulated casing covered by a glass pane. Inside the casing there is an absorber plate with tubes filled with a liquid. The absorber plate is covered with a thin selective coating made of copper or aluminium, aiming at absorbing most of the solar radiation and minimizing the energy losses by convection and radiation. Besides the coating efficiency, the insulation of the casing is an important factor to reduce thermal losses.

Another collector type is made of vacuum tubes located in the collector. The advantage of this design is the reduction of convection losses. Indeed, as air is getting hot, it creates convection and leads to energy losses. By eliminating the air within the tubes, the convection losses are eliminated as well. However, this high-tech system is more expensive.

The selection of the most adapted type of thermal collector should be based on the ratio cost/efficiency, the simplicity of the system and its use, i.e. the temperature difference needed. As a general rule, unglazed collectors are only useful to produce low temperature. Glazed flat collectors have the most varied spectrum. When very high temperature should be reached, vacuum tube collectors have the highest efficiency, but they are also the most expensive.

The performance of a system can also be improved by keeping the water temperature as low as possible, considering that 25% of the heat losses take place in the collectors. Moreover, a well-insulated system prevents energy loss in the storage tank (10%) and in the water pipes (5%).
How to dimension a thermal system?

Analyse the parameters

| 1. What is the resource? | NASA’s surface meteorology and solar energy website offers detailed information on Solar Radiation for free (http://eosweb.larc.nasa.gov/sse/RETScreen). It presents data for the entire world. The Joint Research Centre of the European Commission (JRC) maps represent yearly average of daily total of global irradiation on a horizontal and/or optimally inclined surface. The data is available for the European Union, Africa and part of South-West Asia: http://re.jrc.ec.europa.eu/pvgis/cmaps/afr.htm. The SODA website (Solar radiation data: http://www.soda-is.com/) presents information shared for pay; other meteorological data are commercially available. METEONORM (http://www.meteonorm.com/) is a commercial website offering meteorological reference, incorporating a catalogue of meteorological data and calculation procedures for solar applications and system design at any desired location in the world. |
| 2. What is the demand? | How many litres are needed daily? What temperature should be reached (Take the difference between ambient air and final water temperature into account)? |
| 3. What is the consumption profile? | Is the consumption profile flat all year around? Are there daily or seasonal variations? |
| 4. Is there shading on the collector? | The open source software Carnaval calculates horizon blocking: http://www.incub.net/spip.php?article18 |

Size up the collector surface and the boiler volume with dynamic simulation tools, and estimate the yearly solar production

Dynamic Simulation Programs for Detailed Analysis of Solar Thermal Systems and their Components are downloadable on the Internet:
- T’SOL (free demo available at http://www.valentin.de/en)
- POLYSUN (free demo available at http://velasolaris.com)
- RETSCREEN (full version free at http://www.ertscreen.net)
- CSTB softwares (free downloadable on http://enr.cstb.fr/webzine/default.asp?main=54#72)
- TRNSYS (http://sel.me.wisc.edu/trnsys/index.html)

The simulation can be carried out for different collector and boiler types.

Find an economic optimum between different collectors and boiler types considering the investment, the yearly savings and the maintenance needs.
Photovoltaic installations

Solar Photovoltaic (PV) installations transform solar energy into electricity. The installations are made of modules composed of a combination of cells. The electricity produced in the module is either stored in batteries, or transformed into alternative current in an inverter and injected into a grid or the network of a building.

Different types of PV modules are used. The most common is the Crystalline Silicium module. This module, usually blue and rectangular, represents 91% of the market share. Amorphous Silicium is an alternative offering less efficiency but more flexibility in the placement thanks to its flexible structure. This type of module is usually delivered in rolls, and just needs to be unrolled and stuck to the placement surface. Other module types, such as CIS modules and Cadmium telluride modules are also used but not very common yet.

In developed countries, the choice of the module is mainly determined by the ratio between cost efficiency and available surface. The efficiency can be insured by the presence of the Certificate IEC 61215 for PV terrestrial modules. The modules have to go through a series of tests to get that certificate, which insures a minimal quality. Some technologies are more adapted to specific meteorological profiles: some modules are better adapted to high irradiance level profiles, others to low irradiation profiles. The ambient temperature is another factor that can determine the choice of the technology. The yield of the modules decreases with the temperature rise with noticeable differences from one module type to the other.

<table>
<thead>
<tr>
<th>Material</th>
<th>Thickness</th>
<th>Efficiency</th>
<th>Colour</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monocrystalline Si solar cells</td>
<td>0.3 mm</td>
<td>15 - 18 %</td>
<td>Dark blue, black with AR coating, grey without AR coating</td>
<td>Lengthy production procedure, wafer saving necessary. Best researched solar cell material - highest power/area ratio.</td>
</tr>
<tr>
<td>Polycrystalline Si solar cells</td>
<td>0.3 mm</td>
<td>13 - 15 %</td>
<td>Blue with AR coating, silver-grey without AR coating</td>
<td>Wafer saving necessary. Most important production procedure at least for the next ten years.</td>
</tr>
<tr>
<td>Amorphous silicon</td>
<td>0.001 mm + 1 to 3 mm substrate</td>
<td>5 - 8 %</td>
<td>Red-blue, Black</td>
<td>Lower efficiency, shorter life span. No sawing necessary, possible production in the form of band.</td>
</tr>
<tr>
<td>Cadmium Telluride (CdTe)</td>
<td>0.008 mm + 3 mm glass substrate</td>
<td>6 - 9 % (module)</td>
<td>Dark green, Black</td>
<td>Poisonous raw materials, significant decrease in production costs expected in the future.</td>
</tr>
<tr>
<td>Copper-Indium-Disenliden (CIS)</td>
<td>0.003 mm + 3 mm glass substrate</td>
<td>7.5 - 9.5% (module)</td>
<td>Black</td>
<td>Limited Indium supply in nature. Significant decrease in production costs possible in the future.</td>
</tr>
<tr>
<td>Hybrid silicon (HIT) solar cell</td>
<td>0.02 mm</td>
<td>18 %</td>
<td>Dark blue, black</td>
<td>Limited use of this production procedure, higher efficiency, better temperature coefficient and lower thickness.</td>
</tr>
</tbody>
</table>

Regarding the last years. The key factor is rather the price compared to the energy produced. The price of PV modules has been decreasing thanks to a significant supply increase over the last years. The weight of the various modules can also influence the choice of a technology.

Regarding the type of inverter, the choice depends on the operation and maintenance strategy and on the solar array configuration – whether it is homogeneous or not – and on the presence of the grid. Central inverters are used for large plants with similar arrays. Their cost is low, the maintenance is easy, but central inverters have to be placed in a container to be protected from rain and dust, and they have to be ventilated.

String inverters on the contrary, are used for both large and small plants. They offer a higher flexibility because they work with different arrays. In non-homogeneous fields, for example a roof with different orientations and therefore different inputs, it is better to have various small inverters because the worst performing part influences the rest of the input. By dividing up the production between various inverters, the inputs are maximized.

Off-grid solar systems like in rural electrification, use other types of inverters, creating alternative current from a stable battery voltage. The batteries are charged by the solar panels through a charge controller, that maximizes power output from the solar panels and protects the batteries from overcharging.

Concentrated solar power
Another way of producing electricity from solar power is the concentrated solar power system (CSP). In CSP plants, solar radiation is concentrated (by means of mirrors) to create very high temperatures that are converted through a heat engine to electrical power. For large plants, CSP is more economic than photovoltaic panels and it will become even cheaper as more installations are being built. It has the advantage over photovoltaic power that the intermediate heat at high temperatures can be stored, meaning a CSP installation can deliver a relatively constant power, even during the night. Maintenance puts CSP at a disadvantage compared to PV. Also, CSP is not really feasible on a small scale.

WIND POWER
Wind energy is a derivative of solar radiation: differential heating of the planet creates pressure differences and an air flow know as wind.

Not all wind energy can be harnessed: grid availability, landscape protection, prohibitive installation costs are factors that limit potential investments in wind energy. However, the wind power potential largely exceeds the energy needs of the planet.

The power present in the wind flow is proportional to the cube of the wind speed and to the area covered by the flow. Site location on the most windy spots is therefore crucial. Increasing the hub height exposes the turbine to higher and more stable wind speeds. Increasing the turbine diameter increases the area over which wind energy is extracted. Logically, there is an evolution for ever increasing wind turbine sizes, with larger diameters and higher hub heights. This evolution is mainly limited by noise and other regulations, material constraints and logistical issues. Airborne wind turbines and off-shore (possibly floating) wind turbines all seek to maximize energy output by looking for stable, reliable, high wind speeds.

A big disadvantage of wind energy is its intermittency, comparable to some extent to solar power. This means wind energy will have to be well integrated in the grid, including storage solutions and other (renewable) sources.

Specific to the building context, and contrary to the aforementioned advantages of scale, there has recently been a tendency towards small scale wind turbines (up to 50kW). From an investment perspective, these can never compete with the larger turbines, but in some cases (off-grid remote areas with a good average wind speed) they can be a very interesting source of power. Technology for small scale windmills is relatively simple (transforming mechanical rotational energy in electrical power as is done in any car…) and can be locally produced.

A very old and purely mechanical way of harnessing wind power is drinking water pumping, either into irrigation channels or into a reservoir. A reservoir can compensate for the intermittency problem. Despite its age, this technology is still proving its usefulness in many countries all over the world.
HYDROPOWER

Hydropower, like wind power, is in a way a solar power derivative: solar radiation creates evaporation, which after cooling in higher layers condenses and precipitates. The rainwater runs off towards the seas, and thereby loses height (and potential energy).

Hydropower can be conceived as a “run of the river” system, using the available water flow and converting part of the energy of the water into electricity. This flow can vary between seasons. It is important to use minimum flows in design of these systems.

In other instances, a reservoir at a certain elevation accumulates potential energy (or pressure). This can make hydropower a very reliable source of energy, but comes with the ecological cost of reservoir creation and its possible effects (methane production, siltation, downstream ecosystem disruption, …). Power output is proportional to the height of water drop and the water flow. Different kinds of turbines are used for high or low level differences. Hydropower is characterized by relatively high efficiencies: up to 90% of the energy is transformed into power.

For small-scale hydropower (pico-hydropower), an interesting and cheap option is the transformation of existing mechanical watermills into small hydropower plants, just by adding an electrical generator to the mechanics.

COGENERATION

Cogeneration is the joint production of heat and power. It uses the (low temperature) energy that is otherwise wasted through the chimney after separate heat or power production, and, in doing so, can drastically increase the fuel efficiency (for whatever fuel). It is a clear example of increasing energy efficiency without necessarily changing the energy source. Cogeneration can be installed with either fossil or bio-fuels.

Cogeneration is a very interesting option for applications with a relatively constant heating demand, like heat demanding industries (chemical, food processing,….) but can also be an opportunity for buildings like swimming pools, greenhouses, hospitals,… Adding absorption cooling, this range can be extended to almost any building. In these cases, we speak about tri-generation (heat, cold and power).

Cogeneration is generally done in large grid connected energy plants, involving complex regulating systems and requiring specific technical skills. However, simplified micro-cogeneration machines designed for the individual building needs are making their way to the market, and might become much more common in the future.

GEOTHERMAL ENERGY

Depending on the latitude, a certain thickness of Earth’s surface maintains a nearly constant temperature between 10 and 16 °C. Systems can benefit from the thermal difference between the ground temperature and the outside air, cooling or warming the inside air. For buildings, the geothermal energy is commonly used with heat pumps or ground-coupled heat exchangers.

Geothermal heat pump, or ground source heat pump, is a central heating and/or cooling system that pumps heat to or from the ground. It uses the earth as a heat source or a heat sink. This design takes advantage of the moderate temperatures in the ground to boost thermal inner comfort. Heat pump technologies use a refrigerant pumped through a vapor-compression refrigeration cycle to transfer the heat from the ground to the building, which requires energy. It is a rather expensive technology today and needs electricity to work.

A more ‘basic’ system, called ground-coupled heat exchanger, has been used for centuries. In this system, fresh outside air is not directly blown into the building; it first passes through earth tubes at a depth of 2 to 3 meters. In other words, it works as an underground heat exchanger loop that captures or dissipates heat to or from the ground through air. Earth tubes are often a viable and economical alternative or supplement to conventional central heating or air conditioning systems since there are no compressors, chemicals or burners and only blowers are required to move the air. These are used for either partial or full cooling and/or heating of facility ventilation air.

In the dimensioning of such a system, an optimum between depth, exchange surface and cost has to be found. It is advised to have a bigger exchange surface with the ground. A better efficiency is reached with several small ducts rather than a single big one.
The vital difference between biomass and fossil fuels is the time scale.

Biomass takes carbon out of the atmosphere while it is growing, and returns it as it is burned. If it is managed on a sustainable basis, biomass is harvested as part of a constantly replenished crop. This is either during woodland or arboriculture management or coppicing or as part of a continuous programme of replanting with the new growth taking up CO₂ from the atmosphere at the same time as it is released by combustion of the previous harvest.

This maintains a closed carbon cycle with no net increase in atmospheric CO₂ levels.

The system will be less efficient in places where the temperature difference between day and night is small, because it does not allow the ground to cool down.

The software PHLuft (in German) enables the dimensioning of ground-coupled heat exchangers. It is available at:
http://www.passiv.de/04_pub/Literatur/PHLuft/PHLuft.htm

The process where the heat from the Earth’s mass is used to produce electrical power is called geothermal power. Heat is extracted from boreholes near accessible heat sources (hot water) and converted into power using a heat engine. This kind of power is very reliable. Care has to be taken of the drilling risks (stability issues) and environmental impacts (hydrogen sulphide, carbon dioxide, methane and ammonia are present in the water that is extracted).

Although the first ever geothermal plant in 1904 lit only 4 light bulbs, nowadays geothermal power is a large scale, grid-connected way of power production. Note that geothermal energy is not renewable as such, but the heat present in the Earth’s inner layers is so enormous that it is virtually inexhaustible.

BIOMASS

Biomass is biological material derived from living, or recently living organisms. In the context of biomass for energy it often means plant-based material, but biomass can equally apply to both animal and vegetable derived material. Biomass is stored solar energy that can be converted to electricity, fuel, and heat. Through photosynthesis the energy from the sun is stored in the chemical bonds of the plant material. Biomass energy comes from three main sources: agricultural crop residues, municipal and industrial waste, and energy plantations. To be sustainable, biomass has to be harvested from a source that is properly managed (like energy crops), and not from deforestation.

There are a number of technological options available to make use of a wide variety of biomass types as a renewable energy source. Conversion technologies may release the energy directly, in the form of heat or electricity (combustion, gasification, pyrolysis), or may convert it to another form, such as liquid biofuel or combustible biogas. In that case, chemical conversion is needed. A range of chemical processes may be used to convert biomass into other forms. Biochemical conversion is one option, whereby enzymes of bacteria and other micro-organisms are used to break down biomass and perform the conversion process. Anaerobic digestion, fermentation and composting are examples of biochemical conversion techniques.

The benefits of biomass are numerous. It has got a huge worldwide potential for CO₂ emission’s reduction. It generally uses low-tech conversion systems and can be stored.
### Identification of the Renewable Energy Sources (RES)

<table>
<thead>
<tr>
<th>Renewable energy sources</th>
<th>Type of energy produced</th>
<th>Storable?</th>
<th>Conversion system</th>
<th>Useful energy form</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun</td>
<td>Radiation</td>
<td>No</td>
<td>- Solar water-heater&lt;br&gt;- Solar oven and dryer&lt;br&gt;- Photovoltaic system&lt;br&gt;- Solar thermodynamic power plant&lt;br&gt;- Concentrated solar power&lt;br&gt;- Solar cooling</td>
<td>Heat&lt;br&gt;Electricity&lt;br&gt;Cold</td>
</tr>
<tr>
<td>Wind</td>
<td>Kinetic energy</td>
<td>No</td>
<td>- Onshore and offshore wind turbine (wind farm, isolated or urban turbine)&lt;br&gt;- Water pumping windmill&lt;br&gt;- Sail</td>
<td>Electricity&lt;br&gt;Work</td>
</tr>
<tr>
<td>Hydro-power</td>
<td>Watercourses</td>
<td>Gravitational</td>
<td>Yes &lt;br&gt;- Water mill&lt;br&gt;- Hydropower plant</td>
<td>Electricity and work</td>
</tr>
<tr>
<td></td>
<td>Tide, waves, ocean current</td>
<td>Kinetic energy</td>
<td>No &lt;br&gt;- Tidal power station&lt;br&gt;- Ocean power plant&lt;br&gt;- Wave energy converter (WAEC)</td>
<td></td>
</tr>
<tr>
<td>Biomass</td>
<td>Food</td>
<td>Chemical energy</td>
<td>Yes &lt;br&gt;- Metabolism&lt;br&gt;- Burning equipment&lt;br&gt;- Engine&lt;br&gt;- Cogeneration</td>
<td>Work and heat&lt;br&gt;Heat, work and electricity</td>
</tr>
<tr>
<td></td>
<td>Biogas</td>
<td>Chemical energy</td>
<td>Yes &lt;br&gt;- Metabolism&lt;br&gt;- Burning equipment&lt;br&gt;- Engine&lt;br&gt;- Cogeneration</td>
<td>Work and heat&lt;br&gt;Heat, work and electricity</td>
</tr>
<tr>
<td></td>
<td>Biofuels</td>
<td>Chemical energy</td>
<td>Yes &lt;br&gt;- Metabolism&lt;br&gt;- Burning equipment&lt;br&gt;- Engine&lt;br&gt;- Cogeneration</td>
<td>Work and heat&lt;br&gt;Heat, work and electricity</td>
</tr>
<tr>
<td></td>
<td>&quot;Natural&quot; heat: Geothermal, oceanic or indirect solar heat</td>
<td>Heat</td>
<td>No &lt;br&gt;- Bioclimatic architecture&lt;br&gt;- Natural lighting&lt;br&gt;- Natural ventilation&lt;br&gt;- Ground-coupled heat exchanger</td>
<td>Heat, lightiing&lt;br&gt;Thermal comfort</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Yes &lt;br&gt;- Heat pump</td>
<td>Heat&lt;br&gt;Heat (electricity)</td>
</tr>
<tr>
<td>Others:</td>
<td>Lightning, salinity difference...</td>
<td>Heat</td>
<td>No &lt;br&gt;- Bioclimatic architecture&lt;br&gt;- Natural lighting&lt;br&gt;- Natural ventilation&lt;br&gt;- Ground-coupled heat exchanger</td>
<td>Not significant</td>
</tr>
</tbody>
</table>

Source: Training session on Renewable Energy and Energy Efficiency organised at BTC, Michel Huart, April 2011

For more info:

- [http://www.itdg.org/docs/technical_information_service/micro_hydro_power.pdf](http://www.itdg.org/docs/technical_information_service/micro_hydro_power.pdf)
- [http://www.nrel.gov/docs/fy01osti/29065.pdf](http://www.nrel.gov/docs/fy01osti/29065.pdf)
BTC BURUNDI

Electricity improves basic social services.
MAIN CONSTRAINTS LIMITING THE USE OF RENEWABLE ENERGIES

Using renewable energies instead of conventional energy sources has many advantages: low CO₂ emission; low operation costs; availability of diversified resources in most developing countries and opportunity of job creation.

Moreover, renewable energies can offer a decentralised energy production, the resource is available at the place of use, and therefore do not necessarily require the installation of an electrical transportation grid where it is not available. This enables savings and avoids transport losses.

However, the use of renewable energy is often hindered by financial, technical, legal and socio-cultural barriers.

FINANCIAL CONSTRAINTS
Renewable energies are characterized by a high initial investment cost and low maintenance and operation cost. On the contrary, conventional energies require low investment at time zero and increasing operation and maintenance costs. The implementation of renewable energies therefore requires a long-term approach taking the global cost into account, rather than only the initial investment.

Source: Training session on Renewable Energy and Energy Efficiency organised at BTC, Michel Huart, April 2011
The total lifecycle cost analysis

This technique assesses the environmental impacts associated with all the stages of a product’s life:

- Acquisition costs (or design and development costs)
- Installation costs
- Operating costs (failures, repairs, spares, downtime, loss of production)
- Disposal and recycling costs

The operation costs of conventional energies are increasing exponentially, which is notably linked to the increasing fossil fuel price. Even though the extent of the increase in the future is unknown, some predict it to be very high. Renewable energies, on the contrary, are not dependent on fossil fuel prices. Therefore, the operation costs are virtually stable, only ‘disturbed’ by replacement costs of inverters and batteries, for example.

In projects supported by development agencies, investment is often supported by donors, while running costs are taken on by partner organisations. Projects or infrastructures supported by external donors may tend to underestimate the huge and exponential operation costs induced by conventional energy sources.

TECHNICAL CONSTRAINTS

Intermittence

As the sun is not shining 24 hours a day and the wind is not blowing all year around, renewable energies are intermittent and the accuracy of the prediction can decrease dramatically with the prediction time.

There are different ways to get around the problem of intermittence. One way is to connect the renewable energy produced to the grid. This implies the immediate proximity of the grid, its capacity to absorb intermittent flux, and the legal authorization to add energy to the grid. Another way to avoid intermittence is to use a hybrid system, combining renewable energy production with a conventional generator used as a backup system.

An intuitive evaluation among the different energy production possibilities is shown in the table below. Hybrid systems require relatively high investment but minimize the intermittency.

<table>
<thead>
<tr>
<th></th>
<th>Generator (oil)</th>
<th>Photovoltaic</th>
<th>Wind energy</th>
<th>Hydropower</th>
<th>Hybrid systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment</td>
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<tr>
<td>Operation cost</td>
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<td>Intermittency</td>
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<tr>
<td>Lifespan</td>
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<td>Reliability</td>
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</tr>
</tbody>
</table>

Source: Apere
Hybrid power system design

Software can be used to design and analyse hybrid power systems, for either grid-connected or off-grid environments.

The HOMER software is an energy modelling software, available for free on http://www.homerenergy.com/. HOMER contains a mix of conventional generator, cogeneration, wind turbines, solar photovoltaic, hydropower, batteries, fuel cells, biomass and other inputs.

Storage

In the absence of a local grid and of storable renewable energy sources – such as watercourses combined with a dam – an autonomous energy system has to be implemented. The surplus production is stored in batteries to overcome the intermittent energy production. This leads to the storage issue. Storage implies a correct dimensioning of batteries, which need to be replaced regularly since their lifespan is about 5 years. This potentially creates problems related to the battery supply, the end-users ability to pay and to replace the batteries. Special attention has to be paid to battery waste management.

The experience in poor areas shows that it is wise to give priority to the simplest systems. This especially applies to maintenance needs and spare parts supply. If a specific project is achievable without batteries, it is sound to choose the simplest option and hereby elude the storage problem. But then, it is necessary to clearly set who (what groups of the populations/communities) will have priority when the production is not sufficient to meet all energy needs.

Local manpower

Simple systems adapted to specific uses are not always available on the market. The market of renewable energy production in developing countries is less attractive to the private sector, which implies that products are not adapted to local needs. Most of the Research & Development activities take place in the North and target specific northern uses, where maintenance, competence and supply are generally not an issue. Not enough R&D focuses on the specific Southern context. The role of development actors is to recognize specific needs and promote adapted alternatives.

Limitation of power

Power and energy delivered by renewable energy sources is often limited. Competence and knowledge are required to conduct detailed studies and provide accurate insights on the amount of energy needed and the potential of each specific source.

"I was involved in a rural electrification project in Nicaragua using solar panels and batteries. After a few years, I visited the site and discovered used batteries in the surrounding fields. The batteries were broken, which means they might have contaminated the fields but also the area’s rivers, where the children were playing. This project was aimed to be sustainable, but from a local point of view, it destroyed more than it helped.

Therefore, it is really important to insure that the project works on the long-term by raising awareness about the environmental problems that might occur and train people to maintain the installations."
Legal constraints in the private sector power production in Rwanda

Experience from Erik Van Malderen, BTC technical advisor in Rwanda.

From our experience in Rwanda, the private sector power production (PPP) is not yet taking off due to the lack of an institutional framework: Up to now there is no Energy and Gas law, no renewable energy feed-in tariff, no clear distribution of duties within the Rwanda Utility Regulator (RURA), the Energy Water and Sanitation Authority (EWSA) and the Rwanda Environment Management Authority (REMA).

Private Investment is urgently needed because the Rwandan government is counting on it for future development of the energy sector, but up to now all projects were handled case by case. The institutions and government are working hard on the development of laws, feed-in tariffs, knocking down administrative barriers, but there is still a long way to go, and capacity is needed to ensure future developments.

LEGAL CONSTRAINTS

In most developed countries, investment in renewable energy is done through the private sector. In European countries for instance, photovoltaic installations or wind farms are in many cases owned by private companies, while the national grid is mostly remaining under governmental control. The success of private investments in power production with renewable energies in developed countries is due to Renewable Energy Feed-in Tariffs (REFIT) and accurate institutional, legal and regulatory frameworks. (A feed-in tariff is a renewable energy policy that typically offers a guarantee of payment to project owners for the total amount of renewable electricity they produce, access to the grid and stable, long-term contracts).

To develop private investment in renewable energies, a clear energy policy including useful strategies and guidelines is needed. It is also important to have clear instructions on tax regulation, feed-in tariffs, incentives, contracts and long-term agreements.

Governments must plan how much renewable energy can be added as power supply to the grid per year, and what incentives are needed to reach this goal. Experiences in France, Belgium, Great Britain, Spain… show that quantity limits for renewable energy investment have to be drawn. Incentives and feed-in tariffs (FIT) were sometimes too high for (home) photovoltaic systems, private interest surpassed the expectations and governments had to review their policies.

Success of FIT depends mainly on institutional and legal frameworks. Many questions have to be answered before implementing such policies: Does legislation allow Private Power Production and under which conditions, who is in charge of incentives (central or local government)? Is the private sector involved? Who delivers installation certificates? Does the national regulator intervene in the tariff or certificates? Is a clear distinction made for the professional and public market?

Communication, application and adapted administrative management are important for success in private sector power production. For example, a one stop office reduces administrative and regulatory barriers, and supportive national or regional administrative services are key to success.

SOCIAL AND CULTURAL CONSTRAINTS

One of the big hurdles faced by the renewable energy sector are social and cultural barriers. All new technologies intimidate, require habit changes and raise some fears and questions: Does renewable energy really work? Will it be adapted to my specific need?

For example, some projects face the problem that renewable energy is considered as an inferior substitute for a grid connection:

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“Renewables are occasionally scorned by communities as sub-standard substitutions for the ‘Western’ development path. Stakeholders seem to agree that if communities had a choice they would always hook up to the grid because it is perceived as more advanced. […]

For Namibia’s rural population, development means electricity, and electricity means power lines—it doesn’t really mean solar. Even if people have solar panels, at the end of the day, they still would like a power line running to the house. Mr. Hipangelwa from the MME Solar Homes Program describes a project close to Windhoek where MME electrified several villages with solar energy. The villages, which were seven kilometres away from the grid, were unhappy because the solar prevented them from grid access in the future.”

This reaction can be explained by different factors. Grid access exempts the users from any responsibility such as maintenance, and grid-connection is less risky and often cheaper for the end-users.
**Determine the energy need**

Do you want to light, cool, pump water; use communication devices? The energy need has to be analysed and quantified. Also, the analysis has to take the demand variability into account: daily variability, seasonal variability...

For example, in a public building located in arid regions, electricity could be supplied by photovoltaic modules with few batteries, as there is generally low electricity demand in the building at night, like in most schools.

On the contrary, health centres using fridges have a nearly constant energy demand. Therefore, a storage system or a diesel backup system is needed when the energy source is the sun. This shows that the demand variability has a big impact on the choice of energy supply source.

**Check the availability and the feasibility of the resource**

Is the resource available at all? Are there watercourses, geothermal sources, biomass, wind?

But also, is there sufficient resource to insure the renewal of it? This is for example a big issue with biomass, which needs to be correctly managed to be considered a renewable energy source.

Apart from the price, other specific elements have to be considered when choosing the most adapted energy source: availability of space, local competence and spare parts, legal requirements and environmental constraints. Simple technologies are always to be preferred.
to choose the most appropriate energy source

3
For all available and feasible energy sources, clarify the technical design with or without transmission line, with or without battery systems...

4
Analyse the electricity cost per unit on the entire lifetime of the installation.

5
Check the availability of technology to convert available resources into energy or examine the possibility to adapt the existing technologies through R&D, partnership with the private sector or universities.

6
Make sure you can finance the project. It is important to take the entire lifespan of the project into account by realising a business plan covering the initial investment, the maintenance needs, spare parts etc.
BTC CAMBODIA

Improved school building design contributes to better natural ventilation and solar protection.
TOWARDS ENERGY EFFICIENT BUILDINGS IN THE SOUTH

Buildings and infrastructure represent a great share of the world carbon dioxide emission and an important action field in development cooperation.

Considering their life span – around 50 for the former and 100 years for the latter, their energy consumption will have long-lasting implication. It is therefore important to consider the aspect of energy saving in their design, considering the three-steps principle – consume less, consume better, produce better. First, buildings have to induce less consumption, which means – among others – minimize the heating, cooling and lighting needs. Second, the consumption should be lowered thanks to efficient devices such as heaters or air-conditioning. Finally, the top of the sustainability pyramid can be achieved by covering the energy needs with renewable energy.

The aim is thus to reduce the environmental impact of a building over its entire lifetime, while optimizing its economic viability, the comfort but also the safety of its occupants. To this end, energy efficiency should be a common thread in all building projects, a continuous concern from the start and throughout the whole construction process. But what is the state of play in that regard, respectively in the North and in the South?

In Northern countries, the importance of energy efficiency has been recognized further to the Kyoto protocol and the mitigation goals set up to fight climate change. As a consequence, energy efficiency is gradually becoming a central concern in industrialized countries, supported by strong political will and measures encouraging energy savings in the building sector. At the same time, the quick rise of energy prices leaves few alternatives to consumers but trying to consume less and/or invest in better insulation and more efficient heating or cooling equipments.
Passive architecture and construction norms

‘Passive building’ is an international label delivered to buildings complying with the three following criteria:

- Minimize the annual heat requirement to 15 kWh/m² per year
- Build airtight building shells
- Limit the overheating percentage to 5%

Experience showed that strong political measures support the implementation of energy efficiency in buildings. Germany, a trendsetter in the sector of passive house buildings, has enforced strict construction norms leading to a clear decrease of energy use in buildings.

In Belgium, for example, strong measures will have deep effects on energy efficiency in buildings in the coming years. In Flanders and Brussels new constructions will have to comply with the “passive buildings” criteria as from 2015; in Wallonia it will be strongly recommended as from 2017.

ENERGY EFFICIENCY IN BUILDINGS, ALSO A CONCERN FOR THE COUNTRIES OF THE SOUTH

In Southern countries, the motivation lying behind energy efficiency and energy savings are not exactly the same as in the North. Of course, mitigation measures are necessary, because the climate change and environment challenges are based on shared responsibilities. But the prime motivation for energy saving in some areas might be the lack of availability and affordability of energy supply.

In practice, a lot of buildings in the South are not designed in an energy efficient way. For example, a large number of buildings are equipped with air-conditioning whereas their shell is not airtight. From an energy efficiency point of view this is nonsense. Better solutions exist to achieve comfort with very low energy consumption, such as passive ventilation systems coupled with efficient use of thermal mass, for example.

In short, there is still a long way to go in the field of energy efficiency in Southern countries. Different factors, such as a lack of time, money, expertise and communication about successful techniques and projects are slowing the implementation of energy efficiency in buildings.

Concerning the specific case of buildings in the development cooperation sector, the awareness about the importance of energy efficiency is growing, but few buildings are yet constructed following a consistent energy concept. The implementation of global energy concepts in buildings definitely needs to be pushed.

To remedy this situation, some development cooperation agencies try to find a way to systematically integrate the environmental and energetic issue into their work. One way to achieve this is to implement a green tendering procedure that would bind tenderers to specific environmental criteria, and, at the same time, build up expertise in partner countries, so that they can internally rely on technologies that are adapted to the country.

Since 2010, LuxDev, the development agency of Luxembourg, has provided a concrete example of this kind of green tender procedure. The objective is to generalize the use of this procedure to all type of tenders, including, equipment and materials.
What are the new elements in the green tendering procedure developed by LuxDev?

Green tendering is one of the outcomes of greening the entire Quality Manual and Procedures of the Agency. This process of better integrating environmental and climate concerns into the way the Agency works started more or less 2 years ago. The dynamics extended to the Ministry of Foreign Affairs, which invited the Agency to help elaborate a Strategy on Environment and Climate Change in development work.

The Strategy was adopted at the end of 2009. The aim for the Agency is to green its responsibilities, from the start of the project cycle. It considers the environment in the problem analysis and screens for potential environmental impacts at the formulation stage. As a result the project document should identify, operationalise and budget the necessary actions to be undertaken to protect the environment, e.g. by building in an energy and resource efficient way. In order to make this happen at the implementation stage, we needed green purchasing tools. We therefore designed a green tender dossier, which is different in the sense that it introduces:

- Environmental Title of the tender
- Environmental Evaluation criteria
- Environmental Compliance
- Environmental Recommendations
- Environmental Specifications for a clean building site
- Environmental Resource required in the design team and on the building site
- An environmental Mémoire.

What were the difficulties you encountered when elaborating the procedure?

The difficulty clearly consists in designing a tender dossier adapted to the development context. Designing an energy efficient building and contracting a competent construction company in the South is quite another story than doing it in the North. In fact, after having checked what other development agencies do in this respect, we found out none had environmental criteria when awarding works contracts. The necessary expertise for adapting energy efficiency and low carbon imperatives to other latitudes and contexts seemed to be limited. Add to this that restrictions in developing countries are manifold: weak implementation of environmental standards / legislation, inexperienced architects and builders, limited supply of clean technologies or dumping by cheaper equipment imported from Asia... Sometimes even quality building material has to be imported (CVE...), with a negative consequence on the carbon footprint of the building... The options in the South are limited, the market is more restricted than in high-income countries, which bears the risk to result in unsuccessful tendering processes or to increase the prices.

Besides, while acknowledging that Southern countries will probably suffer most from global climate change, there is no universally unique and shared comprehension of the notion of sustainable development. Applied to constructions, sustainability would deal with switching away from depleting fossil fuels and towards resource and energy efficiency so as to reduce longer-term operations & maintenance cost of a building. It would incorporate broad consultation of all stakeholders and future occupants of the infrastructures and rely on local crafts and knowledge of traditional buildings. After all traditional constructions were energy/cost efficient, recyclable and low carbon long before resources scarcity, environmental degradation and climate change.

Unfortunately, often, in a short time perspective, a prestigious, air-conditioned, high-energy building is preferred to the low-energy variant, even if the latter’s running costs will be lower in the medium and long term (less energy consumption = less costs).

Did the first projects based on the green tendering procedure succeed?

The first green tendering concerned the purchase of project vehicles. It did succeed, with a higher price to be paid for the cleaner car as compared to its conventional equivalent. Concerning constructions, Lux-development launched two architectural contests for High Environmental Quality buildings. The tender process was a success: There was a real competition and choice, the award went to Design Team office whose green solutions were the most convincing, considering the budget available. The first tender for building a green building on the basis of the LD contractual green recommendations is underway. We have so far not encountered a lack of interest from potential tenderers.

What are the limits and specific challenges?

It seems that a real green works tender would try to combine mud/wood/stone buildings, natural cooling / lighting, local masonry etc. with simple and robust modern clean technologies and processes, transferred from the North or developed in the South, but adapted to local conditions.

There is also a significant institutional, ownership and good governance challenge: how to green national purchasing procedures when delegating project/programme management to the national recipient authorities? How to adapt/transpose the environmental standards the Agency designed and tries to safeguard when national counterpart purchasing procedures are applied with local environmental standards? In most cases, these national environmental standards are either weaker than Lux-Development’s or do not exist. It is for the Agency, preceded and supported by the Luxembourg government when signing cooperation agreements, to discuss and negotiate a scaling up to the highest environmental standards of the two, in the interest of real sustainable development of the partner country.

Green tendering procedure
4 Questions to Pascale Junker, Environment and Climate Change Expert, LuxDev

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Common criticism to passive building labelling

A common critic to passive buildings is the high investment cost of insulation, air tightness features and the heavy materials bringing thermal capacity to the building, leading to an increase of around 15% compared to traditional buildings.

But in the long run, lower running costs compensate the price difference. Moreover, some strategies can be applied to lighten the investment, by limiting the use of luxurious materials, as it was the case in a passive school built in Nivelles (Belgium). Here, the building turned out to be 10% cheaper than a classical building.

The passive concept was initially conceived for northern countries, thus for cold climates. But the principle is applicable to southern countries with cooling needs. However, some passive buildings realized in developing countries heavily rely on high technology and are therefore not adapted to environments where maintenance and spare parts supply are difficult.

Finally, some experts consider that passive buildings might pose problems concerning sanitary and fire protection. Others think it is more interesting from economic and health points of view to tend towards low energy buildings than passive buildings.

ENERGY EFFICIENCY PRINCIPLES IN BUILDINGS

Energy efficiency in buildings begins with an appropriate design. It is important to allocate time, money and expertise in the design phase of a building, as the cost and time invested in design are inversely proportional to the operational costs and to the energy consumption generated by a building.

However, this is often problematic in the development cooperation context, because there is generally an important time pressure to use the available money. It is therefore difficult to bring the necessary expertise during the design phase, because it takes time to find consultants with relevant expertise and make complex software simulations.

Energy efficiency implies the respect of a set of inter-related principles to be integrated at the earliest stage of project design, such as environmental integration, compactness, building shell, thermal mass, ventilation, etc. The application of these principles, described below, should take into consideration climatic, geologic, topographic, socio-economic and cultural characteristics of the site as well as the requirements of the functionalities of the building; e.g. the needs in terms of thermal users comfort of a school are not the same as the ones of a hospital.

Environmental integration

Environmental integration implies the building to be integrated in the existing surroundings in different ways.

First of all, the building should be oriented correctly in order to optimize or minimize the solar gains, depending on the heating/cooling needs. Depending on the latitude of the construction site, buildings should be well exposed to the sun to optimize solar gains when heating needs are prevailing, and be protected from it when cooling needs are prevailing.

The orientation should also consider the main wind direction, for both favouring natural ventilation and for protecting the interior from storms. In both cases, the local impacts of both wind and sunlight and existing trees planting should be assessed and integrated into the building implantation.

Efficient solar protection is a good way to reduce unwanted glare and heat gain, and can decrease the energy needs. External shadings can be made of natural elements, such as trees or any type of fast growing vegetation. In a warm climate, evergreen plants offer a protection all year around, while deciduous vegetation will be preferred in temperate climate, to exclude sun in summer and admit it in winter. Simple horizontal devices, including eaves, are also a good way to let the winter sun come in the building and avoid the hot summer sun. Movable shadings are also an option, but require to be set-up correctly, which implies the end-user to know how it works and to be sufficiently involved in the energetic functioning of the building. The position and the type of the external solar protection above windows will have a direct incidence on the direction of wind blow within the building.
Passive design considering solar penetration

**Summer**
- Sunlight enters the living area through the roof.

**Winter**
- Sunlight enters the living area through the roof.


Impact of window shading in internal ventilation flow

- Louvers can direct airflow upward or downward.
- A canopy over a window tends to direct air upward.
- A gap between canopy and wall ensures a downward pressure.
- Downward pressure is improved further in the case of a louvered sunshade.
- Use window styles with 100 per cent opening area such as louver and casement.

© Steve Szokolay
Users’ comfort

Comfort is the very aim of a building. We distinguish four categories of comfort: visual, hygro-thermal, air quality and acoustic comfort.

Depending on the climate, the geographical situation and the local culture and habits, the notion of comfort can be very different.

Building designers need to have an accurate idea of what “comfort” means to the end-users of the building in order to design the building properly. Research was made on the comfort notion in different places, but some regions on the globe still miss this kind of initiative.

As a consequence, initial R&D on the notion of comfort could serve the purpose of energy efficiency.

Compactness

The Compactness of a building is measured using a ratio of surface area to volume. Designing a compact building is a way to reduce the energy need. By minimizing the ratio between surface and volume of a building, the heat exchange areas are reduced, and therefore also the energy losses, which is important when the building has to be artificially heated or cooled down.

But compactness should not be applied blindly, because the form of a building does not only have an impact on the energy losses, but also on daylight and ventilation. In case where natural ventilation should be favoured for cooling down the building, it would then be advisable to expend its volume.

Building shell

The building shell protects the user from external aggressions such as wind, solar radiation, noise and pollution, while it contributes to control inside temperature and humidity levels. But as a consequence, the building shell also blocks daylight, fresh outdoor air and keeps the internal gains inside.

Different energy streams are present in a building and influence each other: light, heating, cooling and ventilation. The mutual influence of these four streams can be illustrated by a simple example: a building entirely made of glass requires very few artificial lighting, but the heating or cooling need is enormous because the transmission coefficient of glass is very high. Therefore, it is important to think in terms of global energy concept to bring the four energy streams together and find the optimal balance between them to realize comfort.

The basic characteristic of a good building shell is good insulation to limit the heat transfers. In building construction, insulating materials are assigned a quantitative measure of the insulating efficiency based on the transmission coefficient, the so-called U-value. The choice of insulation type is not only determined by the U-value, which should be as low as possible. Other factors play an important role, such as availability of the material, affordability, toxicity, inflammability, but also airtightness.

Airtightness is the second very important characteristic of a good building shell. It is necessary to avoid uncontrolled air infiltration, because external turbulences may penetrate the building and cause unpleasant effects in environmental, financial and health terms. The extreme airtightness developed in passive building necessitates the use of mechanical ventilation.

9 | Compactness = V/S, where S is surface and V is volume.
TOWARDS ENERGY EFFICIENT BUILDINGS IN THE SOUTH

**Thermal mass**
Thermal mass is the ability of a material to absorb heat energy. A lot of heat energy is required to change the temperature of high-density materials like concrete and bricks. They are therefore said to have high thermal capacity. On the contrary, lightweight materials such as timber have low thermal mass. Appropriate use of thermal mass throughout a building can make a big difference to comfort and heating/cooling needs, in particular in places with a large diurnal temperature range. In a warm climate, thermal mass is used to defer the heat flow within the building by 10 to 12 hours, so that the building becomes warm at night, when it is possible to cool it down by natural ventilation.

In a cold climate, thermal mass is used to absorb heat during the day from direct sunlight or from radiant heaters. It re-radiates this warmth back into the home throughout the night. Of course, thermal resistance has to be well designed and adapted to the specific use of a building. For example, in buildings with high internal gains due to computers, lighting etc., thermal mass can become problematic because it keeps the warmth inside.

**Ventilation**
Ventilation is important to ensure a good indoor air quality, to regulate the temperature and evacuate internal gains. Various ventilation systems exist, some relying on natural supply and exhaust, other based on mechanical devices.

As a general rule, natural ventilation should be preferred in low-income countries, as it implies no maintenance and no energy consumption, while considering the fact that the air volume transmission is not constant. The context determines whether natural ventilation could be convenient or whether mechanical systems have to be implemented.

Some very successful traditional natural ventilation systems use the temperature stratification to increase ventilation, such as solar chimneys. Here, a vertical shaft utilizing solar energy enhances the natural stack ventilation through the building. The solar chimney consists of a black-painted chimney placed on the top of a building. During the day, solar energy heats the chimney and the air within it, creating an updraft of air in the chimney. The suction created at the chimney’s base can be used to ventilate and cool the building down.

This system was used in a passive school in Syria (see next page). Associated with heavy inertia materials and natural ventilation system, it enables the school to function without any active cooling system. Other traditional systems could be a source of inspiration such as wind catchers or low-energy evaporative cooling systems, developed during the old Persia times.

**Insulation position within the wall**
The position of the insulation towards the inside or the outside side of the wall depends on the specificity of the building.

Insulating from the outside enables to have a continuous building shell without thermal bridges, while keeping the thermal mass available inside the building, which is an asset in most cases. Also, the condensation point is kept closer to the external side of the walls.

Internal insulation is preferred in rehabilitation work because it is easier to implement without affecting the aesthetic of the façade. But it often leads to non-continuous insulation and to cold bridges.
A passive school in Damas

The French school in Damascus (Syria), built in 2008 and designed by French architects from Ateliers Lion, is a project illustrating how traditional techniques can be used to avoid unnecessary cooling/heating consumption. With 10,000 m² net floor area, the school can accommodate 900 pupils.

The school’s image
The designers wanted to show a certain restraint on the site, by erecting low buildings, using mainly traditional materials, respecting the site and taking account of its natural layout.

A garden
The arid site in the Mezze district was turned into a lush garden, which has a significant effect on local life. Various techniques were applied to establish the necessary microclimate.

- First, the existing trees on the site were preserved throughout the construction work.
- Second, local trees, such as ailanthus, jacarandas, Brazilian hollies, were used to form a canopy on patios. These species presents numerous advantages: They grow easily, do not require much water, are hardy in the Damascus climate and are inexpensive.
- Finally, drained rainwater from the site and from the building roofs is used for automatic watering.

A wide avenue crossing the site from north to south between the existing trees allows the pupils to circulate easily between the various classrooms along covered and open walkways. All the premises, especially the classrooms are situated close to patios full of vegetation. The patios are covered with shading cloth in addition to the trees and shrubs.
**Sustainable development and materials**

Instead of using sophisticated technology, the designer made extensive use of traditional features from hot Mediterranean countries, i.e. permanent active ventilation for buildings that are well-protected from the sun and designed with high-level inertia.

The walls consist of a double skin separated by a 5 cm air gap. The outside shell is made of 20 cm hollow concrete blocks; while the inside skin consists of 10 cm solid concrete blocks. During the day, the double skin absorbs the heat. This is released during night time and rejected from the building thanks to the ventilation. Combined with double-glazing, this system provides good inertia to the building.

To avoid overheating, the concrete roofs are constantly ventilated through a 25 cm ventilated air gap. In the premises, air renewal is achieved through naturally ventilated air, which is also used as a cooling system in the summer. The west walls of the classrooms are equipped with two gratings that can be opened or shut down manually.

The fresh air gets in the classes through the bottom grating. In summer, the fresh air is cooled down first by the shadow of the trees and the shading cloth covering the patios, and in second instance by passing through pipes winding in the slab of the ground floor.

The vitiated air is exhausted through the upper rating thanks to solar chimneys: a dark metallic plate situated on the top of a shaft is heated by the sun, which moves the air upwards and creates a natural draught.

The inertia of the building created by thermal mass, the controlled solar power and the garden creating a microclimate are all part of the response to the need for climatic comfort.
FROM VERNACULAR TO HIGH-TECH

Traditional architecture contains elements of sustainable design due to its dependence on available resources and local technologies, while respecting the local climatic constraints.

The appearance of technology, cheap and accessible fossil energy sources, and new materials have modified the way buildings solve our comfort requirements. This is why “sustainable design is not a recent concept; it is a recently lost one.”

Today, an interesting approach is to make the best of the past by going back to traditional architecture, and at the same time, turn to the future by using new technologies to solve remaining problems inherent to these buildings – such as moisture for example. This twofold approach minimizes environmental impacts and further improves comfort and performance of the traditional buildings.

In some places, the vernacular know-how is still available but not documented. Therefore, it is interesting to meet local labour and learn how they built in the past. Vernacular architecture is usually based on local material with very low embodied energy, and offers low-tech, cheap and adapted solutions to the specific climate.

Some successful building projects in the South were based on traditional architecture. But more initiatives could be taken in that field. Partnerships with universities could be a way to generalize the process of documentation of the vernacular knowledge. A good documentation is indeed an important step to encourage South-South transfer of knowledge and experience.

Traditional construction techniques, like adobe, have also been a source of inspiration for developing more appropriate technologies, such as the interlocking blocks. Appropriate technology, a term initiated in Schumacher’s book “Small is beautiful”, describes the use of technology and engineering that results in less negative impacts on the environment and society.

The use of more elaborate technologies should not be rejected, as long as they remain cost-efficient. The use of photovoltaic panels in sunny countries where electricity is not available or is expensive is a good example, as well as computer simulation tools that are required to integrate a large number of parameters to consider when developing low-tech energy efficient buildings.

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School based on traditional architecture in Afghanistan

Within the Basic Education Programme Afghanistan, the Joint Venture Grontmij BGS – archis is consultant for the design and supervision of construction and/or rehabilitation and extension of Teacher Training Centres and Reference Schools under a KfW program.

The basic education project includes accompanying measures to reach sustainability at teacher training colleges and reference schools. The Improved Traditional School (ITS) building concept emerged as a part of the training since it became urgent to reflect on how to repair and improve traditional constructions to meet the extremely urgent demand for classrooms.

Combining traditional construction methods with reasonable improvements applying some modern features brings a very good performance – cost ratio.

Widely used mudstones and other local material are ecological and create jobs in traditional crafts.

The size of a classroom is 32.88 m² and suitable for 30 regular students, with a peak capacity of 45. The cost per square meter of the total net area is 182.48 USD.

The construction uses local material and technologies for the foundations (random rubble stone), the walls (mud bricks), the roof slab (traditional wooden beam and mud construction) and for the roof structure (local round wood). Only a few long span beams and columns are imported sawn wood.

Earthquake safety is achieved by shear walls and concrete bands and vertical bars in the corners. Only the borders of the large combined door and window openings have concrete columns.

Climatic comfort is achieved by orienting the large window opening southward and by using tick walls (time lack and buffer) and a ventilated roof space above the ceiling.

Typical mud construction problems are avoided: the high stone masonry protects the building from outside water and melting snow, the metal roof makes the building tight and the weak mud walls are protected by the inner masonry sill.

The execution is suitable for remote areas as only village-based technology is needed and some special items like the earthquake bands could be introduced by trained foremen. There is not much to transport, as the building contains little steel and cement, so there is even no major danger of misuse or substandard work. Through applied village level technologies, self-help components and possible financing from outside, most of the funds will stay in the village and create jobs.
Cradle to Cradle® design

The Cradle to Cradle® (C2C) concept was developed by Prof. Dr. Michael Braungart and William McDonough. It is based on the idea of fully recyclable products.

C2C promotes a global view on the problem of sustainability, and makes a direct link between the building and all existent systems.

It is guided by nature. In nature all things are products of a metabolic process and useful for other processes. Leaves of a tree are nutrients for the tree itself and other plants. Among leaves there are places to hide for mice or to hibernate for hedgehogs. Every product, no matter how useless it may seem, is beneficial in nature.

Products designed according to the Cradle to Cradle® design concept work exactly the same way. Therefore they are an important answer to the most urgent challenges of our times. They envisage their redesign into circular nutrient cycles in which value, once created, remains of worth to both man and nature. They are part of the lifecycle.

A shirt for example, whose production processes contain only eco-friendly components and which is biodegradable, can simply be composted and is a biological nutrient. Materials can also rotate in technical nutrient cycles. Designed in a way that they can be disassembled, every carefully chosen material can be a follow-up product in a technical nutrient cycle. Thinking in these new ways of design, every television set or every washing machine can be reborn as a new apparatus.

The Cradle to Cradle® design concept is based on three innovative principles:
- Everything is designed to be a nutrient of something else (waste = food)
- Everything is produced by renewable energy from current solar income
- Everything contributes to diversity - be it conceptual, cultural or biological

Concrete examples of building designed following the Cradle to Cradle® concept prove the benefit of this way of thinking. In Addis Abeba (Ethiopia), a project called “Urban Cloud” designed by Synergy International and Art & Built intended to go for an energy efficient building with minimal impact on the direct and global environment. Here, the building frame was made of Eucalyptus laminated beams. As we know, eucalyptus is an invasive plant, often supplanting indigenous vegetation where it grows. In the above-mentioned project, eucalyptus is used as local building material, the production is based on local labour and indigenous vegetation is planted to replace eucalyptus... A good example of sustainability from environmental, socio-economic and biodiversity points of view!
CAPE VERDE ISLANDS: A HIGH POTENTIAL FOR RENEWABLE ENERGY

The Republic of Cape Verde is an archipelago composed of 10 islands with a total surface of 4,000 km². 7 of the islands are home to Cape Verde’s 500,000 inhabitants. The economy is basically a service economy, with tourism playing a major role.

The country still experiences serious difficulties with social and economic development. The lack of natural resources (oil, mineral ore, water) and an incipient industrial sector makes the economy highly dependent on services and ultimately human resources.

The energy supply is also an important challenge to overcome. Consumption of electricity is growing fast (+3.6% in the last 5 years) and despite the fact that the generation capacity is also growing (+6% in last 5 years), 97% of electricity used in the country is generated from imported fossil fuels. The share of renewable sources is still very low (3% wind in 2010) but the country targets an ambitious expansion. The expectation is to provide 25% of the electricity from renewable sources by 2011 and 50% by 2020. Also the plan foresees 100% of electricity from renewable sources in at least one island by 2020.

In the perspective of a significant growth of this industry and the sustained growth required in the services sector, the lack of skilled human resources, and in particular middle-level professionals and managers, represents an important risk to the country’s development.

The support from the Grand-Duché du Luxembourg, tries to address this issue through the support of the vocational sector in the country.

THE CHALLENGE: DESIGNING A NEW “ENERGY-FRIENDLY” BUILDING

By mid 2010, as part of the project “Support to the national programme on employment and technical education & vocational training (TEVT)”, the Institute for Employment and Vocational Training (IEFP) of Cape Verde and Lux-Development launched a design competition for the building that would host the future Centre for Vocational Training on Renewable Energies & Industrial Maintenance, which is to be built in the city of Praia, the capital of the Republic of Cape Verde.

The competition brief was established after extensive consultation with future users of the building, as well as experts in the fields of vocational training, archi-
DEVELOPMENT, A MATTER OF ENERGY

tecture and engineering (technical equipment, energy-efficiency, renewable energy sources...). The brief also outlined the environmental concerns that were to be respected during the design phases.

Consortiums formed by design companies officially registered in Cape Verde and Luxembourg were invited to participate. The mandatory consortium was to be composed by companies that could provide designers and “energy-efficiency” and “renewable-energies” engineers. The design process started in the beginning of 2011.

AN INNOVATIVE CONCEPT

The building consists of three blocks built around a central atrium. A fourth block, not linked to the atrium, completes the training complex. The setting sought by the authors was outdoor nature, covered on the ground floor by a large curved roof to link the distribution and lounge functions. From the central atrium, a ramp and stairway connect the ground floor to a distribution balcony on the first floor.

Each of the blocks has two floors and hosts specific functions. Each one is physically differentiated:
- Block A regroups the administrative services on the ground floor and teaching facilities on the first floor;
- Block B is devoted to a conference room and IT workshops;
- Block C includes workshops, a warehouse for educational material and the technical areas, including the control panel for the energy system.

The designers paid attention to the pedagogical function of the building. The designers have also looked at other aspects that could contribute to the vocational training objective, among which we highlight the renewable energies devices that allow the building to partially produce its own energy.

In addition to the equipment of the workshops, these devices are available for demonstration and training and allow for investigation and performance studies in real time. Screens positioned in the central atrium will expose collected data in the different devices and allow for the building users - and students - to monitor its performance. The overall design of the building had to face a number of constraints and promote environmental alternatives.

Building site location

The building site is situated on the outskirts of the city of Praia, and is adjacent to the first PV field of the city. The land is clear and on average 60 meters above sealevel. The plot presents its greatest length in East-West orientation.

The volcanic nature of Santiago Island soil and its predictable “waterproof” characteristics are visible in water drainage lines that occur throughout the island.
Fairly parallel to the main access road, a water drainage line was preserved and conditioned the building design, namely the position in the plot and accesses. Maintaining the drainage line was key to minimize the impact that could result from erosion caused by storm water.

**Solar passive strategies**

The primary concern of the design team was to produce a building that consumes less energy than traditional buildings and uses alternative energy resources for construction and throughout its lifespan. The building is to be a low-energy building.

Therefore, a comprehensive study on the optimal positioning of the building was conducted to take advantage of the topography, sun exposure and dominant winds. Natural ventilation (using dominant winds from the northeast), passive solar architecture, thermal insulation and shading of the building’s outer shell were at the basis of the concept.

The curved roof that covers all blocks and the central atrium act as a protection against solar rays, shading the blocks as much as possible during the day. The facades that are exposed directly to the sun are equipped with thermal insulation. The effect of natural ventilation throughout the building, taking advantage of the existence of regular northeast winds, also contributes to reducing energy requirements for cooling.

**Low-energy building**

Improving the efficiency of cooling devices contributes to reducing energy consumption during building use. Mechanical cooling is installed in the library, administration area, conference room, training room and computer and drawing rooms. An absorption system for air-conditioning powered by solar heated water will cool these areas. By and large, parabolic solar concentrators for water heating cover 250 m² of surface in this system.

Moreover, regulators and photo sensors are installed in the common areas of the building to restrict the use of energy for lighting. Efficient bulbs like T5 and LEDs will be installed according to the needs. Large windows and skylights protected from direct sunlight will provide natural lighting during the day.

The concern of the design team was also to use alternative resources, namely sun and wind, which could easily be exploited in Cape Verde, to provide energy to the building.

The national power network, after recent adaptation of the legislation concerning feed-in schemes and tariffs, can be used as a buffer, allowing to feed-in energy produced by the renewable systems and consuming energy whenever required. The final aim is to achieve a balance between the energy used and produced. The production limit is set at 60% by local regulation.
The adapted legislation also allowed for reducing the investment since almost no batteries are required to ensure energy supply during periods when energy generation is below consumption levels. The Centre will have just a few batteries for training and for back-up of computers.

As buildings have a relatively long lifespan, in most cases CO₂ emissions result mainly from energy consumed during building-use. Buildings still consume more than half of their energy during operations, and thus Operations & Maintenance definitely constitute the greatest environmental impact that needs to be taken care of. Therefore, the first priority of the design team was to focus on the greatest possible reduction of the energy requirements of the buildings during use. Throughout the design process the team focused on obtaining a low-energy building.

(Eco) materials and building sustainability

Once the operational energy is reduced at maximum, the choice of low-impact materials was in the forefront of the concerns. The aim was to choose low-impact construction materials as much as possible. The impact of materials was analysed separately and as a whole.

The design team, whenever possible, has prescribed environmentally friendly construction materials. Low-polluting, recyclable, reusable and low-waste generation materials were to be studied and inform the choice of the building technologies and materials. The main aspects that have been taken into account in the selection of materials are:

- Impact of production material: habitat destruction, toxins released;
- Risks to health or to the local environment, during the construction and use;
- Lifetime of the material;
- Reduction/waste segregation and reduction of production and disposal of toxic waste;
- Nature of the resources involved: renewable or scarce non-renewable or abundant;
- CO₂ emissions (in Kg) during production or, in case the information is available, the embodied energy (in kWh/Kg);

The environmental impact of the transport of the materials is naturally a cause of concern. In this case, this concern is amplified given the near absence of construction materials produced on the islands of Cape Verde. In the case of islands, the means of transport used in the import of materials is the sea, which several studies consider to have the lowest environmental impact. Moreover, the materials chosen such as concrete blocks for exterior and interior walls or reinforced concrete for structural elements meet acceptable conditions of sustainability because most of the components required are manufactured and applied locally. For the same reason staining concrete was selected to cover the largest area possible of interior floor.

Wood laminated structures, fibro-cement panels, agglomerated cork panels, as well as other industrialized building components were chosen, ensuring the absence of waste not only during construction but
also in its manufacturing stage whereas material use is highly controlled. Detailed design and specifications, as well as detailed tracing of the components, have been prioritised in order to reduce the waste produced during construction and the pollution effects that these components could generate in Cape Verde, where no recycling or adequate waste disposal exists.

**Water management**
The building uses systems of grey water treatment and storage for later use in irrigation. Since the area is not equipped with a public wastewater network, a compact water treatment station will collect and treat wastewater from the building also to be reused for irrigation.

**LESSONS LEARNED**

**Careful selection of environmental criteria**
Environmental criteria were successfully used to evaluate design teams. Even though sustainable buildings are the result of a complex and delicate trade-off between diverging environmental concerns - comfort, health, energy and carbon intensity, materials & resources, dependence from non-renewables etc. - selection criteria can be chosen with regards to environmental priorities or the significance of potential future impacts (e.g. water savings and harvesting in drought prone areas). The elements requested through the competitive tender (drawings, texts, etc.) were adapted accordingly to enable an informed evaluation.

Design teams were invited to integrate environmental constraints in their internal processes and asked to provide a life-cycle building design, optimising energy and water consumption, choosing the materials used carefully and taking into account maintenance needs.

**Green building site specifications**
At the construction stage, it is often too late to address sustainable measures. However, the construction site itself might be polluted and result in damage to the environment. Bidders were asked to conform to the green building site specifications as elaborated.

The Cape Verde experience shows this requirement does not discourage companies from bidding. Actual implementation of the green building site specifications will depend on the company’s internal capacities and organisation, as well as on the existence of external waste treatment facilities. Constraints for building companies regarding separation, reuse, recycling, and disposal of construction and demolition waste need to be adapted to the local reality; for instance, the existence of efficient treatment and disposal options for the produced waste.

**Building local green competences**
Proper planning and detailed design briefs, design teams selected on the basis of their environmental competences, solid supervision during the design and construction phases and building companies engaged in reducing their potential negative impacts on the environment are some building blocks for delivering more sustainable, climate-proof, eco-friendly buildings in low-income countries.
RECOMMENDATIONS

Many challenges are emerging for development agencies with regards to low carbon development. The first challenge is for northern society to accept our responsibility, do more to communicate about global warming and fight for mitigation. The second challenge is to mainstream and adapt the tools and management strategies. Finally, the role of development agencies is to mitigate the low speed of international mechanisms, show the way and reinforce local competences.

1 Strong commitment

Promoting energy efficiency in buildings and renewable energy implies mentality and behavioural changes. To that end, a resolute political commitment of development actors is necessary.

Energy efficiency promotion should not be limited to communication activities. It requires a continuous effort, and must be translated in concrete actions in all projects. In order to be coherent, the energy efficiency strategy should concern all services and activities realised in the cooperation framework. Energy management could for instance be included as part of the environmental dimension tackled as a cross-cutting issue in the project design and at every step of the project’s cycle. Mainstreaming the environment can therefore be translated in a very concrete and operational manner, including budgets, indicators, training sessions related to energy use in the programmes supported by donors.

2 Awareness raising

The implementation of energy efficiency and the use of renewable energies generally involve high upfront investments, which are paid off after a long period through savings on the energy bill. The sometime long payback period looks unappealing to most local authorities, which rarely buy fossil energy at the real price and are often impervious to the climate change issue, whatever their official standpoint might be. As a consequence, the budget that they could spend for energy efficiency and renewable energy is frequently allocated to other ‘classical’ investments. The national legal frameworks represent another major barrier to the implementation of any energy efficiency initiative, when no clear strategy on the development of a low carbon economy is foreseen.

To overcome these obstacles, substantial awareness raising should be carried out with all partners, ranging from political to end-user levels. To this end, it is necessary that the development agencies grant additional funds, which would be used to promote renewable energy sources, demonstrate their efficiency and support technological research and innovation applied to Southern countries.

3 Exchange platform and development of tools

There is a clear need from the partners in developing countries to enhance the South-South transfers, that is to say, to capitalize the knowledge gathered through field experience between actors who are working in similar environments and climates.

Based on that acknowledgment, the creation of a platform among donor agencies aiming at experience exchanges, events organisation and the specific development of tools should be initiated.

The platform would gather and communicate about projects promoting energy efficiency and renewable energy. These projects are not so numerous yet, but the platform could promote their development.
The platform could support the organisation of events organised on a regular basis, like seminars, debates, conferences and training sessions on specific subjects. It could also be a way to disseminate, promote and finance a series of tools. The first identified tool to be developed is a green tendering procedure for buildings and equipment supply.

A further foreseen action is the drafting of guidelines on best practices in the field of eco-construction. The guidelines will be based on the analysis of vernacular architecture and summarize in a very practical way the existing work. At least three climate types should be covered in first instance, namely Mediterranean climate (Palestine, Morocco, Algeria...), tropical humid climate (Democratic Republic of Congo, Mozambique, Benin, Vietnam...) and tropical altitude climate (East region of Democratic Republic of Congo, Rwanda, Burundi). The guidelines would aim at promoting thermal comfort for the end-users of various buildings constructed by development agencies thanks to adapted “low-tech” principles and to the use of renewable energies. This tool would enable designers to avoid obvious mistakes during the starting phase of a project, even when time-pressure to use the allocated budget is high. The objective of such guidelines is also to tackle the legal and normative framework in which this type of architecture could bloom.

A third tool to be developed is an energy audit procedure for local offices and projects abroad. Such a tool would help the different actors on the field, such as the representation of the donor agencies or partners headquarters, to evaluate the weaknesses of their office building in term of energy efficiency and to define a long-term investment plan with the owner to conduct the necessary works.

**4 Research, action, training**

Renewable energies and passive or low energy buildings are often assimilated to ‘high tech’ devices, which were initially designed for emergent or industrialized countries, where these markets generate the most benefit. The transfer of such technologies to the South is not optimal. The latter need simple technologies, which are less expensive and more robust. However, the so-called “appropriate” or “low-tech” technologies are generally not the first choice in these countries. Yet, to be efficient, the low-tech solutions require advanced assessment, among others via simulation software, which is currently not readily available. Some of that software might be free, but its use is bound to a training session.

It is therefore necessary to initiate Research & Development dynamics with universities and consultants to promote appropriate technologies in BTC partner countries, but also to study the lifecycle of specific materials that can be used in the context of “cradle to cradle” concept.

The applied research could be carried out in the scope of framework agreements between donors’ projects/programmes and North-South inter-university consortia. On that basis, specific topics, such as photovoltaic installations with batteries, ground-coupled heat exchangers and solar chimneys, could be identified for training or action initiatives. Players like Train4Dev or the above-mentioned platform could support such actions.
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