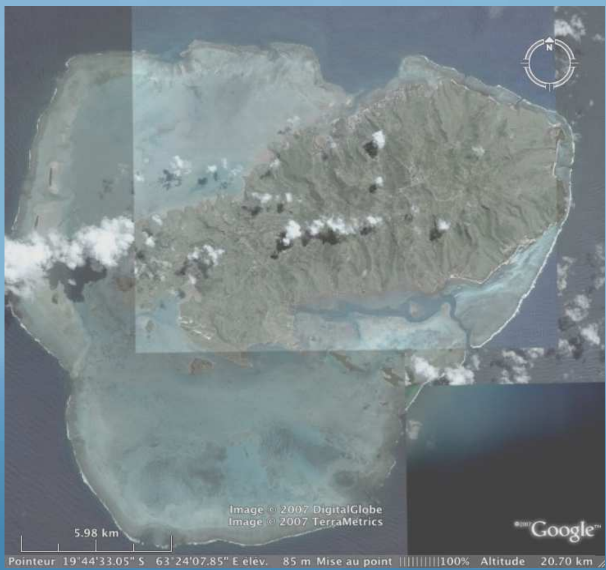
Republic of Mauritius

Regional Assembly of Rodrigues



Electricity Energy self-sufficiency strategy for Rodrigues, security supply, Sustainable Development and Climate Change,

100% Renewable energy - 2007-2012-2020

Energy at the heart of sustainable development and water management

« Review Climate Change Policies In View Of Energy and Water Security Implications »

"Rodrigues Island of Nature, Sun and Wind!"

La Reunion Island's Regional Energy Agency – http://www.arer.org

Contents

Figure 1: The "Grand Passe" of Port Sud Est

SUMMARY FOR POLICYMAKERS

Confronted to Climate Change, the topic of energy and water security is a key factor for our islands: they are very exposed and must prepare themselves for this climate change, rapidly and thoroughly.

Climate Change is a scientifically recognised global phenomenon. *In terms of energy and sustainable development, our islands are very vulnerable, with a range of phenomena already present and which are likely to continue. Sustainable development and climate change are interdependent. We need to reduce greenhouse gas emissions. That means a transfer to energy systems with no greenhouse gas emissions. The cost and the end of fossil reserves are determining factors in global economic instability, and therefore in energy security of our islands. Limited oil reserves and concentration of oil reserves conduct to high prices oil and degradated islands economic systems. The global context of forestry and reforestation for climate change is another key point in Capture and storage of carbon, as for resisting against climate change. Strategies for energy and water self-sufficiency as a solution to climate change need to be carefully and extensively explored.*

Therefore, all islands in Indian Ocean are currently experiencing a large rise in their energy dependency on fossil fuels, despite all their enormous reserves of renewable energies*. Projects are in place on each of the islands, and we now need to pool our resources and our knowledge and develop a very ambitious regional policy. Madagascar "La Grande Ile", could become a global leader example in the transition to 100% renewable energy and thus preserve its oil reserves for worthy uses over the mid and long-term. Developing renewable energies on a large scale and for all islands in Indian Ocean is an ambitious and indispensable programme to implement with the IOC and governments of the Indian Ocean region. The context and cooperation of islands, the why and how of developing cooperation for islands' strategies of energy self-sufficiency up to 2050, mobilize ONERC and the I.O.C. in the Indian Ocean to adopt multilateral programmes, as well as ARER/Island Natural Energy Way's S toward selfsufficiency, to work towards reductions greenhouse gas emissions. Proposals promote a multi-lateral programme for IOC and Island NEWS "Programme Strategy for energy self-sufficiency to mitigate climate change". Bilateral agreements of cooperation must also be organised.*

Within what framework and in what form could this bilateral cooperation about energy and climate change be developed with Rodrigues*? Regional cooperation between Rodrigues and Reunion for secure energy and water supply and preparations for climate change, could be engaged between Regional Assembly of Rodrigues, ARER, Island-NEWS, Natural Energy Ways towards Self-sufficiency and the governments of France and Mauritius. To initiate the process, a technical conference for "Energy self-sufficiency for Rodrigues with zero greenhouse gas emissions" was held in October 2007, under the impulsion of Paul VERGES and Johnson ROUSSETTY and organised by the Regional Assembly of Rodrigues with the technical support of ARER.*

The main conclusions of the project design is that Rodrigues Island can technically promote a strategy of energy security and self-sufficiency 2007-2010 – 2015-2020 using 100% Renewable electricity.

Renewable resources can sustain all the future need in electricity*: Hydro energy and micro hydraulic can be used for water distribution, storage of wind energy, desalination. Energy from ocean swell and hydro energy currents are long-term resource to be investigated. Thermal energy from oceans has real potential for future water supply and a diverse economic sector which is to be studied. Wind energy is a major resource in short-term energy strategies. Biomass is a major energy source, an important economic sector and a crucial area for Rodrigues to adapt to climate change. Biomass needs a plan of potential actions for short term implementation, with the aim of preparing the island for climate change, a specific organisation of key players, an economic plan, an essential short-term monitoring of land usage. Solar energy in the short-term plan is for solar powered water heaters for tourist sector, individual housing sector to be evaluated. Solar photovoltaic is for specific uses. Non-consumed energy and energy management present significant short term potential, profitable and easy to implement. Energy storage technologies for Rodrigues' energy self-sufficiency, as Vanadium batteries or Hydraulic storage, as well as Technology for electricity storage potential are to be scheduled with strong partnership.*

Integrating those renewable systems in planning territory, urbanism and building *: Improving ecological performances of building constructions, houses, gites, inns, hotels, schools and public buildings is a first stage, including guides and audits.*

There is important interaction between energy, water and agricultural/forestry issues, between windpower production, seawater desalination and water distribution management. An ecological and environmental industrial park could be developed on a key site: Grenade. Of course, possible supply scenaries for 2007-2025-2050 are according to the present analysis. The needs and energy for transports have not been explored.

Integration solutions for land management, building, agriculture and forest management are to be arbitrated. Frequent information actions, sensitization and communication with citizens and key players on the running policy and its progress, must be managed.

Reforestation and biomass development is considered as a mutiple economic sector and a key action to prepare the island to climate change. The story of reforestation in Rodrigues has implanted a real know-how there, means and a precious wood capital to be sustainably managed, with the assistance of the Rodrigues Regional Assembly forestry department. A private initiative for the reforestation of endemic plants capitalizes the acquired experience: the Anse Quittor tourist park. Some of the species represent a problem for water resources. The surface area at stake, reforestation potential, wood availability, today's means, priorities. « Priorities must be set for land management policy: particularly reforesting against climate change » - dixit the symposium participants.

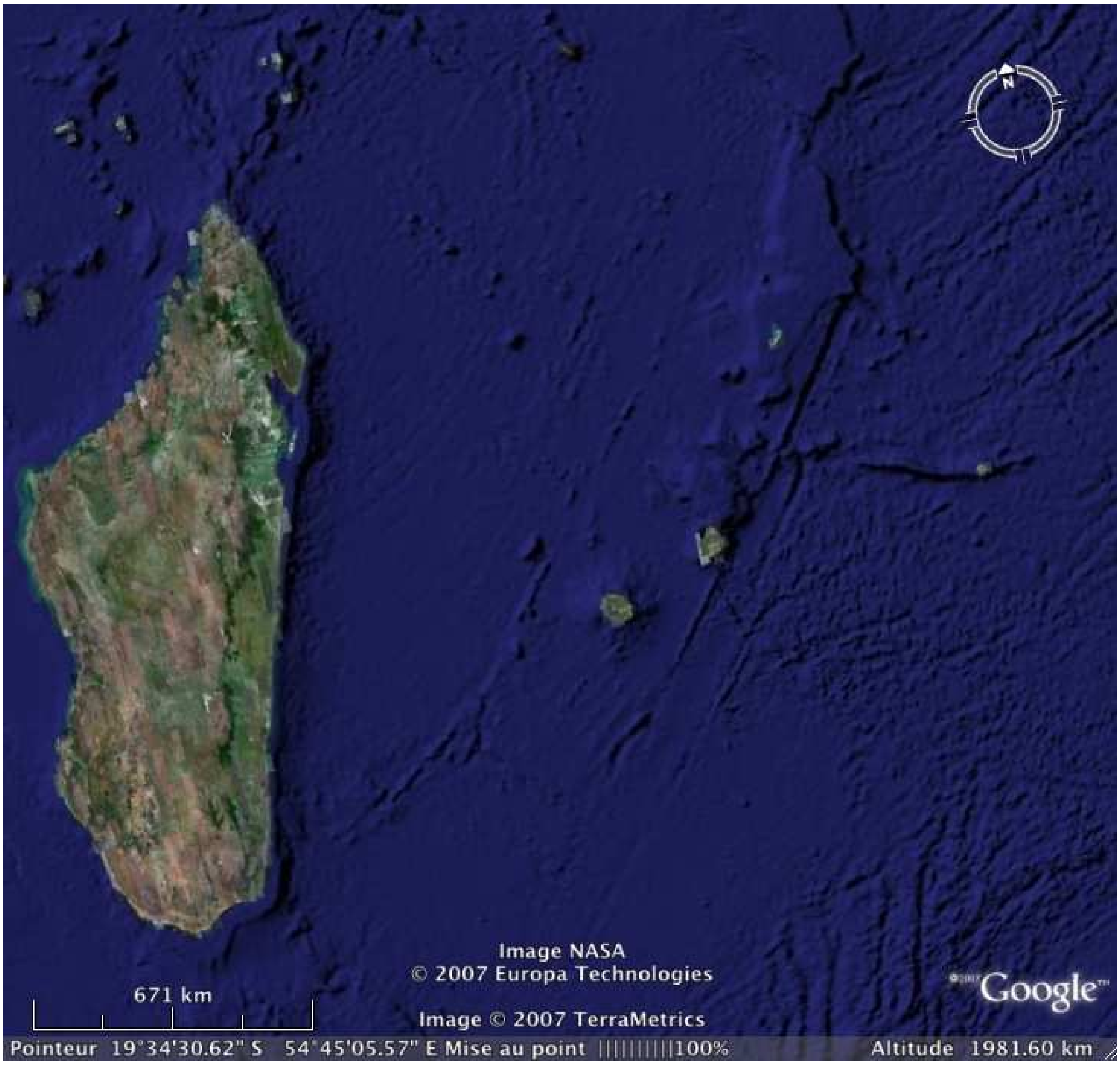
Rodrigues Island now entails political, technical and land management choices: « How can some order be brought and how can the sharing process be carried out regarding pastures, forests and agricultural lands? ». Various scenarios are standing out, the functions of the decisions to be taken, for diversifying and reinforcing the means. An economic activity of existing wood cutting and transformation is necessary. Energy wood for gasification is a real opportunity. In what ways can the biomass policy become an operational programme fighting against climate change? Synthetic presentation of the global action programme to be set up in details in a future specific technical meeting with Rodriguan experts. The Territory management project needs to organize a programming meeting to integrate this plan into the Rogriguan territory management programme.

Tools, human resources and financial support organize the mobilisation of the Rodriguan and international key players, *as a strategic, technical and organisational energy politic. Investment costs and exploitation costs are compared in the way of 100%Renewable to GES assessment and global planning. A chapter examine how speed up the local, national and international financing as Clean Development Mechanism and carbon credits.*

This is a necessary first step for a long way through climate change.

I / Climate change - energy and water security - our islands are very vulnerable

Figure 2: Satellite image of Indian Ocean

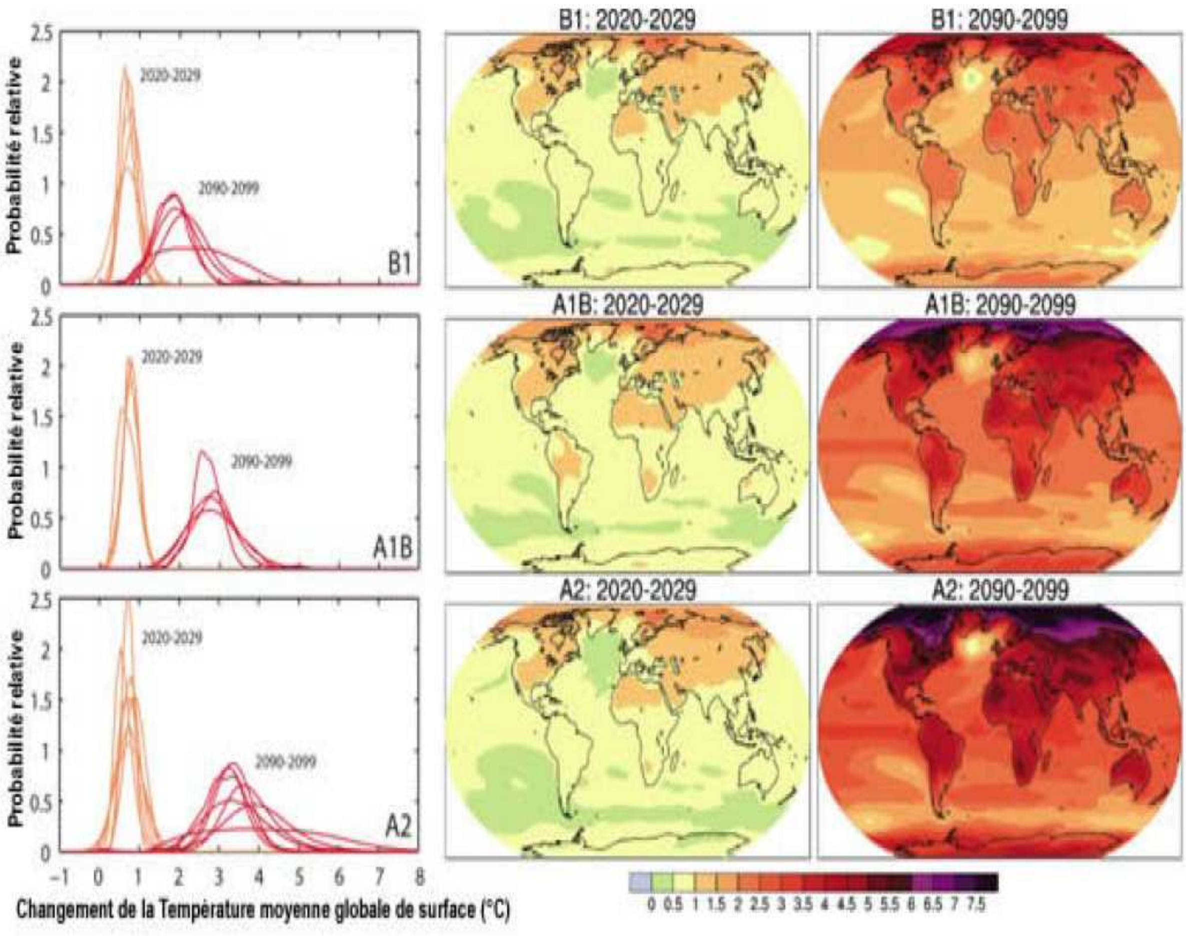


Our islands must prepare for climate change rapidly and thoroughly

Climate change is a scientifically recognised global phenomenon

The Intergovernmental Panel for Climate Change (IPCC) works as a network and produces reports which inform decisions that govern the planet. The reports from 2007 are scientifically rigorous and highlight a serious phenomenon.

Figure 3: Change in average global temperature - source IPCC Report 2007



The seriousness of this phenomenon is clear: current global carbon dioxide, methane and nitrogen oxide levels have risen significantly due to human activity since 1750 and are now far beyond the pre-industrial levels established through the study of ice caps which are several thousand years old (see figure SPM-1). The increase in carbon dioxide is mainly due to fossil fuels and changes in land use, whereas methane and nitrogen oxide levels are mainly due to agriculture. Global warming is unequivocal: proof can be found in observations of increases in average global sea and air temperatures; the melting of snow and ice and the rise in the average global sea-level.

In terms of energy, sustainable development and climate change, our islands are very vulnerable, with a range of phenomena already present and which are likely to continue

Table 1: Range of Climate change phenomena (IPCC)

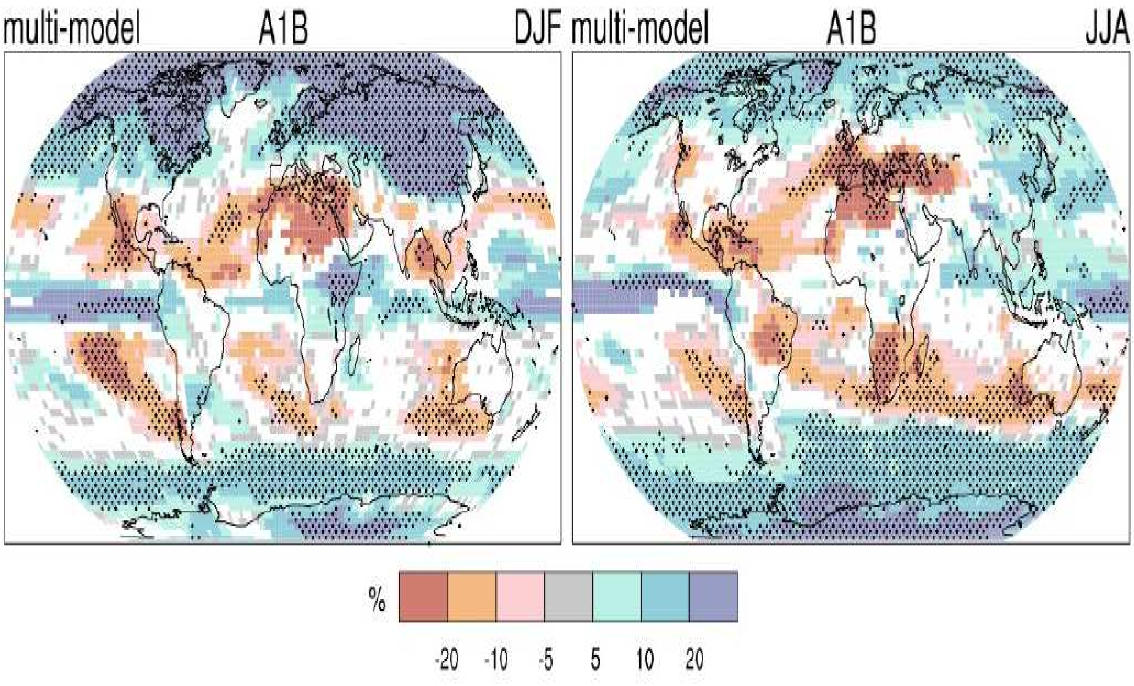
Phenomenon[a] and direction of trend	Likelihood that trend occurred in late 20th century (typically post 1960)	Likelihood of discernible human influence on observed trend	Likelihood of continuation of trend based on projections for 21st century using SRES scenarios.
Warmer/fewer cold days/nights over most land areas.	*Very likely*[b]	*Likely*[d]	*Virtually certain*[d]
Warmer/more hot days/nights over most land areas.	*Very likely*[c]	*Likely (nights)*[d]	*Virtually certain*[d]
Warm spells / heat waves. Frequency increases over most land areas.	*Likely*	*More likely than not*	*Very likely*
Heavy precipitation events. Frequency (or proportion of total rainfall from heavy falls) increases over most areas.	*Likely*	*More likely than not*	*Very likely*
Area affected by droughts increases.	*Likely* in many regions since 1970s	*More likely than not*	*Likely*
Number of intense tropical cyclones increases.	*Likely*, since 1970	*More likely than not*	*Likely*
Increased incidence of extreme high sea level (excludes tsunamis).	*Likely*	*More likely than not*	*Likely*

Notes:
(a) See Table 3.7 for definitions
(b) Decreased frequency of cold days/nights (coldest 10%)
(c) Increased frequency of hot days/nights (hottest 10%)
(d) Warming of the most extreme days/nights each year

Source: IPPC

On a continental scale, and for regions and oceanic basins, several long term changes in the climate have been observed. These include changes in the temperature of arctic ice, widespread changes in precipitation, ocean salinity, wind structures and extreme weather conditions such as droughts, heavy precipitations and heat waves.

Figure 4: Model of change in rain patterns

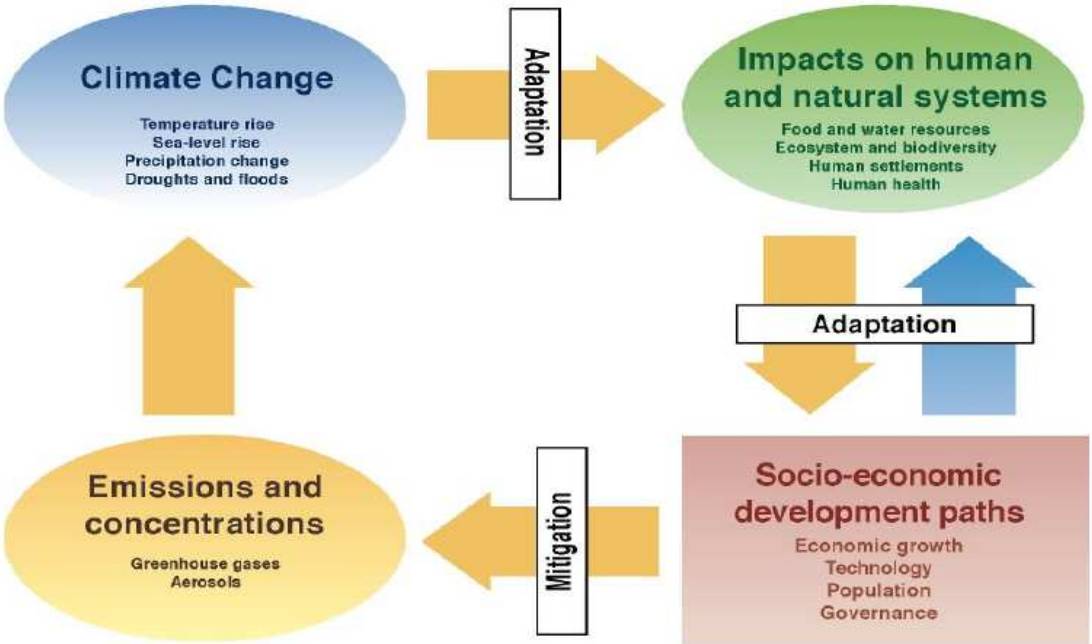


Source: IPCC

We can now identify human influences in other aspects of the climate, such as oceans warming up, higher average land temperatures, extreme temperatures and changes in wind patterns.

Sustainable development and climate change are interdependent

Figure 5: synoptic CC/DD - WG3 - WG2 IPPC -February 2005 Saint Denis Reunion



The impact of climate change on the islands of the Indian Ocean will continue to increase. From citizens to the highest level of State governance, everybody must act.

Sustainable development amongst insulated societies is only meaningful if it takes into account the immediacy of climate change, considers the capacity of adaptation of human societies to this serious phenomenon and works towards for a reduction in greenhouse gas emissions (see the 2007 GIEC report). The majority of Indian Ocean islands do not currently have an operational strategy of greenhouse gas emission reductions, even though these islands have considerable renewable energy resources. We must make it a priority to continually mobilise Presidents, Ministers and actors in economic and civil society, because sustainable development is not possible without a stable energy system.

Reducing greenhouse gas emissions means a transfer to energy systems with no greenhouse gas emissions

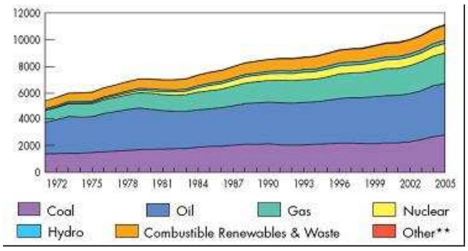
The trends in greenhouse gas emissions (GHG) are proven. Short and mid-term reductions are identified for each sector (up to 2030). Long-term reduction (after 2030) is to be planned. The policies, monitoring and tools are to be implemented. Sustainable development and reduction in climate change are inter-linked. Knowledge gaps exist, especially with regard to the inter-tropical belt. The project for Rodrigues can be used as a foundation for the IPCC and other islands on the inter-tropical belt.

The cost and the end of fossil reserves are determining factors in global economic instability, and therefore in energy security of our islands

Beyond the problems linked to climate change, the current energy situation is not sustainable because it is largely dependent on non-renewable natural resources.[1]

[1] International Energy Agency (IEA), Key World Energy Statistics 2007, website: http://www.iea.org

Figure 6: Evolution between 1971 and 2005 of global energy supply IEA



In 2005 global energy consumption reached 11,435 millions of tons of oil equivalent with the following distribution:

- oil : 35,0%
- coal : 25,3%
- natural gas : 20,7%
- nuclear and renewable : 19%

Regarding oil, which represents nearly all the energy supply of Rodrigues, there are limited reserves which are concentrated in a geo-politically unstable area with high volatile prices.

Limited oil reserves

Proven oil reserves[2] are currently estimated at around 1,317 billion barrels[3], at 1st January 2007, compared to an oil demand in 2007 of 31.4 billion barrels.[4] Proven reserves represent the equivalent of 42 years of supply, based on 2007 figures.

It is useful to describe at this point three phenomena which influence how long reserves will last:

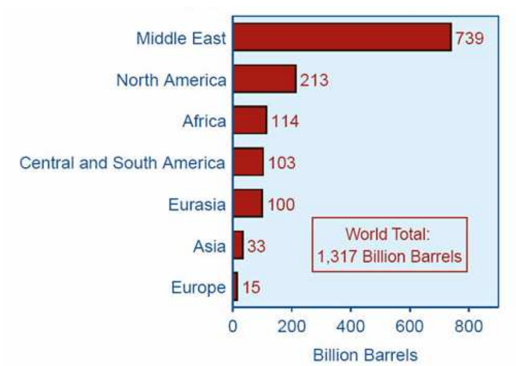
- improvements in economic and technical conditions necessary for oil exploitation, especially regarding price increases
- the discovery of new reserves
- the growth in global consumption

The first two phenomena will increase the amount of proven reserves whereas the third will reduce them.

Concentration of oil reserves

Beyond their life length, oil reserves are particular due to their concentration in one world region, the Middle East, and are under the control of one organisation, the Organisation of Petroleum Exporting Countries (OPEC) (6).

Figure 7: Global proven reserves, 1st January 2007



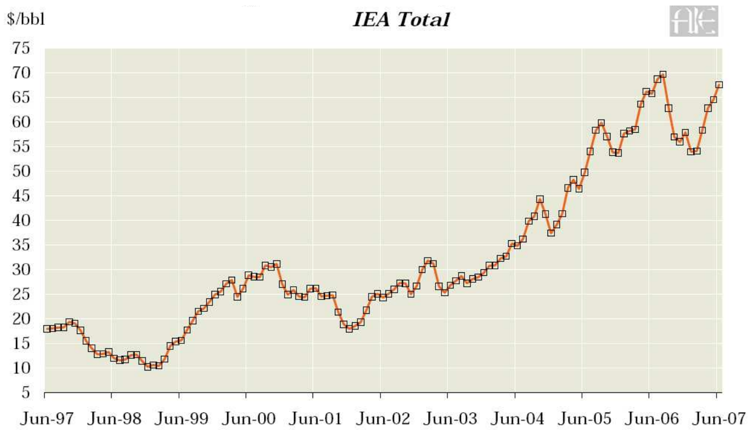
[2]Proven reserves are those defines as identifired reserves whcih are exploitable under curent economic and techincal conditions.
[3] "Worldwide Look at Reserves and Production," Oil & Gas Journal, Vol. 104, No. 47 (December 18, 2006), pp. 24-25.
[4] International Energy Agency (IEA), « Oil Market Report », 12 September 2007 issue, website http://www.oilmarketreport.org

This situation of near-monopoly along with the geopolitical instability in the Middle East does not favour open access to these reserves.

The cost of oil

Restricted access to oil is dued to its concentration in the Middle East and OPEC, but also to natural occurrences, such as cyclones in the Gulf of Mexico. So the result is in high and volatile prices.

Figure 8: Average cost of imported oil, brut.



In September and October 2007, the price of WTI (6) exceeded 80 dollars a barrel. In November 2007, it almost reached 100 dollars a barrel. Oil is an unreliable resource due to its limited stocks, its concentration and price volatility

The global context of forestry and reforestation in climate change point of view

Figure 9: Extract of the IPPC 2007 report abour state of forestry on Earth planet

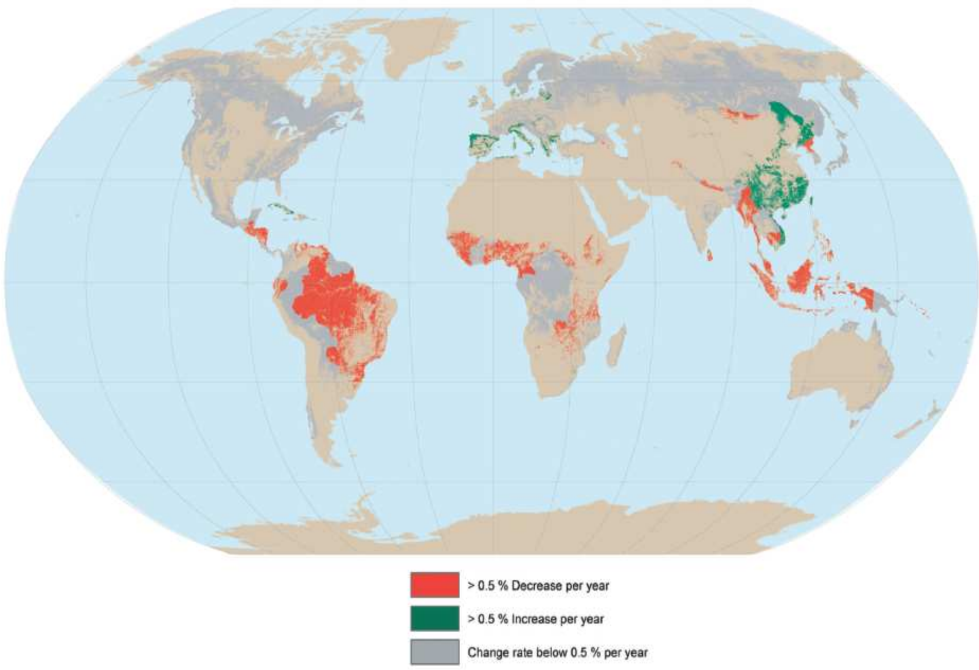


Figure 9.1: *Net change in forest area between 2000 and 2005*
Source: FAO, 2006a.

Figure 10 : Extract of the IPPC 2007 report about « forest carbone balance per région » for climate change

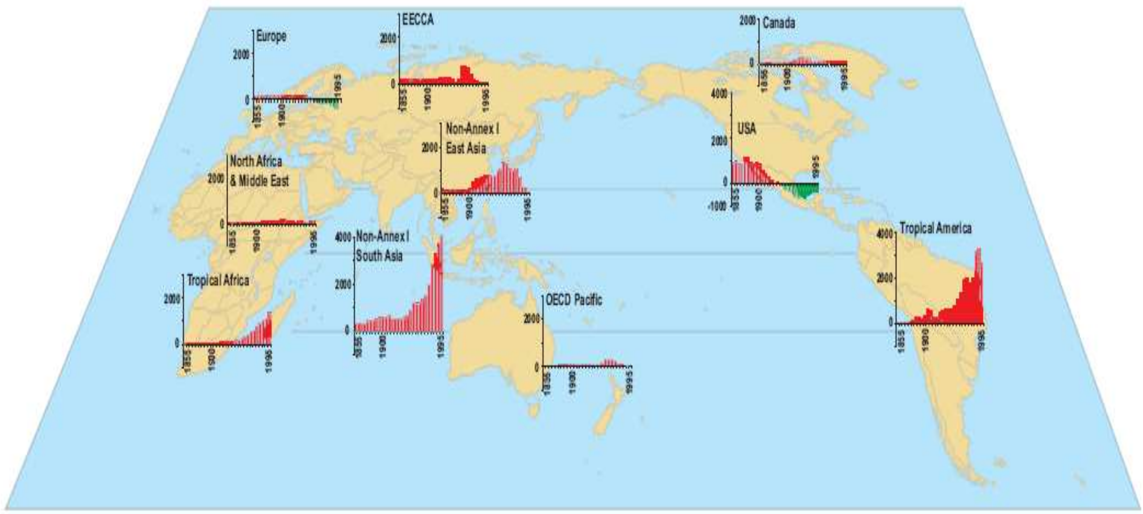


Figure 9.2: *Historical forest carbon balance ($MtCO_2$) per region, 1855-2000.*

Notes: green = sink. EECCA=Countries of Eastern Europe, the Caucasus and Central Asia. Data averaged per 5-year period, year marks starting year of period.
Source: Houghton, 2003b.

Figure 11 : Extract of the IPPC 2007 report about « forest sector mitigation strategies » for climate change

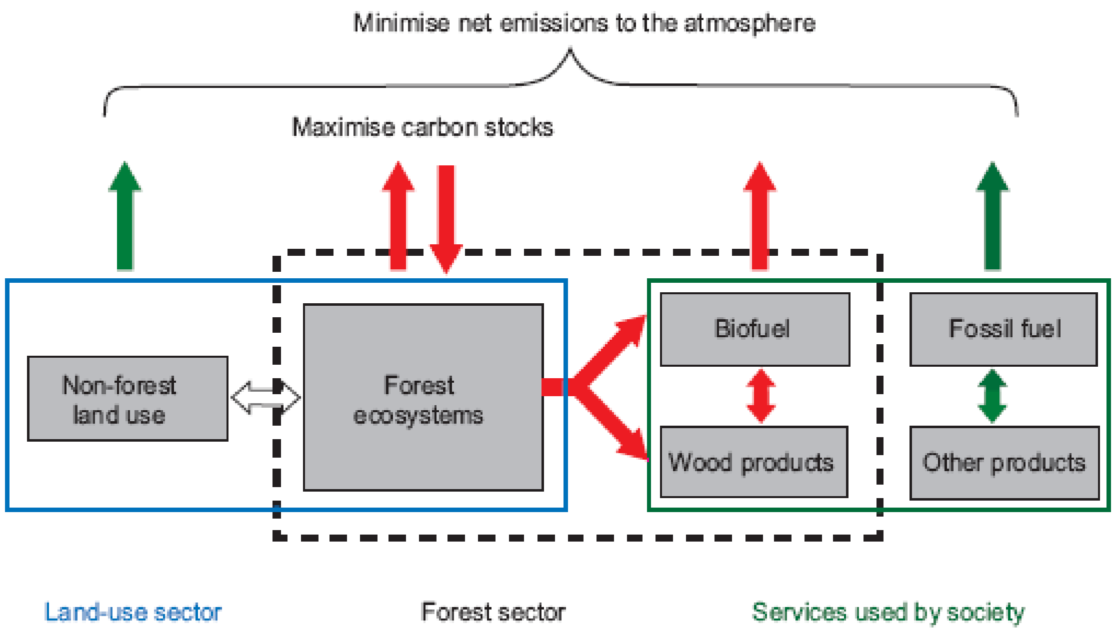


Figure 9.3: *Forest sector mitigation strategies need to be assessed with regard to their impacts on carbon storage in forest ecosystems on sustainable harvest rates and on net GHG emissions across all sectors.*

Figure 12 : Adaptation and mitigation Matrix by IPCC report 2007 about forestry

Table 9.8: *Adaptation and mitigation matrix*

Mitigation option	*Vulnerability of the mitigation option to climate change*	*Adaptation options*	*Implications for GHG emissions due to adaptation*
A. Increasing or maintaining the forest area			
Reducing deforestation and forest degradation	Vulnerable to changes in rainfall, higher temperatures (native forest dieback, pest attack, fire and, droughts)	Fire and pest management Protected area management Linking corridors of protected areas	No or marginal implications for GHG emissions, positive if the effect of perturbations induced by climate change can be reduced
Afforestation / Reforestation	Vulnerable to changes in rainfall, and higher temperatures (increase of forest fires, pests, dieback due to drought)	Species mix at different scales Fire and pest management Increase biodiversity in plantations by multi-species plantations. Introduction of irrigation and fertilisation Soil conservation	No or marginal implications for GHG emissions, positive if the effect of perturbations induced by climate change can be reduced May lead to increase in emissions from soils or use of machinery and fertilizer
B. Changing forest management: increasing carbon density at plot and landscape level			
Forest management in plantations	Vulnerable to changes in rainfall, and higher temperatures (i.e. managed forest dieback due to pest or droughts)	Pest and forest fire management. Adjust rotation periods Species mix at different scales	Marginal implications on GHGs. May lead to increase in emissions from soils or use of machinery or fertilizer use
Forest management in native forest	Vulnerable to changes in rainfall, and higher temperatures (i.e. managed forest dieback due to pest, or droughts)	Pest and fire management Species mix at different scales	No or marginal
C. Substitution of energy intensive materials			
Increasing substitution of fossil energy intensive products by wood products	Stocks in products not vulnerable to climate change		No implications in GHGs emissions
D. Bioenergy			
Bioenergy production from forestry	An intensively managed plantation from where biomass feedstock comes is vulnerable to pests, drought and fire occurrence, but the activity of substitution is not.	Suitable selection of species to cope with changing climate Pest and fire management	No implications for GHG emissions except from fertilizer or machinery use

Figure 13 : Forestry and sustainable developement - IPCC 2007 - Matrix impact

Table 9.10: *Sustainable development implications of forestry mitigation*

Activity category	*Sustainable development implications*		
	Social	**Economic**	**Environmental**
A. Increasing or maintaining the forest area			
Reducing deforestation and forest degradation	*Positive* Promotes livelihood.	*Positive or negative* Provides sustained income for poor communities. Forest protection may reduce local incomes.	*Positive* Biodiversity conservation. Watershed protection. Soil protection. Amenity values (Nature reserves, etc.)
Afforestation/ reforestation	*Positive or negative* Promotes livelihood. Slows population migration to other areas (when a less intense land use is replaced). Displacement of people may occur if the former activity is stopped, and alternate activities are not provided. Influx of outside population has impacts on local population.	*Positive or negative* Creation of employment (when less intense land use is replaced). Increase/decrease of the income of local communities. Provision of forest products (fuelwood, fibre, food construction materials) and other services.	*Positive or negative* Impacts on biodiversity at the tree, stand, or landscape level depend on the ecological context in which they are found. Potential negative impacts in case on biodiversity conservation (mono-specific plantations replacing biodiverse grasslands or shrub lands). Watershed protection (except if water-hungry species are used) . Losses in stream flow. Soil protection. Soil properties might be negatively affected.
B. Changing to sustainable forest management			
Forest management in plantations	*Positive* Promotes livelihood.	*Positive* Creation of employment Increase of the income of local communities. Provision of forest products (fuelwood, fibre, food, construction materials) and other services.	*Positive* Enhance positive impacts and minimize negative implications on biodiversity, water and soils.
Sustainable forest management in native forest	*Positive* Promotes livelihood.	*Positive* Creation of employment. Increase of the income of local communities. Provision of forest products (fuelwood, fibre, food, construction materials) and other services.	*Positive* Sustainable management prevents forest degradation, conserves biodiversity and protects watersheds and soils.
C. Substitution of energy intensive materials			
Substitution of fossil intensive products by wood products	*Positive or negative* Forest owners may benefit. Potential for competition with the agricultural sector (food production, etc.).	*Positive* Increased local income and employment in rural and urban areas. Potential diversification of local economies. Reduced imports.	*Negative* Non-sustainable harvest may lead to loss of forests, biodiversity and soil.
D. Bioenergy			
Bioenergy production from forestry	*Positive or negative* Forest owners may benefit. Potential for competition with the agricultural sector (food production, etc.)	*Positive or negative* Increased local income and employment. Potential diversification of local economies. Provision of renewable and independent energy source. Potential competition with the agricultural sector (food production, etc.)	*Positive or negative* Benefits if production of fuelwood is done in a sustainable way. Mono specific short rotation plantations for energy may negatively affect biodiversity, water and soils, depending on site conditions.

Strategies for energy and water self-sufficiency as a solution to climate change

All islands in Indian Ocean are currently experiencing a large rise in their energy dependency on fossil fuels, despite all their enormous reserves of renewable energies

- The Seychelles archipelago: negawatt, solar, biomass and ocean energy
- The Comoros archipelago: negawatt, biomass, solar, geothermic and ocean energy
- Mauritius and surrounding islands : negawatt ,hydraulic, biomass, solar, wave and ocean energy
- Rodrigues: negawatt, biomass, solar, wind and ocean energy and hydraulic storage
- Reunion Island and Madagascar have huge potential reserves: hydraulic, biomass, solar, wind, geothermic and ocean energy.

We can develop strategies for each island and join together at a regional level for a common action plan on renewable energies and energy management.

Projects are in place on each of the islands, and we now need to pool our resources and our knowledge and develop a very ambitious regional policy

Madagascar, the Comoros and Seychelles archipelagos and scattered islands have benefited from competition between several international players and some experiments which could be useful to everyone. However, a suitable legal framework must be developed along with strong continuous official political support.

Mauritius has an ambitious programme for ethanol and thermal ocean energy and a network of experts can offer their experience. Mauritius is currently organising structured studies to develop its renewable energy potential.

"Solar for all Mauritians" is an ambitious programme to generalise solar power on all buildings of Mauritius, which could mean big financial savings in terms of imported fossil fuels and could generate a dynamic solar-based economy, numerous jobs and financial savings for households.

Reunion developed a Regional Energy Agency in 2000, ARER, and in 2002 began a programme of energy self-sufficiency for 2025, based entirely on renewable energies and storage of intermittent energies, and is currently experiencing large scale development of renewable energies, thanks to a suitable legal framework and an unprecedented mobilisation of all the Reunionese concerned.

Madagascar - the large island could become a global example in the transition to 100% renewable energy and thus preserve its oil reserves for worthy uses over the mid and long-term

Current consumption of biomass in the form of coal derived from wood renders the country and its people poorer every day. The government has opened oil exploitation of Malagasy oil deposits, and is planning to launch the exploitation of carbon minerals.

The abundance of renewable energy resources in different areas of Madagascar, especially solar wind, hydraulic, and very probably geothermic, wave energy, (in the long-term) and the considerable potential of biomass energy (sugar cane and jatropha), means Madagascar can envisage a serious strategic plan for full energy self-sufficiency with no greenhouse gas emissions, a large factor in the fight against poverty.

Madagascar's Action Plan (MAP) 2006-2013 can be supported by structural changes in the organisation of Madagascar's energy.

Several key players from the Energy Working Group (GTE) can potentially make up this strategic platform for energy transition. The government has decided to declare the year 2007 "The year of alternative energy" and may elaborate on the project in order to make it a national and international priority, similar to 100% renewable.

Developing renewable energies on a large scale and for all islands in Indian Ocean would be an ambitious and indispensable programme to implement with the IOC and governments of the Indian Ocean region

This has led to the development of several industrial sectors, numerous jobs and economic development programmes which increase local wealth instead of spending money abroad on fossil energy.

Ambitious programmes over several years in energy sectors, such as hydraulic, wind, biomass, geothermal, solar and energy savings, will gradually reduce the need for fossil energy and ensure the essential energy transition to energies with no greenhouse gas emissions.

Structures and qualified staff trained in energy agencies connected to the highest levels of each state, can link with those involved in energy in order to implement programmes over several years and the necessary institutional framework.

As soon as our islands have defined long-term ambitious objectives to ensure this energy transition, it will be possible to negotiate internationally for necessary funding for these plans which are inevitably ambitious, and to mobilise large multi-nationals, through the concept og Carbon Capture Ocean Indian Process

Context and cooperation of islands

The why and how of developing cooperation for islands' strategies of energy self-sufficiency up to 2050

Recognised facts:

- The urgent global need to alleviate the effects of atmospheric warming and to limit greenhouse gas emissions,
- The direct impacts on islands of global warming: risks for the populations and insular ecosystems,
- Insular wealth : 4,000 territories, 500 million inhabitants, a large percentage of global biodiversity,
- Economic vulnerability of several islands in terms of the sustainability and the cost of energy supply, despite plentiful local resources (solar energy for example),
- The gap between developed and developing islands, in terms of their access to energy, partly due to inequality in the distribution of technology and training,
- Increase in population and energy needs of several islands, as well as significant tourist development on nearly all the islands,
- The modesty of each insular territory and people, which requires alternative energy strategies, but which also gives the islands an experimental status, to experiment with future global sustainable energy strategies at smaller levels over short periods of time in smaller economies.

European Islands, islands of the Indian Ocean, Hawaii and the island of Chong Ming (China), decided to embark upon energy cooperation as a means to plan or support sustainable self-sufficiency energy strategies in their countries, based on natural, local, efficient energies. This common challenge led to the Island NEWS project,

open to all islands, regions and experts in renewable energies and energy management worldwide.

A working group was established at the meeting Energy Reunion 2005, founder of the network Island-NEWS, to which a Rodriguan expert was invited as an expert.

Since 2006 ARER, funded by Reunion's local government, has developed a project and elected a project manager, Franck Al Sharkachi, for the development of Island NEWS, Natural Energy Ways toward Self sufficiency, in 2006 – http://www.island-news.org. Bilateral cooperation projects are under discussion and begin with Mauritius, Rodrigues, Mayotte, Comoros and the Seychelles. A multilateral cooperation project is being debated.

Climate change: mobilisation of ONERC and the IOC in the Indian Ocean to adopt multilateral programmes, and Island NEWS to work towards reductions

Declaration of the President VERGES at the third meetings of sustainable development in February 2007 in St Denis, Reunion:

"At this third meeting for Agenda 21 organised in 2007 by the Region Reunion, Reunion has officially signed the contract of partnership with Island NEWS with the aim of developing a strategy for energy self-sufficiency in the Indian Ocean with other islands of the area. This step aims to promote the stages necessary for a levelling and a reduction in greenhouse gas emissions.

Regards the necessary adaptation procedures, ONERC has currently established a programme of multi-lateral cooperation with the islands of the IOC with the support of Region Reunion.

A similar step is proposed by Region Reunion and Island NEWS to the ministers of the IOC, for the work needed for a levelling of emissions."

Proposal for a multi-lateral programme for IOC and Island NEWS "Programme Strategy for energy self-sufficiency to mitigate climate change"

The 'Région Reunion' supports all the actions aiming at adapting to and mitigating climate change. ONERC works alongside governments of the Indian Ocean islands in order to implement a plan of adaptation to climate change. This multi-lateral programme is one of the topics of this session. Parallel to this, the 'Région Reunion' would like to propose a similar project on the stabilisation of climate change, in particular the reduction of energy emissions.

Beyond the issue of mitigation, we all agree that renewable energies are essential to the social and economic development of our islands. Renewable energies help us and will continue to help us in the future to secure our energy supply. In this way, our islands will become more independent and less vulnerable to geopolitical crises and fossil reserves, which have nearly, ran out and are vulnerable to price changes.

It is with this in mind that the 'Conseil Régional' (Reunion's local government) has asked Reunion's Regional Agency Energy (ARER) to initiate and develop a network of cooperation between islands: Island Natural Energy Way's toward self sufficiency

The 'Région Reunion' sees Island-NEWS as a framework of cooperation between our islands in order to:

- Define strategies for energy self-sufficiency
- Reinforce the capacity of institutions and public administrations
- Develop operational projects in energy efficiency and renewable energies with private companies
- Implement education projects and awareness amongst the population

We also expect Island-NEWS to seek international funding, to reduce the cost of such actions on our budgets.

Island-NEWS is already in contact with some of you. We invite you to render this technical collaboration official regards your administrations and to designate a correspondent for Island-NEWS. These teams should propose projects and identify necessary funding.

Finally, we invite you to endorse the idea of launching a multi-lateral programme of cooperation supported by the IOC and member states and partners, "Programme of strategies for energy self-sufficiency to stabilise climate change" and to include this programme on the agenda of the next IOC meeting. Prior to this, the ARER team and Island-NEWS will be able to work in collaboration with our IOC correspondents with the aim of finalising programme contents, its organisation in terms of human and financial resources and its planning, and to incorporate it into our various usual procedures.

Bilateral agreements of cooperation must also be organised. Within what framework and in what form could this bilateral cooperation be developed with Rodrigues?

In November 2005, a representative of Rodrigues, Mr Perrine, participated in the Energy meetings which led to the creation of Island-NEWS and the implementation of a network of key players to promote energy strategies for a transition to clean energy within insular systems.

Within the framework of Island-NEWS actions in the Indian Ocean, the director of ARER met certain key players of Rodrigues in November 2006 and March 2007. They considered how to begin the work of cooperation between Island-NEWS and those involved in Rodrigues, within the framework of ARER's programme of action and especially that of Island-NEWS. The President of ARER, Paul VERGES, met the President of the Regional Assembly of Rodrigues in June 2007 and they agreed to establish joint work on energy.

II / Regional cooperation between Rodrigues and Reunion for secure energy and water supply and preparations for climate change

Cooperation between Rodrigues and Reunion Island is through a partnership between the Commission of Public Infrastructures of the General Regional Assembly of Rodrigues and the Reunion's Regional Agency for Energy, presided by the 'Conseil Régional' of Reunion. This cooperation was made concrete with the conference "Energy autonomy in Rodrigues – Island-NEWS" which led to the establishment of the current strategy.

Regional Assembly of Rodrigues

The Rodrigues Regional Assembly Act (act 39 of 2001) received the President of the Republic's consent on the 20th of November 2001 – The Assembly met for the first time on the 12th of October, 2002. The first meeting saw the swearing in of members, the elections of the Chairperson, the Deputy Chairperson, the Chief Commissioner, the Deputy Chief Commissioner and the appointment of Commissioners by the President of the Republic of Mauritius. The Prime Minister, the Deputy Prime Minister and other ministers attended. High Commissioners and Ambassadors accredited to the Republic of Mauritius as well as other dignitaries were also present.

The Rodrigues Regional Assembly is empowered to make Regulations for matters falling within its purview. It may initiate legislation which then has to be ushered into the National Assembly in order for it to become law in Rodrigues. The Assembly prepares and adopts its annual budgetary estimates. These are then considered by the Cabinet of Ministers before being incorporated in the National Appropriation Bill. The budgetary provision for the Rodrigues Regional Assembly features as a one line all-comprehensive item in the National budget.

In view of geographical distance and for the sake of greater efficiency, the law provides for regular interaction between the Rodrigues Regional Assembly, through the Chief Commissioner and the Prime Minister. Commissioners are also encouraged to consult relevant Ministers on the mainland as often as is necessary.

Among the commissions of the regional assembly, one regroups all the departments, such as Environment, Housing, Public Infrastructure, Marine Park and Transport. Public Infrastructure includes Highways and roads and Public Buildings and Utilities.

ARER, Island-NEWS, Natural Energy Ways towards Self-sufficiency

The experience gained by ARER since its creation in 2000, especially through international meetings on energy between 2002 and 2006, organised by Reunion, under the leadership of its President Paul VERGES and the Vice-president Philippe BERNE, has generated **Island NEWS**, **Natural Energy Ways toward Self sufficiency**, a structure managed by ARER. The aim of this is to develop cooperation between islands, engineering and the means necessary for "Clean and Sustainable Strategies for Energy Self-sufficiency for Islands and Regions", in response to insular territories and regions vulnerable to climate change.

The ARER team draws upon experience gained in the finalising and development of the energy self-sufficiency programme of Reunion Island, based on clean and renewable energies for electricity by 2025, and for all energies by 2050. The aim is to contribute, along with all those involved in energy in Rodrigues, to the development of a strategy of energy self-sufficiency based on clean and renewable energies, funded mainly by international negotiation of carbon credits and Clean Development Mechanisms (CDM).

A technical conference for "Energy self-sufficiency for Rodrigues with zero greenhouse gas emissions"

Objective "electrical self-sufficiency by 2025"

Within the framework of its plan for sustainable development and the fight against climate change, the Regional Assembly of Rodrigues organised a technical meeting on the 3rd, 4th and 5th of October 2007 in Rodrigues. The aim of the meeting was to evaluate the possibility of developing a strategy of energy autonomy for Rodrigues

2007-2025-2050, to establish an energy self-sufficiency programme and the transition to energy with no greenhouse gas emissions and secure energy supplies.

Organisation

This work is aimed at establishing a strategic analysis and programme recommendations for mitigating climate change and for securing energy supply for Rodrigues. These documents will serve as a basis to establish a proposal for the programme "ACP-EC Facility" for which there will be a tender in 2008, likewise for the CDM programmes.

This document will describe in detail the necessary equipment, financial resources and communication. Building on the basis of the pre-programme document, established by the Regional Assembly of Rodrigues and ARER, the idea is to progress on each of the axes during the three days of seminars, following these themes:

- contents and plan of action,
- financial evaluation of actions
- Identification of key players in Rodrigues who could make up a central core, with the aim of building a Rodrigues energy team.

ARER / Island-NEWS ensures the draft monitoring and detailed drafts along with the Regional Assembly of Rodrigues which will gather certain documents, such as metrological data, graphs, particular considerations and proof-reading. These work sessions will be most profitable in the form of a pre-programme of mitigation of climate change, relying on clean energy with no greenhouse gas emissions.

The finalised document serves as the foundation for a proposal of a joint application from the Regional Assembly, the Conseil Regional of Reunion and ARER, to the EU Energy Facility, and perhaps other funding such as that of the Clean Development Mechanism, and to integrate these axes into the energy policies of the Republic of Mauritius.

In order to achieve the above, six work sessions were conducted as follows:

There were six work sessions during the conference

Numerous people wished to participate in the workshops and opening and closing sessions. These people were important sources of information for a better understanding of the island and its people, but also in evaluating the opportunities and putting together the action plan. They are potential key players in the Energy plan for Rodrigues.

The participants

Table 2: list of conference participants

Nom	Prénom	Organisation	Fonction
Pierre Louis	Jean-Claude	Chief-commisser office	Officer in charge
?? Oozeer	Mohammad Yousouf	Meteorological services	Officer in charge
?? Bothile	Stephen	National Coast Guard	Officer in charge
?? Hang siam	Joseph	Commission for Agriculture	Departmental Head
Perrine	Rosaire	Independent	Adviser
St Pierre	Jean-Noël	CEB	Engineer
Yetty	Surandra	CEB	Officer in charge
Soobadoo	Christophe	Construction company	Manager
André	Aurèle	François Leguat Reserve	Manager
Albert	Alex Salomon	Water Resources	Officer in charge
Meunier	Hugot	Forests	Officer in charge
Alain	Pierre	Pompiers	Officer in charge
Gebert	Gaëtan	Police	Officer in charge
Tolbize	Mario	IRERO	Area Manager
Hung	James	Rotary Club	Economic Actor
François	Rujobert	RRA	
Hee Hong	Davis	Commission for Public Infrastructure	
Perrine	J. Nachaniel	Commission for Public Infrastructure	
Soonarane	Pradeep	Ministry of Public Utilities	Deputy Director, Technical Services
Colin	Jean-Paul	Chief-commisser office	Departmental Head
Meunier	Dario	Bambou villa	Tour operator
Capdor	Jean-Marc	Fisheries	Assistant controller
Law San	Joseph Law Thion	Commission for Public Infrastructure	Draughtsman
Matadeen	Chandrasen	Commission for Public Infrastructure	Departmental Head
Feliure	Jérôme	Services agricoles	Senior Agricultural Officer
Begue	Berno	Coton Bay	Maintenance
Castel	Marie Lindsay		Conseillère - Femme & développement de l'enfant
Juste Meunier	Rachel	Rodrigues Tourist Office	
Leopold	Patricia	Cadastre	Surveying and mapping assistant
?? R. Bhewary	R.	Rotary Club	Bulletin officer

Opening Session and Group 1: Strategy of energy self-sufficiency for insular island of Rodrigues 2007-2050

Towards energy autonomy of an insular energy system and supply security for clean and renewable energies wit means to regulate supply and demand, an energy strategy as a response to the insular energy systems and climate change. Clean Development Mechanism, Carbon Trading, ACP/UEfacility and Energy Facility

3rd October, 10h00-12h00, official opening

M. R. Matadeen, (departmental Head for the Commission for Environment, Fisheries, Forestry, Housing, Infrastructure, Marine Parks, and Transport) introduces the conference, thanks and welcomes all the participants.

M. Christophe Rat, director of ARER, on behalf of Monsieur VERGES, the president of ARER, thanks the regional assembly for organising these technical meetings on the theme of energy autonomy from 100% renewable energy with zero greenhouse gas emissions. The French national environment conferences (Le Grenelle) take place at the same time in Reunion and mobilise local forces who host a delegation of French Ministers. Christophe RAT (Civil and Urban Engineer) and Frank AL SHARKACHI (Polytechnic and Supelec engineer and manager of the Island-NEWS network) make up the technical team at the regional assembly's disposition. This team will follow the three days of work and meetings along with other participants. It is to be noted that there are strong cultural ties and a common history which links Reunionnais and Rodriguans, and the people of Indian Ocean islands in general. The beginnings of climate change mean we face similar challenges: planning in order to adapt to climate changes and ensuring the transition to autonomous insular systems, such as preparing future energy security.

M Grandcourt, Commissioner of public infrastructure, greets the assembly and highlights the importance of this work for the economy and environment of Rodrigues. He repeats Rodrigues' commitment to the environment and is has high expectations of this work. He wishes everyone a profitable working session and states the meeting for everyone for the "Closing Session" which will mark the end of this first stage of cooperation, and kick start the implementation of the water and energy plan against climate change in Rodrigues.

M. Gaëtan Jamib, deputy chief commissioner, welcomes everybody and expresses his interest in this work. He also highlights the importance of the current increase in fossil fuel prices which has negative impacts on household economies. He quotes various examples of renewable energy projects which are possible to develop in Rodrigues, such as wind, solar and maybe even ocean energy.

An introductory presentation from Christophe RAT displays data on climate change and the situation for islands of the Indian Ocean.

This is followed by a discussion on the question of energy autonomy strategy:

Dr. Soonarane, Deputy technical director, MPU: do you think that Rodrigues has the potential to become selfsufficient in energy? What do you think of the problem of the intermittent supply of solar and wind energy? What are the costs? What is the length and output of storage solutions? The diversity of resources for electricity production in Mauritius and Rodrigues comes from an internal decision and not a political one. We must consider the implementation and political decisions.

Questions and responses from certain participants: the political decision and implementation are significant factors for Rodrigues, especially due to the relationship between Rodrigues and Mauritius. For the moment, we define technical solutions: where we want to go from here. We will determine methods afterwards. We could have 200 conferences on the subject but nothing would come of them if there is not a team based in Rodrigues to work on the subject.

M. Matadeen: following the signing of the contract Friday, a team will be made up with Mr Perrine as the contact for ARER. We count on you to give your vision and your knowledge of Rodrigues to help the subject progress and to determine the plan of action.

Group 2: current and potential situations of energy resources, technological sectors, jobs, training and research development

The 3rd October 13.30-17.00, Session 2: to describe and map local energy resources, to identify sectors and clean energy technology available for the islands, their progress and levels of development. Which jobs, qualifications, trainings and Research and Development are to be created alongside these insular energy strategies?

A general overview of the biomass was made, and also a review of different sources of renewable energy.

Group 3: Regulation of Rodrigues' insular energy system

4th October 10h00-12h00: how to control supply and demand of energy with decentralised production systems and clean and renewable energy stocks, to secure the supply of Rodrigues' insular energy system.

A start was made on a calculation of storage-supply of wind energy in the form of hydraulic energy. An initial project of 44,000 Low Energy Bulbs was outlined.

Group 4: planning, construction and transport on Rodrigues to eliminate annual growth in energy demand

4th October 13h30-17h00: concentrated efforts for sustainable planning, transport and buildings, actions to integrate renewable energies with Energy Management and Rational Energy Use, to eliminate the growth in energy demand.

Economy, tourism, planning, construction and transports: C. RAT presents an introduction outlining the targets for environmental management of profitable hotels, and more generally the question of how to build for energy self-sufficiency

For example, solar water heaters on hotels; identification of needs; a joint tender for swimming pools, a pumping system for wind and sea water; communication and electronics; a secure system of PV and batteries; an environmental system of compost for gardens, parks and agricultural allotments; hotel funding; energy savings, with the guidance of a technician 20% of the costs will be easily recuperated on energy bills.

Discussion with the workshop participants highlights several interesting ideas:

It was suggested to implement solar pumps for farmers, like in Rivière Banane and to make this common place for all farmers. The majority of these pumps, or at least their batteries, are broken. No maintenance is guaranteed. But these can be repaired or we can build collective irrigation systems powered by wind energy. The maps of the agricultural zones will allow the evaluation of the positioning of wind-powered irrigation systems, because of a sector already in place in Rodrigues and which already requires maintenance jobs and with a large stock of separate pieces.

The case of Coton Bay is raised. Demand for hot water is increasing at Coton Bay. Electricity consumption is high and is more than 100kRs per month, sometimes 600kRs. Cleaners must control the air conditioning more carefully. Roof insulation must be checked, but no limits should be imposed on air conditioning as the clients' comfort comes first. Air conditioning outside is not protected or ventilated. The group directors are interested in saving and how to raise awareness amongst hotel managers. There is a possibility of increasing energy awareness, which is already the case for water.

Two hotel cases are discussed:

- old hotels : audit
- new hotels : specification guide

Regarding hotels, a law has just been passed that must be applied to hotels. We must introduce energy regulation and ban non-energy saving bulbs in the five hotels and the gites / inns, i.e. 60 establishments. One hotel will be used as an example to show the savings.

As for individual houses, a lengthy discussion is centred on the project Rodrigues Guide based on the model CASA DD (sustainable house design in Reunion) but adapted to the needs of Rodrigues. The infrastructure department is responsible for building licences. The **Pb** for building licences: how to react regarding the consumption and storage of rain water? For housing, the problem of budgets for material is apparent. Some participants suggest a programme for solar water heaters. How can we help individuals, as with the LBC? Awareness building must be developed. The initial step is to introduce people to the idea that there are building regulations to follow. Rodrigues is an easy case as it is small. There are qualified people who do not yet work together. In Reunion Island, the CMO houses inititated by ARER helped to perfect the sustainable housing guide and advice for building licences. In Reunion Island recommendations came first followed by changes in the law and the solar village. Between these stages of recommendations and law there are subsidies, especially from the government, the CEB and the Regional General Assembly of Rodrigues. These are to be followed: offer advice on roof insulation, ecological solution of vegetation on tiled roofs, are there any sceptic tanks? People say that there are, but they are more like pools. Reference is made to the ecological solution of Baton Mourong and bamboo, used as ecological plant purifiers. Banana trees could sustain the same purpose.

In Mauritius there is a guide for architects but only for buildings larger than 250m², this should become standard practice. The number of buildings higher than 250m² is perhaps less than that of small buildings, but they use more energy. Develop two different approaches:

- with individuals : advice
- with administrations and businesses : more direct approach

Energy criteria do not currently influence the according of building permits, but it may become the case.

How can we develop the concept of solar schools with energy education?

- Primary schools in Rodrigues = 13
- Secondary schools : 5
- No sixth form.

Education is already partly in place.

In the administrations, the question of education and of politicians and civil servants setting the example is important. There is a possibility of simplified GTB/GTC for certain buildings. Lighting of sports grounds works by children turning out lights when they leave. Public lighting? The Olympic pool?

How can we introduce an energy agency in Rodrigues?

Group 5: Project planning over several years and organisation of a team to implement the energy strategy of Rodrigues 2007-2010-2015-2020

5th October 10h00-12h00: Project planning for several years and organisation of a team to implement the energy strategy of Rodrigues 2007-2010-2015-2020

A written summary of previous sessions has been produced. There was a lengthy discussion on the organisation of Rodrigues' PRERURE and of a Rodrigues energy team. A meeting took place in December with an energy team from Mauritius so that the Regional Assembly of Rodrigues could put forward its project, so it is incorporated into the project research conducted by Mauritius.

Closing Session: general conclusions and signing of the contract

4th October 13h30-16h00: Final review of work, closing session, signing of the contract ARER Island-NEWS – Regional Assembly of Rodrigues

III / Presentation of the conclusions of project design in the "Closing Session": Rodrigues can envisage a strategy of energy security and self-sufficiency 2007-2010 – 2015-2020: 100% Renewable

Aim of this meeting: strategic analysis and programme suggestions for a strategy to stabilise climate change and ensure secure energy supply in Rodrigues. These documents serve as a foundation for the creation of a proposal to the Mauritian government and key international players. It could also serve as an aid to organise funding through the ACP-EC facility, for which there will be a tender in 2008 and funding thanks to Carbon Credit Trading. We have made progress on each of the sections during these three half days of seminars, in terms of content and action plans, financial evaluation of actions, identification of key Rodriguan players who could make a core team and with whom we will work and gradually train with the idea of creating a Rodrigues energy team.

The detailed sections presented in the closing session are included with each relevant chapter.

Hydro energy, micro hydraulic for water distribution, storage of wind energy, desalination and ocean energy

Hydraulic energy does not exist as a resource in itself. But the island's relief means small hydraulic systems can be built on different sites for different functions as storage and supply of intermittent wind, solar and other renewable energy. The energy strategy can be combined with that for water, a necessary step from a conceptual point of view. The technical and financial aspects of combining hydraulic and wind energy are proven, along with the desalination of sea water. A detailed map must be completed showing the position of the systems combined with wind and the water network (2007). The site of Grenade stands out in particular, as it has all the necessary attributes to become an integrated zone of ecological industrial activity for water production, waste management, energy production and material production.

Energy from ocean swell is a long-term resource to be investigated

Energy from swell is a potential resource (Wave Energy Converter). Part of the coast in particular shows favourable conditions for potential exploitation. Between Pointe Coton and Port Sud-est, there is no lagoon and the bathymetry is between 50 and 100metres, and up to 200m in depth not far from the coast, this is an advantage and would allow an easy connection to the CEB network. This medium to long-term resource, (2015-2020) has a potential of several megawatts. Evaluation of the potential must be mapped out (2007). Its compatibility with Megapteras whales who occasionally visit the north of the island must be checked.

Hydro energy: currents can be used over the long-term

Energy from currents is possible in at least one place: the"Grand Passe" of Port Sud-est is 50 metres in width with an equivalent depth, it is a suitable place for hydro-turbines. An Australian company has developed a micro-system which could be placed in the large pass of Port Sud-est. The bathymetry of the pass is available (document provided by the marine reserve). Data on currents is to be collected (2007). The Australian company can be consulted for economic and financial feasibility studies. A meeting with representatives from Reunion and this company is planned for the end of November 2007. ARER will request the expertise of this company for Rodrigues. The compatibility of the system with the marine reserve must be studied. Planning period: 2015-2020.

Thermal energy from oceans has real potential for future water supply and a diverse economic sector which is to be studied.

The map of deep bathymetry (-1000m) indicates the minimum distance from the coast of the sea bed at around 6 nautical miles. Mauritius organises this sector (MRC and the Finance Minister), as does Reunion. Hawaii is a current example. An evaluation of this sector must be carried out and could be conducted by Mauritius Research Council. The scale of industrial investment requires export of aquaculture products and mineral water.

Wind energy – a major resource in short-term energy strategies

Wind as an energy source is one of the best of all the Indian Ocean islands. There is significant potential. We need to establish an atlas of wind sources, pinpointing suitable sites, far from houses, and potentially with technical links to the CEB network and/or to the hydraulic stations of stocks of intermittent energy. This atlas is designed to guarantee rational development of wind power and to respect the landscape, (2008). This atlas must be communicated to the local planning department to reserve suitable sites. Three turbines VERGNET of 60kW are in place at Trèfles (2003). A CEB project is under way at Grenade. Ten machines of 220 kW could be installed, i.e. around 2.2 Megawatts. The first machine of 200kW will be installed in 2008.

Biomass - a major energy source, an important economic sector and a crucial area for Rodrigues to adapt to climate change

- Forested area of Rodrigues in 2007 is around 3,500 hectares, of a total island surface area of 10,000 hectares. There is realistic potential for a further 1,000 hectares of forest, which would lead to a total of 4,500 hectares of exploitable forest. The quantity of exploitable wood would be around 150,000m3, 10% of which would be from renewable sources.
- Advantages: good experience, available funding within the CDM framework, wood potential for a wood energy sector linked with a system of gasification. The reintroduction of endemic species shows initial promise. Coconut trees, bamboo and the Mourong Baton are growing well and have diverse economic and environmental potential. With real political will, the wood industry and the biomass industry in general, can contribute significantly to energy self-sufficiency in Rodrigues, making use of gasification with a potential base of 1 megawatt of electrical production.
- Drawbacks : centralised actions which are not widespread and little known, little possibility of private projects, length of return on the plots, lack of funding and means, decisions to be made on the division of land use, lack of communication with the population regards climate change and the need for a plan of economic development and adaptation to climate change.

Biomass - plan of potential actions for short term implementation, with the aim of preparing the island for climate change

- Development of an economic sector "Wood", general reforestation of the island with a minimum of 1,000 hectares of endemic species, 2,000 hectares is possible, giving a future total of 4,500 to 5,500 hectares of forest, out of a total island surface area of 10,000 hectares.
- Development of an economic sector "Coconut trees" plantation of a row of trees along the island perimeter where it is possible, (50 hectares, which represents potentially 10,000 coconut trees).
- Development of a multi-functioning ecological sector for houses and gardens of the island: bamboo, Mourong Baton and banana trees for the 11,000 houses on Rodrigues. There is a potential problem of space on certain plots for this project.
- Establishment of forest village projects: bamboo, vacoas, vetiver, medicinal plants, i.e. 90 village forests with a potential of one or two hectares per village.
- Investment in a unit of gasification of biomass: for the electrical production and heating for energy self-sufficiency of the island.
- Reinstating the waste depot at Roche Bon dieu: at the Grenade site in the context of the ecological industrial zone of Grenade.

Biomass – a separate organisation of key players, an economic plan, an essential short-term monitoring of land usage

Monitor the division of land usage between forest, agriculture and breeding. Quantify and closely monitor the general reforestation programme. Develop the reforestation programme and the economic sector in greenhouse gases and in CDM/CC. Organise the group of key players (those involved in economy, the Forest Commission, WWF, etc.) training, animation and planning. Organise reforestation by sector, prepare and develop jobs for the collection and transformation process of wood. Communicate and coordinate the plan to the population and key players and mobilise those concerned.

Solar energy

Solar energy is abundant. The few solar water heaters installed are of poor quality and present a rather negative image of this technology. Some PV installations supply energy for lighting the marine signals. Hotels are equipped with electric or gas water heaters and air conditioning, and indicate high consumption. An economic plan for solar is proposed. This plan is based on an analysis of needs and on the choice of efficient and high-quality technologies.

Short-term plan for solar powered water heaters for tourist sector, individual housing sector to be evaluated

- Solar water heaters for the 40 guest houses, 10 hostels and 5 hotels and for all future building of this sort, i.e. a potential of about 300 solar water heaters for the tourist sector. Care must be given to quality, especially regards corrosion (2008-2010)
- Household solar water heaters : there is significant potential, but the regulation of drinking water presents a problem of the supply of solar water heaters – subject to be studied in detail to evaluate the sector feasibility, especially through use of stored water (2007-2008)
- A detailed study of solar water heaters for the hospital could be carried out. An energy management study could complement this system (2007-2008)

Solar energy and photovoltaic for specific uses

- PV sector: an equipment programme for photovoltaic supply for building energy autonomy is proposed. Targeted buildings to be equipped are public or semi-public buildings such as the airport at Plaine Corail, the CEB power station, the 13 primary schools, the 5 secondary schools and a dozen of government buildings, i.e. about 1 MWc of photovoltaic power. Equipping certain other sites can also be envisaged.
- PV sector: in terms of the concept, it is not essential to energy self-sufficiency. A feasibility study of the sector could be carried out for specific uses.

Non-consumed energy and energy management - a significant short term potential which is profitable and easy to implement

- Distribution campaign of 44,000 low energy bulbs by the CEB and Assembly of Rodrigues
- Systematic audits of all the current guest houses, hostels and hotels to reduce electricity bills by at least 20%
- A specific study of the hospital, the cold rooms, and certain buildings with potentially high consumption
- A "Mr / Mrs Energy" to manage energy savings in all the government buildings : the Regional Assembly to set the example and communicate the message
- Regular awareness campaigns by the CEB and the Regional Assembly of Rodrigues or by voluntary associations, on the radio and in schools.

Improving ecological performance of building constructions, houses, gites, inns, hotels, schools and public buildings - first stage includes guides and audits

- HOTELS: audits for old hotels and specification guides for new hotels, ban on non-low energy light bulbs, regulations, use one hotel as an example to demonstrate savings and environmental management. A law has just been passed that must include hotels, add the environmental recommendations to the appendices.
- HOUSES: begin with recommendations by creating the Rodrgiues Guide to practical, economical and ecological housing, with designers and builders, to be distributed to citizens and those responsible for building permits. Regular information campaigns, followed up with building permit regulations to impose rain water storage, sceptic tanks and the ecological solution of banana trees, bamboo and baton

Mouroung. Individuals can be helped between the suggestion and law stages with subsidies and zero interest loans, especially from the government, the CEB, the Regional Assembly and banks.

- SCHOOLS: Equip 13 schools with solar power and develop energy education programmes.
- BUILDING licences: granting of building licences does not depend on energy criteria, but this could become the case, with the help of specification booklets and technical guides. A specification guide could be given for large buildings and for buildings higher than $250m^2$.

This overall Rodrigues Energy plan is the foundation for general project implementation

- This overall plan must now be implemented, assessed and planned in detail, and could serve as a plan for climate change, to be negotiated and funded at an international level, and also as a marketing plan to promote Rodrigues "Island of Nature" or "Island of Sun" or an alternative slogan.
- The ideas in this plan can undergo the same studies that were conducted for the reference plan "Energy Policy 2007-2025" for Mauritius to include characteristics specific to Rodrigues. The consultation session in December 2007 (the first week) should be proceeded by an exchange between the consultant and ARER under the control of the Regional Assembly of Rodrigues.
- Language used for the reports will be English. The report must be given to the Regional Assembly for consultation by the 15^{th} October 2007.
- The strategic approaches and necessary sites must be incorporated into land planning and the Sustainable Plan of Rodrigues, selection of all required sites and submission of proposals.
- Project management: Regional Assembly of Rodrigues.
- General coordination can be the responsibility of an Energy Agency in Rodrigues, or of a department in the Regional Assembly.
- Government make up for this local agency: a minimum of Rodriguan key players (Regional Assembly of Rodrigues, the CEB, the Mauritius government, those involved in economics and tourism, Meteo Rodrigues and Mauritius etc).
- Operational team of this agency: a Rodriguan team headed by Mr JN PERRINE of the Infrastructure department

IV / Presentation of Rodrigues Island

This chapter presents the main socio-economic indicators for Rodrigues. For more details, we recommend readers to refer to the Synthesis Paper "Formulation of a Sustainable Integrated Development Plan for Rodrigues" ([5]).

Population

The Central Statistics Office (CSO) publishes, on a yearly basis, a digest of demographic statistics.

Rodrigues had a population of 37,079 in 2006 with an annual growth rate around 0.45%.

2006 digest provides population projections for Rodrigues up to 2046. It should be noted that CSO projections are useful data that are not 100% reliable. In reality, CSO projections differ from year to year:

- in 1997, CSO projected a population of 50,001 in 2037
- in 2005, CSO projected a population of 49,219 in 2045
- in 2006, CSO projected a population of 48,640 in 2046

Table 3: Population – historic data and 2006 CSO projections

Year	Population
1983	33082
1990	34204
2000	35779
2006	37079
2011	37910
2016	38799
2021	39903
2026	41318
2031	43234
2036	45130
2041	46974
2046	48640

Households

The average household size is estimated at around 4 persons and the total number of households is estimated at around 9270.

In 2007, it is assumed that all households have access to piped water and electricity.

Table 4: Households and Household Size, Rodrigues 1983-2000 - Author: KPMG Advisory Services Ltd

Item	1983	1990	2000
No. of Households	6655	7080	8564
Aver. Household Size*	5.0	4.8	4.2
		1983-1990	1990-2000
Household Growth Rates		0.9%	2.0%

**NB. Calculations include population not resident in private households. Average size of private households would be approximately 0.1 persons less than the figures shown in the Table*
Source: CSO 1983, 1990 and 2000 Census Reports

[5] UNDP - Rodrigues Regional Assembly, *Synthesis Paper - Formulation of a Sustainable Integrated Development Plan for Rodrigues*, KPMG Advisory Services Ltd, August 2006.

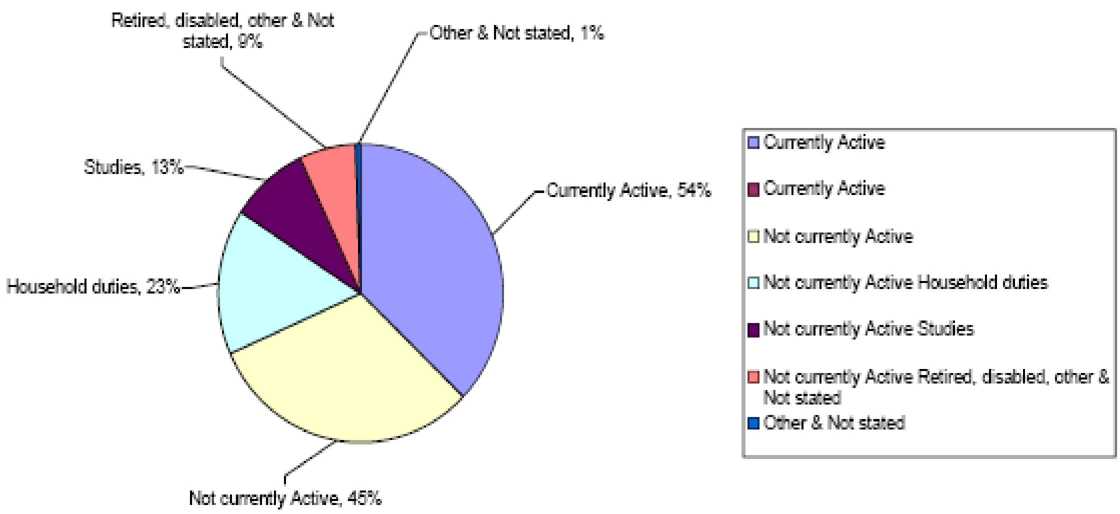
Table 5: Housing Amenities, Rodrigues 1983-2000 - Author: KPMG Advisory Services Ltd

Amenity	1983	1990	2000
Piped water	50.5	60.6	87.7
Electricity	19	68.3	92.2
Toilet	86.7	88.3	94.1
Bath	43.4	60.6	81.7
Fuel for cooking (LPG or electricity)	4.6	27.2	76.6

Source: Outline Scheme for Rodrigues 2001, Halcrow Group Limited

Activity and employment

Figure 14: Resident population 12 years of age and over by current activity status, both sexes, 2000 - Author: KPMG Advisory Services Ltd



"The Employment Division of the Ministry of Labour, Industrial Relations and Employment issues a quarterly report on the unemployment situation in Rodrigues from its office at the Human Resources centre at Malabar, Rodrigues. According to its latest report 5, the number of unemployed reached a peak of 3,040 in 2002 from 1,604 in 2000, but fell to 2,847 in 2004."[6]

"The average monthly earnings for all sectors were Rs 10,505 in 2004, representing an increase of 71% since 2000. As shown in the Annex section, the sub sectors with the highest and lowest monthly earnings were Education and Manufacturing respectively. The sub sectors which have benefited from the highest increases since 2000 were Public Administration and Defence, Social Security, and Hotels and Restaurants."[7]

[6] Ibid, pp 23.
[7] Ibid, pp 24.

Table 6: Employment population by economic sector, Rodrigues 1990-2004- Author: KPMG Advisory Services

Industrial Group	**1990**		**2000**		**2002**		**2004**	
NSIC[1]	Both sexes	%	Both Sexes	%	Both Sexes	%	Both Sexes	%
Primary								
Agriculture, forestry and fishing	5280	46%	4000	31%	3910	29%	3910	28%
Mining and quarrying	1	0%	100	1%	100	1%	100	1%
Total Primary	5281	46%	4100	31%	4010	29%	4010	29%
Secondary								
Manufacturing	857	7%	1062	8%	1024	8%	1057	8%
Electricity, gas and water	*		53	0%	56	0%	67	0%
Construction	*		840	6%	1110	8%	1400	10%
Electricity & Construction	1948	17%		0%				
Total secondary	2805	24%	1955	15%	2190	16%	2524	18%
Tertiary								
Wholesale & retail trade; repair of m/vehicles, personal &	*		1206	9%	1309	10%	1363	10%
household goods	*							
Hotels and restaurants	*		531	4%	588	4%	591	4%
Transport, storage and communications	465	4%	713	5%	802	6%	852	6%
Financial intermediation	*		113	1%	110	1%	117	1%
Real Estate	*		50	0%	62	0%	92	1%
Financing, insurance, real estate and business services	65	1%						
Public administration & defense; compulsory social security	*		3258	25%	3383	25%	3192	23%
Education	*		419	3%	426	3%	498	4%
Health and social work	*		50	0%	60	0%	60	0%
Other services	*		645	5%	677	5%	726	5%
Govt, Community and Personal Services	1889	16%						
Total tertiary	*3434*	*30%*	*6985*	*54%*	*7417*	*54%*	*7491*	*53%*
Total	**11520**	**100%**	**13040**	**100%**	**13617**	**100%**	**14025**	**100%**

1. National Standard Industrial Classification - an adapted version of International Standard Industrial Classification Rev. 3

Note: (i) Estimates are based on different data sources: they refer to population aged 12 years and over

(ii) All departments of the Rodrigues Regional Assembly are classified under 'Public Administration & Defence'.

2. Revised

Source: Adapted from the National Development Strategy – Final Report (2003). Figures have been updated.

V / Energy and water context

An electricity balance describes all activities related to electricity:

- energy supply: production, import, export, stock change
- electricity generation: from primary energy to electricity
- electricity transport and distribution
- final electricity consumptions
- Economic and environmental balance
-

Most data were provided by the Central Electricity Board (CEB)[8]. Some hypotheses were used: these are clearly identified to prevent confusion for the readers. Most recently available data are presented: in some cases, 2005 data are presented instead of 2006.

Historical overview – Capacity, Demand, Production and Sales – 1989-2006

The following table provides an historical overview of the electricity situation for Rodrigues.

Table 7: Capacity, demand, production and sales - 1989-2006

Year	Installed Capacity (kW)	Max. demand (kW)	Production (MWh)	Sales (MWh)	No. of Customers
1989	1616	1240	4652	3942	5690
1990	2616	1380	5482	5043	6157
1991	2616	1520	6428	5323	6476
1992	3616	1762	6627	6417	7097
1993	3616	2130	8241	7464	7393
1994	3616	2340	9718	8646	7692
1995	4000	2600	11936	9860	7905
1996	4000	2980	13210	10980	8279
1997	5000	3200	15055	12214	8608
1998	6000	3600	16920	13903	8964
1999	6000	3750	18112	14882	9689
2000	6000	3820	19616	15552	9959
2001	6000	4240	20625	16833	10112
2002	6000	4400	22558	18164	10229
2003	6000	4750	24397	19673	10311
2004	9800	5570	26767	21900	10484
2005	14092	5960	30024	25207	10825
2006	14092	6500*	30751	25818*	11144

Source: CEB; * indicates ARER estimation

Energy supply for electricity 2006

Local energy production

So far, wind-power is the only locally exploited energy source.

- Wind-power (2006): 410MWh i.e. 35 toe[9]

Energy imports

Heavy fuel oil as well as diesel is imported:

- HFO (2006):7500 m3 i.e. 6711 toe[10]

[8] Directly; Integrated Electricity Plan 2003-2012, CEB, 2003; 2005 Annual Report, CEB
[9] For windpower, solar electricity, hydroelectricity, 1 MWh generation is equivalent to 0.086 toe supply
For final electricity consumption, same ratio
[10] HFO : density = 0.94 kg/l ; energy equivalence for 1 ton HFO = 0,952 toe

- Diesel (2006): 270 m3 i.e. 225 toe[11]

Table 8: Energy supply 2006

Energy supply		Amount (toe)	Share (%)
Local production	Windpower	35	0.5%
Imports	HFO	6711	96.3%
	Diesel	225	3.2%
Total		**6971**	**100%**

Source: CEB

The primary energy dependency rate for electricity generation is **99.5%.**

Electricity Generation 2006

In 2006, there were three electricity "plants".

Table 9: Rodrigues power stations, effective capacity and electricity generation (2006)

Name		Pointe Monnier	Port Mathurin		Trèfles	Total
Energy source		*HFO*	*HFO*	*Diesel*	*Wind power*	
Usage		*Base*	*Peak*		*-*	
Effective capacity		*2 x 1,98 MW*	*3 x 1 MW*	*6 x 400 kW*	*3 x 60 kW*	*9,54 MW*
Primary energy consumption (toe)		*4474*	*2237*	*270*	*35*	*6971*
Electricity generation	*GWh*	*19,17*	*10,13*	*1,04*	*0,41*	*30,75*
	Toe	*1649*	*871*	*89*	*35*	*2644*
	Share	*62,4%*	*32,9%*	*3,4%*	*1,3%*	*100%*

Source: CEB

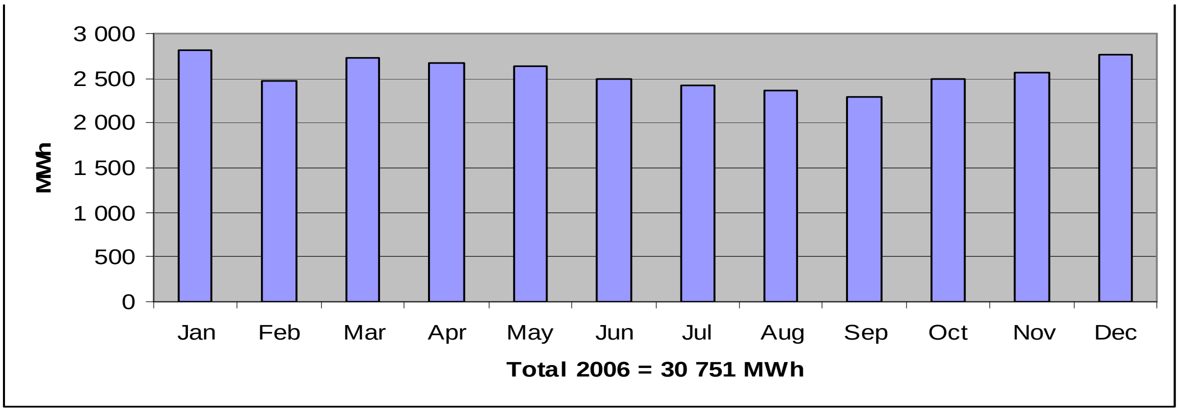
Table 10: Rodrigues future power stations, effective capacity and electricity generation

Name		Grenade
Energy source		*Wind power*
Usage		*-*
Effective capacity		*200 kW*
Primary energy consumption (toe)		*35*
Electricity generation	*GWh*	*0,41*
	Toe	*35*
	Share	*1,3%*

Source: CEB

The share of electricity generated from RES is **1.3%.**

Figure 15: Monthly electricity generation 2006



Source: CEB

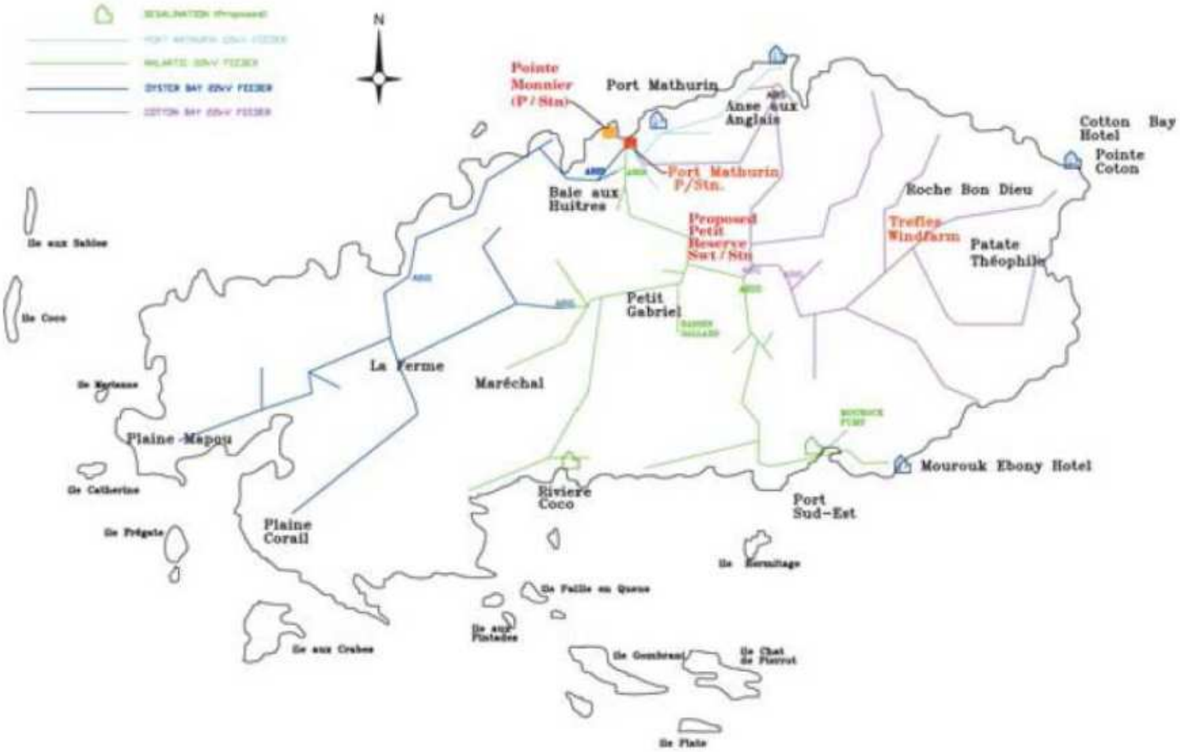
[11] Diesel : density = 0,835 kg/l ; energy equivalence for 1 ton diesel = 1 toe

Electricity transport and distribution

"The distribution network begins at Port Mathurin power station, from where electricity is distributed through four feeders, [...] operating at a voltage of 22 kV. The shortest feeder is 5 km long and serves the Port Mathurin area. The other three feeders average 25 km in length and provide electricity service to all parts of the island. Each of the four feeders is secured by another feeder line to provide security in the event of faults which may occur for various reasons on the primary distribution network.

The 22 kV network is made up of a total of some 130 km of overhead lines with mainly 50 mm2 aluminium alloy conductors. There are presently about 115 distribution transformers with a total capacity of 20,500 kVA. All are protected with both individual and group fuses. The low voltage network is comprised of twisted insulated cables, which make it highly reliable compared to a network comprised of bare conductors. Moreover, this type of construction reduces the time taken for reinstatement works following cyclones. Following the intensive electrification program on the island, the low voltage network has grown to 350 km."[12]

Figure 16: Rodrigues Electric Grid



Source: CEB

Table 11: No. of Distribution Transformers

Feeder Name	50 KVA	100 KVA	150 KVA	250 KVA	Total
Malartic	25	8	8	1	42
Oyster Bay	21	9	4	4	38
Cotton Bay	21	6	5	1	33
Port Mathurin	3	6	9	3	21
TOTAL	**70**	**29**	**26**	**9**	**134**

Source: CEB

[12] CEB, Integrated Electricity Plan 2003-2012, pp 67-68, 2003

Final Electricity Consumption 2006

The CEB tariff categories are divided into:

- Domestic
- Commercial (included public administrations, schools, hospitals, etc)
- Industrial
- Irrigation
- Street Lighting

Table 12: Final electricity consumptions per client categories 2005

Type of Category	No. Of Customers		Electricity consumption (2005)		
	2006	2005	MWh	toe	Share (%)
Domestic	9930	9621	14 256	1 226	56.6%
Commercial	1019	1013	8 152	701	32.3%
Industrial	163	159	1 904	164	7.6%
Irrigation	25	25	419	36	1.7%
Street Lighting	7	7	477	41	1.9%
TOTAL	11144	10825	25 208	2 168	100

Source: CEB

Table 13: Average Consumption Per Customer Category 1994-2005

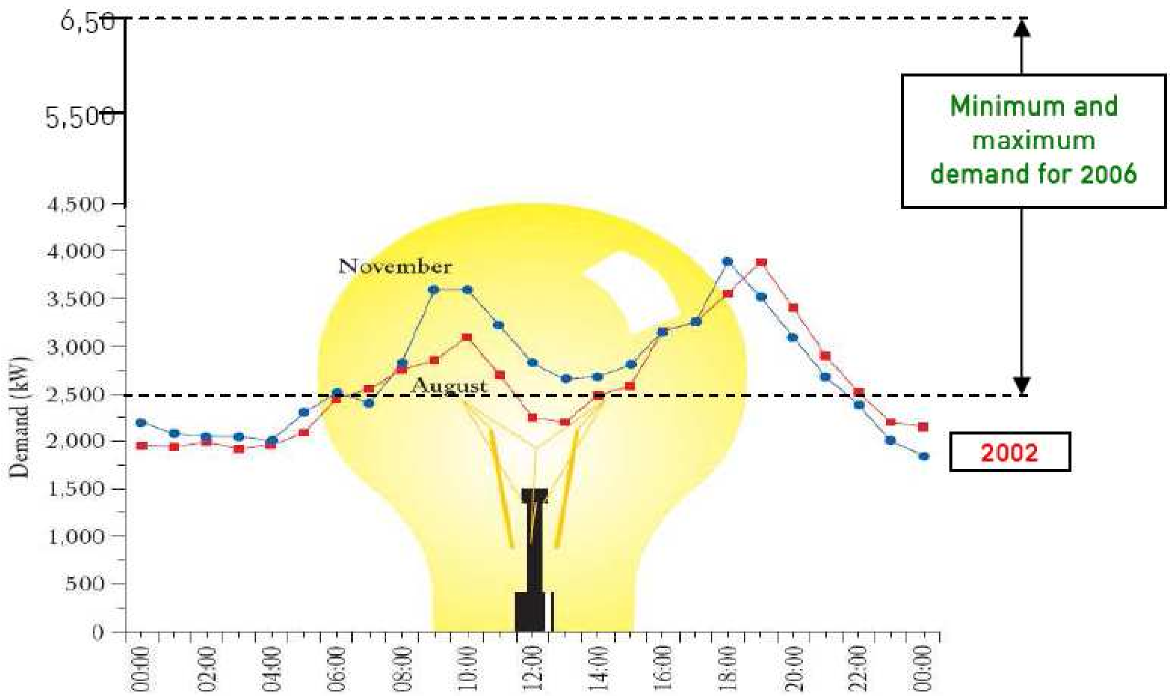
Average Consumption Per Customer Per Category						
Year	Domestic		Commercial		Industrial	
	Gross value (kWh)	Growth n/n-1 (%)	Gross value (kWh)	Growth n/n-1 (%)	Gross value (kWh)	Growth n/n-1 (%)
1994	751		3 458		9 587	
1995	833	10,9%	3 683	6,5%	11 765	22,7%
1996	890	6,8%	3 599	-2,3%	13 204	12,2%
1997	963	8,2%	3 713	3,2%	13 104	-0,8%
1998	1 082	12,4%	4 519	21,7%	16 017	22,2%
1999	1 127	4,2%	4 352	-3,7%	13 958	-12,9%
2000	1 130	0,3%	4 793	10,1%	9 546	-31,6%
2001	1 242	9,9%	4 860	1,4%	8 192	-14,2%
2002	1 269	2,2%	5 315	9,4%	9 670	18,0%
2003	1 303	2,7%	6 193	16,5%	8 707	-10,0%
2004	1 339	2,8%	6 948	12,2%	9 265	6,4%
2005	1 482	10,7%	8 047	15,8%	11 973	29,2%

Source: CEB

Daily demand profile

Typical daily demand profile for Rodrigues 2002 as well as the minimum and maximum demand 2006 is presented in the following figure.

Figure 17: 2002 typical daily demands and 2006 maximum and minimum load

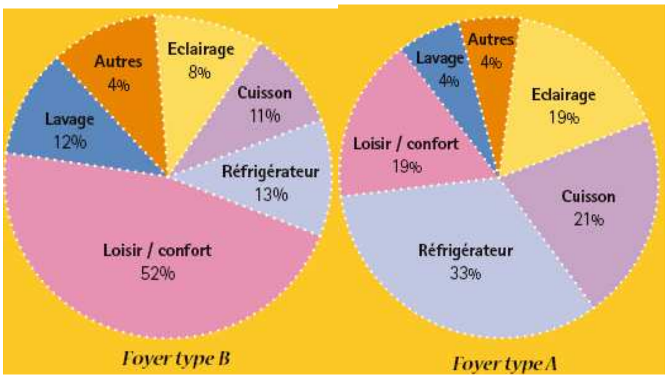


Source: CEB

Electricity consumption repartition for Mauritian households

The "save energy" guide[13] by MPU and CEB shows the average electricity consumption repartition for two categories of Mauritian households. The average consumption of Rodriguan households is 1482 kWh/yr i.e. 124 kWh/month.

Figure 18: Average repartition of electricity consumption for two types of households 2006



Source: CEB

Economic and environmental balance 2006

The main parameters to analyse are:

- the initial investment and the depreciation time
- the operation and fuel costs
- the maintenance costs

No prospective analysis with future prices and discounted cash flows will be carried out.

Table 14: Economic and environmental balance - installed power stations 2006

Name	Pte Monnier	Port Mathurin		Trèfles
Initial investment	*226 MRs**	*246 MRs**	*...*	*15 MRs**
Effective capacity	*2 x 1,98 MW*	*3 x 1 MW*	*6 x 400 kW*	*3 x 60 kW*
Commissioning date	*2004*	*1995 - 1998*	*1985 - 1993*	*2003*
Lifetime	*30 years*	*30 years*	*30 years*	*20 years*
Depreciation time	*20 years*	*20 years*	*20 years*	*15 years*
Depreciation cost (2006)	*11.3 MRs**	*12.3 MRs**	*0*	*1 MRs**
Electricity generation (2006)	*19,17 GWh*	*10,13 GWh*	*1,04 GWh*	*0,41 GWh*
Fuel costs (2006)	*70 MRs**	*35 MRs**	*7 MRs**	*0*
Operation & maintenance costs[14] (2006)	*3.5 MRs**	*2 MRs**	*1.5 MRs**	*0.7 MRs**
Total costs (2006) depreciation incl.	*85 MRs**	*50 MRs**	*8.5 MRs**	*1.7 MRs**
Total cost per unit (2006)	***4,4 Rs/kWh****	***4,9 Rs/kWh****	***8.2 Rs/kWh****	***4.1 Rs/kWh****
GHG emissions per unit (2006)	*654 gCO2éq/kWh*			
GHG costs[15] per unit (2006)	*0,55 Rs/kWh*			
Global cost per unit (2006)	***5 Rs/kWh****	***5.5 Rs/kWh****	***8.7 Rs/kWh****	***4.1 Rs/kWh****

[13] http://cebweb.intnet.mu/ceb/save_energy/save_energy.pdf

[14] Excluding depreciation, fuel and maintenance costs

[15] Considering 1T CO2 equivalent = 20€ i.e. 840 Rs; this is not the price on the carbon market but the environmental cost

Source: CEB; * indicates ARER estimation

ARER's estimation of fuel costs is:

- 3.5Rs/kWh for HFO corresponding to 1/4liter/kWh at 14Rs/liter
- 7Rs/kWh for diesel corresponding to 1/4liter/kWh at 28Rs/liter

The average electricity generation cost per unit for 2006 is estimated at 4.7 Rs/kWh.according to ARER.

These figures do not include costs related to distribution, customer services and administration. These additional costs are estimated at 25 MRs for 2006.

Table 15: Economic and environmental balance - future power stations as planned in 2007

Name	Trèfles
Initial investment	*25 MRs**
Effective capacity	*200 kW*
Planned commissioning date	*2008*
Lifetime	*20 years*
Depreciation time	*15 years*
Depreciation cost (2006)	*1.7 MRs*
Electricity generation (2006)	*0,700 GWh*
Fuel costs (2006)	*0*
Operation & maintenance costs[16] (2006)	*0.8 MRs**
Total costs (2006) depreciation incl.	*2.5 MRs**
Total cost per unit (2006)	***3.6 Rs/kWh****
GHG emissions per unit (2006)	*0*
GHG costs per unit (2006)	*0*
Global cost per unit (2006)	***3.6 Rs/kWh****

Source: CEB; * indicates ARER estimation

Table 16: CEB charges for 2007 according to 2006 consumption

Rate Category	Type of Category	No. of Customer	Net Amount (Rs)	Running charge[17] (Rs/kWh)	Demand charge (Rs/kVA)
Tariff 217	Commercial	23	15 161 856	4.46	142
Tariff 313	Industrial	7	4 387 989	2.37	120
Tariff 317	Industrial	1	25 233	2.17	120
Tariff 515	Irrigation	25	54 439	3.99[18]	
Tariff 510	Street Lighting	7	2 870 714	5.83	
Tariff 110	Domestic	1,407	6 309 423	4.62	
Tariff 110A	Domestic	894	1 135 608	3.29	
Tariff 120	Domestic	7,001	35 694 998	4.62	
Tariff 140	Domestic	628	5 505 023	4.62	
Tariff 215	Commercial	996	27 560 420	7.28	
Tariff 315	Industrial	155	1 418 863	4.09	
SUB -TOTAL		11144	100 124 566		
Meter rent			801 444		
Grand Total			100 926 010		

Source: CEB

The average CEB receipt[19] per unit for 2006 is 3.26 Rs/kWh.

[16] Excluding depreciation, fuel and maintenance costs

[17] http://cebweb.intnet.mu/ceb/tariffs/Overview.asp / Marginal running charges are presented for tariffs with multiple running charges considering the average electricity consumption per customer category

[18] Peak rate per kWh; off-peak rate per kWh = 2 Rs

[19] Including running and demand charge; excluding meter rent

Water situation and its dependency on energy - no water without energy and vice-versa.

The conference proceedings and the different technical approaches revealed the interdependence of water and energy:

- Electric energy is used to fuel the production and distribution of water.
- The water distribution system in certain cases could integrate micro turbines to produce electricity.
- In order to produce water for the population's needs, it is necessary to construct two new "dams" as well as a sea water desalination plant, a high energy-consuming process. This point is highlighted in the 2000 Study "THE RATIONALIZATION, REHABILITATION, UPGRADING AND EXTENSION OF THE WATER TRANSMISSION/DISTRIBUTION NETWORK OF RODRIGUES ISLAND".
- The current system of electricity production requires water to cool the generators.
- In order to store intermittent energy, one solution is to integrate into the systems of water distribution and local planning, reservoirs which stock water (a turbine on a hill) and distribute water (micro hydro electricity).

Water and energy strategies are interdependent. The islands of Madere and El Hierro have combined their water and energy strategies towards water and energy self-sufficiency. Similar strategies are needed in Rodrigues.

The sea water desalination process

The study of a seawater desalination plant dates from 2005: the objective at Mourouk was 5,000 m3/day

Following the study "Desalination project Rodrigues", June 2005, objectives of the project and an overview of the service which were arbitrated in the studies are presented below:

"To cope with the future increasing demand of domestic and tourist drinking water on the island of Rodrigues and to overcome any water deficiency, the RODRIGUES REGIONAL ASSEMBLY (RRA) is considering the development and implementation of a seawater desalination plant as a source of drinking water production and supply in addition to the existing facilities.

A design capacity of **5,000 m3/d** drinking water is the intended plant size, produced by Seawater Reverse Osmosis (SWRO) desalination technology. The plant shall be located at Mourouk and the water produced in the plant will be transferred to the Mourouk drinking water reservoir. At this reservoir it will be mixed with drinking water, originating from natural sources and the resulting water shall than be fed into the drinking water distribution network of Rodrigues.

Extraction of the seawater feed for the SWRO plant should preferably be from beach wells or infiltration galleries, installed at the shore line near to the desalination plant location.

Concentrated brine will be discharged at the "Grand Passe" near the Mourouk site with appropriate location of the discharge point and distribution support to enable intensive mixing and dilution of the salt content with the currents and seawater flow in the passage. Any damage to the sensitive eco-system within the coral reef must be safely avoided. This will be an important issue in the environmental impact assessment to be carried out by the selected contractor.

The desalination project shall be implemented on a turnkey basis. The Contractor shall design, supply, install and commission the desalination plant including the additional works and operate and maintain the complete plant during an initial compulsory period of five years following the successful commissioning of the Plants.

The normal services required from the Contractor are given below:

- Design of the Desalination Plant - The Plant shall have a daily production of 5000 cubic meters of desalinated water satisfying the Drinking Water Standards in force in Mauritius (see Annex B0.1-2) including the application for all required approvals for plant construction and operation with all amendments as required for permit by the permit granting authorities,
- Supply of the Desalination Plants and all required auxiliary systems and accessories,
- Construction of all intake pre-storage and pre-treatment, post storage and post-treatment works required,

- Installation of the Desalination Plants and connection to all pre-storage and pre-treatment works constructed,
- Connection of the outlet of the Desalination Plant to existing service reservoirs via their respective post-storage and post-treatment systems,
- Installation of the outfall system for brine and wash water discharge,
- Operation and maintenance of the Plants for a period of five years,
- To design and carry out all civil, structural and other works required in connection with the proposed Desalination Project including all necessary additional works,
- Design, installation and commissioning of various overland pipelines.

Position of the seawater desalination plant regards the "Environmental and ecological activities of GRENADE area"

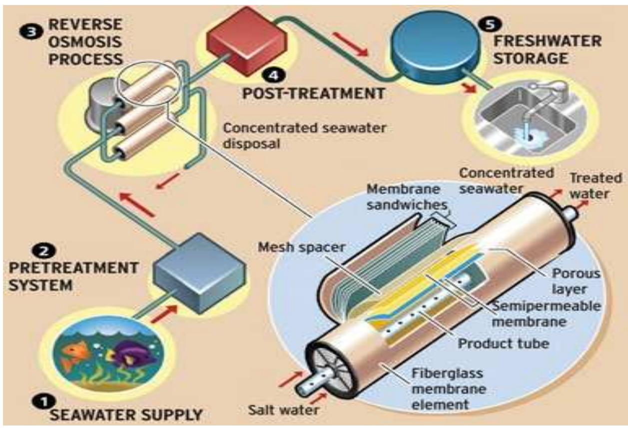
The storage and regulation techniques of wind energy in the form of micro hydraulic production procure an excess of electric energy of wind origin, which can directly feed the desalination process of sea water. Concentrating the desalination plant on the Grenade site represents multiple advantages:

- Land is available and can be allocated under the planning scheme of the zone of ecological activity in Grenade,
- The potential of wind turbine plants is adequate in order to feed the desalination process,
- The pass of River Banane is very close to the coast to receive the pumping and residues.

Evaluation of electricity consumption of the sea water desalination plant

Membrane processes: A more recent and more widely used development, it relies on what is called a semi-permeable membrane to separate salt from water. Simply put, a synthetic membrane is made with pores so tiny that water molecules can pass through it, but other molecules, especially salts, cannot. This separation does not happen easily though; it requires very high pressure to force the water through the membrane. A natural process, called osmosis, operates in all living cells, to equalise the salt concentration on either side of the membrane. Because the process for desalination is the exact opposite, it's called reverse osmosis, or just RO. A pre-treatment stage is required before RO to provide high quality water and reduce membrane soiling. The most common pre-treatment steps include coagulation and filtration or micro filtration.

Table 17: Reverse osmosis process



Desalination is a practical way of making salty water drinkable and it is now used widely around the world, especially in very dry countries, on ships and small islands. The process is quite expensive and requires a lot of energy.

Table 18 : Consumption of energy by different types of desalination plants

Legend :

- Don't know= to be confirmed
- n/a= not applicable
- ABRÉVIATIONS PROCESS: TCD = Thermo Compression Distillation, MVC = Mechanical Vapour Compression, SWRO = Sea Water Reverse Osmosis, BWRO =

Brackish Water Reverse Osmosis, MSF = Multi Stage Flash

- These figures include neither the energy required for pumping from sea level to the plant nor the running of control systems, instrumentation, etc.

Process	Min Power	Max Power	Min Steam	Max Steam	Minimum	Maximum
Units	kWh/tonne	kWh/tonne	kgs/kgd	kgs/kgd	GOR	GOR
BWRO	0.26	1.85	n/a	n/a	n/a	n/a
EDR	dunno	dunno	n/a	n/a	n/a	n/a
MED	0.75	1.75	0.10	1.00	1	10
MED-TC	0.75	1.50	0.07	0.33	3	15
MSF-BR	2.64	3.96	0.08	0.25	4	12
MSF-OT	2.38	3.17	0.13	0.50	2	8
MVC (all elec.)	8.50	12.00	0.03	0.05	20	40
SWRO	3.96	7.93	n/a	n/a	n/a	n/a

- For a 5,000m3/day production, the basic needs of electricity should be evaluated between 19 800 and 39 650 kWh/day (7,2 – 14,6 GWh / year)
- To pump these 5 000 m3 from sea level up to 300 meters for distribution of the water, the basic energy need is 1,5 GWh / year
- TOTAL = 9 – 16 GWh / year

Environmental impacts of the desalination process

It is not possible to use desalination as a water source and to assume that it has no environmental impact. As mentioned earlier, the high energy consumption leads to greenhouse gas production (this is a problem in the case of wind farm electricity). It also produces a very concentrated waste stream of brine (35 grams of salt in every litre of water), and the salt that has been extracted has to be disposed of.

Depending on the process, the salt concentration in the waste stream could be anywhere from double that of the source water, up to a solid salt product (although that would seldom happen in practice). Managing that salt stream is by no means a trivial problem and even in a coastal community, the environmental management issues associated with the brine disposal have to be carefully managed. In an inland community, of course, there is no easy disposal route, so dedicated brine ponds may be needed. There have been proposals to link gourmet salt manufacturing to desalination, but that is not a common occurrence. Yet, a specific impact evaluation of the brine and of its treatment must be carried out.

One treatment technique could consist in pumping the necessary amount of sea water to recombine seawater with brine, before rejecting it back into the ocean. This could be an argument to develop the "ETM". So the Environmental and Ecological Activities Area of Grenade could dispose of a lot of fresh and clean sea water, without any electricity consumption, and be allotted to different applications.

Financial investment and exploitation costs

A significant part of the cost equation for desalination is due to the high energy consumption, (that should not be a problem in the case of wind farm electricity).

But desalination plants are sophisticated pieces of equipment with high capital costs and also quite significant maintenance requirements. Desalination plants do not last as long as traditional water treatment plants, so the capital cost has to be amortised over a relatively short life, which also adds to the cost. The actual cost for a given plant is very site specific and also depends on the size of the plant. To give a very rough idea, it is now possible to produce desalinated water from seawater for slightly more than 1 euro/m3, if the plant is large, for instance 100,000 m3/day (serving a medium-sized city for example). For smaller plants and less favourable conditions, the cost could be 3 euros/m3 or more.

A desalination plant is complex and presents serious challenges in terms of corrosion and soiling, regardless of the specific process being used. While it is possible to design a small RO plant for rugged conditions for example, it is not feasible to expect a large desalination plant of any sort to operate reliably without expert operational and maintenance support. This means that implementing desalination in small, remote communities has to be dealt with carefully, if significant breakdowns are to be avoided.

VI / Potentials for sustainable energy technologies

From a technical point of view, a sustainable energy situation can be achieved by combining three types of solutions:

- Rational Use of Energy (RUE)
- Renewable Energy Sources (RES)
- Control and storage of intermittent RES

Applied to electricity self-sufficiency, this means:

- saving electricity with Rational Use of Electricity
- producing local electricity with Renewable Electricity Sources
- controlling intermittent renewable electricity with electricity storage

Rational use of electricity is demand-side orientated, whereas renewable electricity generation, as well as control and storage of intermittent renewable electricity offer solutions for electric systems management.

Such technologies will be presented and their potential when applied to Rodrigues will be evaluated. The environmental & economic impacts will also be presented. After which a possible plan and schedule will be proposed.

These technologies will constitute the technical basis for an integrated energy policy aiming at developing sustainable electricity consumption and production. Integrated energy solutions will then be presented.

Rational Use of Electricity (RUE)

RUE aims at saving energy by addressing each type of final electricity consumption. The method used consists in analysing each sector's consumption items. It implies that electricity balance, as well as sector-based audits, have been performed. From an institutional point of view, this activity could be led by a regional energy observatory.

The two main energy consumer sectors are:

- households (customer category: domestic):
- service sector (customer category: commerce):

To a certain extent, these 2 sectors share similar electricity consumption items:

- lighting
- electrical appliances
- water heating
- air-conditioning

Energy saving technologies addressing these items will be presented. Extrapolations will be carried out from current saving potential to future potential. From these sectors saving potentials, hypothesis on other sectors saving potentials will be proposed,

The Ministry of Public Utilities, the CEB and other actors have published a "save energy" guide[20] concerning energy saving in households. This guide will be used.

The estimations of the CEB savings on fuel bills, which will be presented below, are based on:

- electricity generation reduction due to final consumption savings: consumption = 80% of generation
- fuel cost per type of electricity generation

20 http://cebweb.intnet.mu/ceb/save_energy/save_energy.pdf

Low energy lighting

Technology presentation

A 15W low energy light bulb provides the same lighting as a 75W incandescent light bulb. However, they do not have the same price, life length nor electricity consumption.

Table19: Comparison between a Low Energy Light Bulb and an Incandescent Light Bulb

Light bulb[21]	**Low energy**	**Incandescent**
Power	15 W	75W
Lighting capacity	900 lumens	960 lumens
Price	100 Rs	15 Rs
Life length	6000 h	1000 h
Equivalent life length in years[22]	6 ans	1 an
Electricity consumption over life length	90 kWh	75 kWh
Yearly electricity consumption	15 kWh	75 kWh
Global cost over life length	515 Rs	278 Rs
Yearly cost	**86 Rs**	**361 Rs**
GHG emissions per bulb over life length[23]	59 kgCO2eq	49 kgCO2eq
Yearly GHG emissions per bulb	**10 kgCO2eq**	**49 kgCO2eq**

Despite a lower yearly cost for low energy light bulbs, domestic customers prefer incandescent bulbs. This can be explained by:

- higher initial investment with low energy bulbs
- lack of information

Global energy saving potential

The Potential figure for this solution when applied to domestic customers is estimated at 4 low energy light-bulbs per household i.e. 40 000 low energy light-bulbs for Rodrigues. The potential electricity saving with all households using low economy light-bulbs is estimated from 0.6 GWh to 2.4 GWh per year, depending on real lighting habits[24].

Besides electricity consumption reduction, low energy bulbs also reduce the power load. If households use their lights at peak load, then 40000 low energy bulbs will reduce the peak load of the system. As installed capacity depends on the peak load, 40 000 low energy bulbs would also reduce initial investment in power stations. Peak load reduction varies from 0.6 to 2.4 MW[25]. The following figures are examples to explain this phenomenon: power load for lighting is divided by 5.

Efficient lighting can be developed in the commercial sector and industry. Energy efficiency can also be applied to public lighting. The corresponding saving potentials should be investigated.

[21] Cost analysis was done considering the marginal running charge for domestic customers: 4.62 Rs/kWh

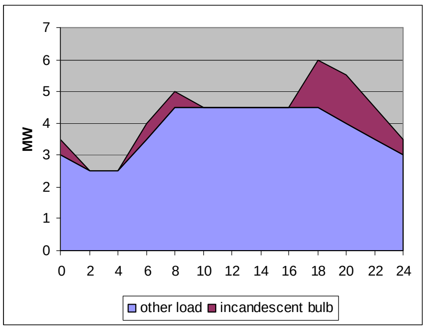
[22] Assuming 3hrs/d of functioning

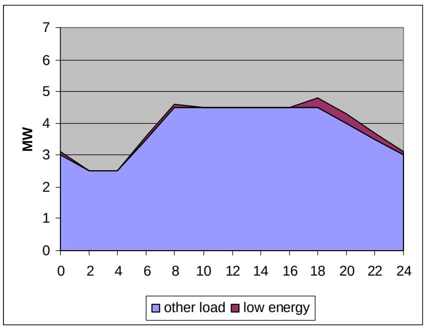
[23] Assuming 654gCOeq/kWh

[24] 0.6GWh corresponds to an average lighting habit of **one** light-bulb functioning 3 hrs/d per household (1000h per year); 2.4GWh corresponds to **four** light-bulbs functioning 3 hrs/d per household

[25] 0.6MW corresponds to an average lighting habit of **one** light-bulb functioning during system peak load per household; 2.4MW corresponds to **four** light-bulbs functioning during system peak load per household

Figure 19: impact of low energy bulbs on peak load





Implementation cost – Economic and environmental impacts

The extra-cost of one low energy bulb compared to an incandescent bulb is 60 - 85 Rs. The extra-cost for 40 000 low energy bulbs is 2 400 000 – 3 400 000 Rs. The following table shows the economic impact of low energy bulbs on households and on CEB as well as the environmental impact on GHG emissions.

Table 20 : economic impact of low energy bulbs on households and on CEB

40 000 low energy bulbs	
Cost	**3.4 MRs**
Life-length	6 years
Yearly electricity saving	0.6 – 2.4 GWh
Total electricity saving over life-length	14.4 GWh
Peak load reduction	0.6 – 2.4 MW
Yearly saving on electricity bill per household 110A / others[26]	**200-685 / 277-1100 Rs**
Yearly saving on fuel bill for CEB[27]	**5.25 – 13.13 MRs**
Yearly reduction on CEB receipts	2.77 – 9.33 MRs
Global cost for 1MW peak load reduction over 30 years[28]	**5 – 29 MRs**
Investment cost for 1MW HFO power station (30 years)[29]	**57 MRs**
Yearly GHG emissions reduction	390 – 1 560 Tons CO2 eq
Yearly GHG emissions cost saving (1TCO2 = 840 Rs)	0.327 – 1.310 MRs
Total GHG emissions reduction over life length	**9 400 Tons CO2 eq**

Schedule and partnership

The project with regards to households should be implemented on a short-term basis: 2008-2010.

A feasibility study is necessary to estimate the actual number of low energy bulbs as well as to launch a consultation phase with appliance distributors and customers. Evaluation of the actual type and number of low energy bulbs on Rodrigues is necessary. From 2011, it is considered that all households will use low energy bulbs.

Energy efficiency in industrial and commercial lighting as well as public lighting can implemented from 2011 following studies to be carried out from 2008 to 2010.

The CEB could be the project leader as well as the main finance provider.

26 excluding saving on incandescent bulbs purchasing; tariff 110A customers marginal running charge is 3.29Rs/kWh for initial 120kWh saving then 2.37Rs/kWh; other savings are at a marginal charge of 4.62 Rs/kWh

27 Assuming that low energy bulbs reduce 750MWh generation from diesel at Port Mathurin and the rest from HFO

28 Calculation considers that a peak load reduction of 0.6 – 2.4 MW costs 2..22 – 3.145 MRs for 6 years

29 Considering 226 MRs were invested in 2x1.98MW Pte Monnier power station

Energy efficient appliances – fridge and freezer

Technology presentation

Energy efficiency in industrial and commercial lighting as well as public lighting can implemented from 2011 following studies to be carried out from 2008 to 2010.

As with low energy light bulbs, energy-efficient appliances provide the same service as others, with lower electricity consumption. The "save energy" guide from MPU and CEB provides an example of a combined fridge-freezer. It is also relevant for small businesses (tariff 215).

Despite a lower global cost for energy efficient appliances, domestic and commercial customers may prefer non-efficient appliances. This can be explained by:

- the higher initial investment with energy efficient appliances
- the lack of information

For larger companies, energy audits need to be completed.

Similar approaches are also possible in industry with a specific approach for each site.

Table 21: energy-efficient appliances with lower electricity consumption fridge-freezer for house holds

Combined fridge-freezer for household	Efficient	Non-efficient
Volume	350 L	300 L
Price	16 000 Rs	12 000 Rs
Life length	10 years	10 years
Yearly electricity consumption	480 kWh	720 kWh
Global electricity cost over life length	19 200 Rs	28 800 Rs
Global cost over life length	**35 200 Rs**	**40 800 Rs**
GHG emissions over life length[30]	3139 kgCO2eq	4709 kgCO2eq
Yearly GHG emissions per appliance	**314 kgCO2eq**	**471 kgCO2eq**

Table 22: energy-efficient appliances with lower electricity consumptions fridge-freezer for small business

Combined fridge-freezer for small business	Efficient	Non-efficient
Volume	350 L	300 L
Price	16 000 Rs	12 000 Rs
Life length	10 years	10 years
Yearly electricity consumption	480 kWh	720 kWh
Global electricity cost over life length	34 944 Rs	52 416 Rs
Global cost over life length	**50 944 Rs**	**64 416 Rs**
GHG emissions over life length[31]	3139 kgCO2eq	4709 kgCO2eq
Yearly GHG emissions per appliance	**314 kgCO2eq**	**471 kgCO2eq**

Global energy saving potential

The potential for this solution depends on the actual appliances in use in Rodrigues. The following hypothesis will be used:

- 95% of households equipped (9 000) + 100% of small commerce/hotels (1 000)
  - **10 000 combined fridge-freezers**
- Repartition of combined fridge-freezer:
  - 25% energy-efficient; price = 16 000 Rs
  - 25% with 80kWh yearly over-consumption; price = 14 500 Rs
  - 25% with 160kWh yearly over-consumption; price = 13 000 Rs
  - 25% with 240kWh yearly over-consumption; price = 12 000 Rs

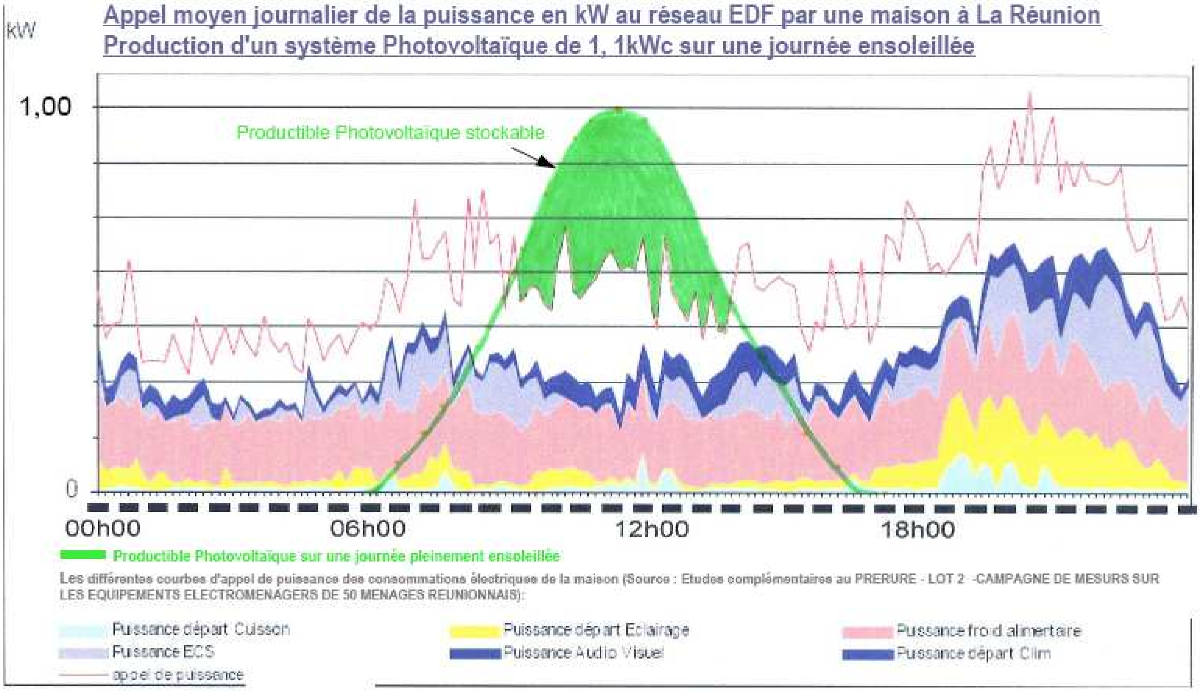
30 Assuming 654gCOeq/kWh

31 Assuming 654gCOeq/kWh

- **Total yearly electricity over-consumption = 1.2 GWh**
- **Total electricity over-consumption over 10 years = 12 GWh**

The impact of energy efficient fridges and freezers on peak load needs to be investigated in the case of Rodrigues households. It is probable that power load will be reduced. The following figure shows a detailed household daily demand with all items.

Figure 20: fridge- freezer impacts on daily peak – load charge of a household in Réunion Island



Implementation cost – Economic and environmental impacts

The extra-cost of 10 000 energy-efficient fridge-freezers compared to the previous hypothesis of repartition is 21 250 000 Rs. This budget is to be spent over a period of 10 years and will be used to change all fridges and freezers which have reached end of life. This means a yearly budget of 2 125 000 Rs i.e. a yearly budget per customer of 213 Rs.

The following table shows the economic impact of energy-efficient fridge-freezers on households/small businesses/hotels and on CEB as well as the environmental impact on GHG emissions.

Table 23: economic and environmental impacts of energy efficient fridge-freezers

10 000 energy efficient fridge-freezers	
Cost	21.25 MRs
Life-length	10 years
Yearly cost if spread over life-length	2.125 MRs
Average electricity saving per customer	120 kWh
Yearly electricity saving	1.2 GWh
Total electricity saving over life-length	12 GWh
Yearly saving on electricity bill per house hold 110A / 110&120 / 140[32]	284 / 490 / 554 Rs
Yearly saving on electricity bill per small commerce/hotel[33]	874 Rs
Yearly saving on fuel bill for CEB[34]	5.25 MRs
Yearly reduction on CEB receipts	5.158 MRs
Yearly GHG emissions reduction	785 Ton CO2 eq
Yearly GHG emissions cost saving (1TCO2 = 840 Rs)	0.659 MRs
Total GHG emissions reduction over life length	7 850 Ton CO2 eq

32 Depending on new marginal running charges after electricity saving from low energy bulbs: 4.62Rs/kWh for tariff 140, 4.09 Rs/kWh for tariffs 110 & 120, 2.37 Rs/kWh for tariff 110A

33 With running charge of 7.28 Rs/kWh

34 Assuming that energy efficient fridges and freezers prevents electricity generation from HFO at Port Mathurin

Schedule and partnership

This project should be implemented on a mid-term basis: 2011-2015.

A feasibility study is necessary to estimate the actual repartition of appliances per energy categories as well as to launch a consultation phase with appliance distributors and customers.

Cost difference between efficient and non-efficient appliances is expected to decrease as is already the case in European countries. The operation should be financed by households through a reimbursement system based on electricity bill savings. It is therefore necessary to find the initial investment body.

RRA or CEB could be the project leader. A bank or CEB would provide the initial investment.

Impact of use of energy-efficient appliances for large commerce and industry could be evaluated progressively through sector -based and site audits. Implementation for these sectors could also start from 2011.

After 2011, it will be considered that every new customer will use energy efficient appliances.

Energy saving attitude and behaviour

Technology presentation

No particular technology is involved here. Consumers' behaviour has a large impact on final electricity consumption. This is all the more important regarding appliances with the "stand-by" option. Appliance stand-by power consumption is not negligible as these appliances spend most of their time on "stand-by".

The MPU & CEB "save energy" guide provides estimations of potential electricity saving by choosing to switch off an appliance instead of simply putting it on stand-by.

Table 24 : appliance stand-by power consumption

Appliance \ yearly power consumption	Real functioning	Stand-by
TV	146 kWh	37 kWh
VCD/DVD		26 kWh
Hi-Fi		22 kWh
Video recorder		30 kWh
Microwave oven		23 kWh
Total power consumption		**138 kWh**
Average household electricity bill		**454 Rs**
Small commerce electricity bill		**1000 Rs**
Yearly GHG emissions		**90 kgCO2eq**

Adapted from CEB

Energy saving behaviour does NOT cost anything besides the willingness to pay attention to energy consumption. The minimum effort which everybody could make is to switch off an appliance as soon as it is no longer needed. Obviously, appliances like fridges and freezers must remain switched on at all times.

Energy saving behaviour is not widespread enough amongst the population. This can be explained by a lack of information as well as a lack of interest from customers.

Global energy saving potential

The energy saving could potentially be 50% of the power consumption from TVs, VCD/DVDs and Hi-Fis concerning all households and small businesses/hotels who implement correct energy saving behaviour.

- Stand-by power consumption for TV, VCD/DVD and Hi-Fi: 85 kWh
- 50% of stand-by power consumption for these appliances for all households and small business/hotels:
    - **10 000 x 50% x 85 kWh**
    - **Total yearly electricity saving = 0.425 GWh**

Impact on peak load reduction needs to be investigated.
Saving potential in other sectors due to energy saving attitude needs to be investigated.

Implementation cost – Economic and environmental impacts

There is no direct cost concerning appliance/technology purchasing. The only direct cost concerns the implementation of a communication campaign on this issue.

The following table shows the economic impact of energy saving behaviour on households/small business/hotels and on CEB as well as environmental impact on GHG emissions.

Table 25 : economic and environmental impacts of Energy saving behaviour

Energy saving behaviour	
Cost	0
Life-length	N/A
Yearly cost if spread over life-length	0
Average electricity saving per customer	42.5 kWh
Yearly electricity saving	0.425 GWh
Total electricity saving over life-length	N/A
Yearly saving on electricity bill per household 110A / 110&120 / 140[35]	100 / 174 / 200 Rs
Yearly saving on electricity bill per commercial customer[36]	310 Rs
Yearly saving on fuel bill for CEB[37]	1.86 MRs
Yearly reduction on CEB receipts	1.660 MRs
Yearly GHG emissions reduction	278 Ton CO2 eq
Yearly GHG emissions cost saving (1TCO2 = 840 Rs)	0.233 MRs

Schedule and partnership

This project should be implemented on a short-term basis: 2008-2010.

A short feasibility study is necessary to establish all means of communication that could be used. All the material for this communication campaign is ready as MPU & CEB had already prepared it for the "save energy" campaign.

CEB could be the project leader as it has already carried out similar actions.

Depending on the sector and site audits, this could be organised by the regional energy observatory, similar action could be developed in the other sectors.

35 Depending on new marginal running charges after electricity saving from low energy bulbs: 4.62Rs/kWh for tariff 140, 4.09 Rs/kWh for tariffs 110 & 120, 2.37 Rs/kWh for tariff 110A

36 With running charge of 7.28 Rs/kWh

37 Assuming that electricity generation reduction is from HFO at Port Mathurin

Bioclimatic design and energy efficient air-conditioning

Technology presentation

Bioclimatic design refers to building design adapted to the local climate conditions: it aims at optimizing building users comfort and reducing building impacts on environment. It uses techniques like building orientation in regards to sun movement, vegetal surroundings, thermal isolation of walls and roofs, natural ventilation as well as solar protection. It also considers use of electric fans when necessary.

Energy efficient air-conditioning refers to all means of reducing air-conditioning electricity consumption: choosing an efficient appliance, protecting air-conditioning motors from direct solar rays, increasing room temperature levels,...

Thanks to bioclimatic design and energy efficient air-conditioning, air-conditioning electricity consumption can be reduced by more than 80%.

Bioclimatic design and energy efficient air-conditioning is considered to represent an extra-cost of 5 to 10% with a ROI time from 5 to 10 years.

Global energy saving potential

The main potential of energy saving is linked to electricity consumption in air-conditioning:

- Number of air-conditioning units: 600 in hotels and public administration
- Average consumption by unit: 1500 kWh/year
- Yearly electricity consumption for air-conditioning = 900 MWh
- Yearly energy saving potential = 720 MWh
- Yearly GHG emissions reductions: 471 tons CO2 eq
- Life length of material and equipment for bioclimatic design: more than 30 years
- Global electricity saving potential over life-time: 21.6 GWh
- Global GHG emissions reductions over life-time: 14 100 tons CO2 eq

Impact on peak load reduction needs to be investigated.

Use of air-conditioning in other sectors like households and industry needs to be studied.

Implementation cost – Economic and environmental impacts

Direct cost with bioclimatic design needs to be evaluated. In Reunion Island, it is considered that it introduces an initial extra-cost of 10% with a ROI time from 5 to 10 years.

Besides positive direct impact on the environment, society and local economy, there are also multiple positive indirect impacts: health, productivity, etc.

Saving on fuel bill for CEB could be 4.9 MRs.

Schedule and partnership

This project should be implemented on a short to mid-term basis: 2008-2015.

All studies about bioclimatic design adapted to Rodrigues Island could be carried out during 2008. Pilot projects could be implemented in 2009 and 2010. Guides and communication campaigns would promote this solution.

From 2010, bioclimatic design could be made mandatory for communal buildings (individual houses excluded). Bioclimatic design for individual houses could be promoted from 2011 and made mandatory from 2016.

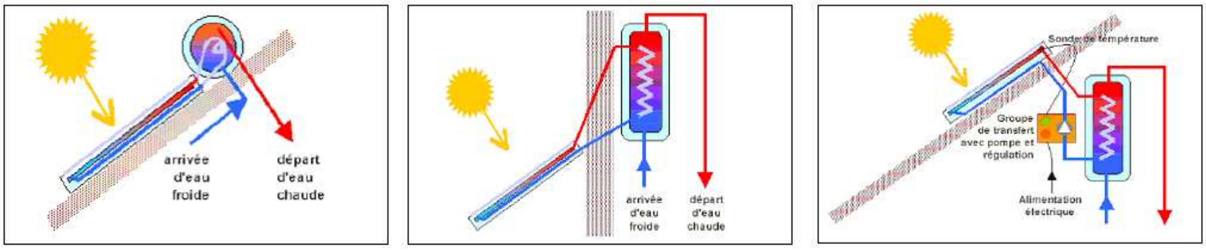
In the first phase, actions could focus on collective buildings: in particular, hotels and public buildings.

CEB and RRA could jointly act as leader for the project.

Solar water heaters

Technology presentation

Figure 21: solar water heater technologies



Monobloc	Thermosiphon à éléments séparés	A éléments séparés avec pompe et régulation

A solar hot water system is composed of solar panels, where water is heated due to solar radiation, and a tank, where hot water is stored. There are multiple sizes to comply with all types of demand. For a family of five or more, the most common solar water heater used is a 300l storage tank and 4m² solar panels.

Note that in the case of Mauritius and Rodrigues, a second tank is integrated in the system to store additional water. The architectural integration then becomes an issue.

Figure 22: example of actual type of solar water heater installed on Rodrigues Island

Solar hot water systems are considered to last 20 years whereas electric systems last less than 10 years. In order to be conservative on solar systems profitability, calculations are made with 10 years life length for both types.

Despite a lower global cost for solar hot water systems, these systems are not sufficiently used amongst the population. This can be explained by:

- the higher initial investment as with low energy bulbs
- the lack of information
- the lack of confidence in the quality of products available in Mauritius

- the lack of confidence in maintenance and guarantees

Figure 23: an old solar water heater on a waste disposal

It is most important to underline the question of recycling all the waste from electrical appliances, including solar-powered systems. For example, we can actually find disposed of solar water heater systems in certain districts of Port Mathurin.

Table 26 : comparison between solar water heater and electric TRITON type

Hot water systems	Solar	Electric TRITON type
Electric power	0	8 kW
Hot water capacity	300l / 4m²	-
Price	35 000 Rs	5 000 Rs
Life length	10-20 years	5-10 years
Yearly electricity consumption	0	1000 - 2000 kWh[38]
Yearly electricity bill for domestic customers – tariff 140[39]	0	4 620 Rs
Yearly electricity bill for small hotels – tariff 215[40]	0	10 920 Rs
Yearly electricity bill for large hotels – tariff 217[41]	0	16 000 Rs
Global cost for 10 years – domestic customer	35 000 Rs	51 200 Rs
Global cost for 10 years – small hotels	35 000 Rs	104 000 Rs
Global cost for 10 years – large hotels	35 000 Rs	165 000 Rs
Yearly GHG emissions	0	654 - 1308 kgCO2eq

Global energy saving potential

450 electric showers are currently in use in households[42]. It is considered that 300 hot water systems are currently in use in small and large hotels, including the new offices of the "Françoit Leguat Reserve":

- 200 electric: 100 in small hotels and 100 in large hotels
- 100 gas in large hotels

Potential electricity saving with this technology concerns:

- 450 electric showers in households □ 450 MWh potential saving
- 100 electric showers in small hotels □ 150 MWh potential saving
- 100 electric shower in large hotels □ 200 MWh potential saving

38 Assuming there is 20 minutes to 40 minutes of daily functioning

39 Assuming 1000 kWh yearly consumption at marginal running charge of 4.62Rs/kWh

40 Assuming 1500 kWh yearly consumption per electric shower at marginal running charge of 7.28Rs/kWh

41 Assuming 2000 kWh yearly consumption per electric shower at running charge of 4.46 and assuming that each electric shower generated 4kVA demand at 149 Rs/kVA month demand charge

42 UNDP - Rodrigues Regional Assembly, *Synthesis Paper - Formulation of a Sustainable Integrated Development Plan for Rodrigues*, KPMG Advisory Services Ltd, August 2006. pp 259

- **Total potential electricity saving = 0.8 GWh**

Solar hot water systems are also relevant as a means to prevent future electricity consumption growth as both tourism development and social development will increase hot water demand. With solar water heater development, future needs will naturally be directed towards a sustainable solution.

Impact on peak load reduction needs to be investigated. However, as shown on figure "fridge-freezers impact on daily peak – load charge of a household on Réunion Island", the solar water heater impacts positively on the peak load.

The Olympic swimming pool requires a specific study to assess the accurate need in solar water: the swimming pool is actually heated by electricity. Data have to be collected.

Implementation cost – Economic and environmental impacts

For this technology, two separate operations should be launched:

- one operation for businesses/hotels: 300 units
- another for households: 450 units

The reason for having two operations is that solar hot water systems have different profitability depending on the end-user category:

- ROI time for businesses/hotels: less than 3 years
- ROI time for households: 7 years

The following table shows the economic impact of 300 solar hot water systems on businesses/hotels and on CEB as well as environmental impact on GHG emissions.

Table 27 : economic and environmental impact of 300 solar hot water systems for hotels

300 solar systems for hotels	
Cost	10.5 MRs
Life-length	10 years
Yearly cost if spread over life-length	1.05 MRs
Yearly electricity saving per hotel – small / large	1500 / 2000 kWh
Yearly electricity saving	0.35 GWh
Total electricity saving over life-length	3.5 GWh
Yearly saving on electricity bill per solar system per hotel – small / large[43]	10 920 / 16 000 Rs
Return On Investment time[44]	3 years
Yearly saving on fuel bill for CEB[45]	1.53 MRs
Yearly reduction on CEB receipts	2.692 MRs
Yearly GHG emissions reduction	229 Ton CO2 eq
Yearly GHG emissions cost saving (1TCO2 = 840 Rs)	0.192 MRs
Total GHG emissions reduction over life length	2 290 Ton CO2 eq

As this operation is profitable for hotels with a rather short ROI time, no other financing is needed. However, it is necessary to guarantee the systems quality as well as an efficient maintenance system.

The following table shows the economic impact of 450 solar hot water systems for households and on CEB as well as environmental impact on GHG emissions.

43 Excluding saving on initial investment for electric system purchasing; relevant for replacement of electric system

44 Including saving on initial investment for electric system purchasing

45 Assuming that solar hot water systems reduce electricity generation from HFO at Port Mathurin

Table 28: economic and environmental impact of 450 solar water heating systems for households

450 solar systems for households	
Cost	15.75 MRs
Life-length	10 years
Yearly cost if spread over life-length	1.575 MRs
Yearly electricity saving per hotel – small / large	1000 kWh
Yearly electricity saving	0.45 GWh
Total electricity saving over life-length	4.5 GWh
Yearly saving on electricity bill per household – tariff 140[46]	4 620 Rs
Yearly saving on fuel bill for CEB[47]	1.97 MRs
Yearly reduction on CEB receipts	2.08 MRs
Yearly GHG emissions reduction	294 Ton CO2 eq
Yearly GHG emissions cost saving (1TCO2 = 840 Rs)	0.247 MRs
Total GHG emissions reduction over life length	2 940 Ton CO2 eq

Schedule and partnership

This project should be implemented on a short to mid term basis:

- 2008-2010 for operation with hotels
- 2011-2015 for operation with households

The cost of solar systems should decrease for households following the operation which should have already been set up with hotels.

A feasibility study is necessary to estimate the actual need of hot water in hotels: solar hot water systems could also provide hot water for laundry, kitchens and swimming pools. The feasibility phase could also allow for negotiation with solar system providers on systems price, guarantee and maintenance.

Concerning solar systems in hotels, the project leader could be a hotel association, if it exists, or RRA.

The operation with households should be financed by households through a reimbursement system based on electricity bill savings. It is therefore necessary to find the initial investment body. RRA or CEB could be the project leader. A bank or CEB would provide the initial investment.

Summary for RUE

So far, five energy solutions were identified for reducing electricity consumption of domestic and commercial customers. These options can save from 3.75 GWh to 5,5 GWh i.e. from 16 to 25% of these sectors specific consumptions i.e. from 14 to 21% of total final electricity consumptions. These solutions can reduce peak load by up to 2.4 MW i.e. 37%.

Table 29: RUE operations, electricity saving potential and peak load reduction potential

Operation	Electricity saving potential		Peak load reduction potential		Yearly direct economic impacts (MRs)		
	Gross value (GWh)	Ratio to total consumption (%)	Gross value (MW)	Ratio to peak load (%)	Cost	CEB fuel bill saving	Saving on investment
40 000 low energy bulbs	0.6 – 2.4	2.3% - 9.3%	0.6 – 2.4	9 % – 37 %	0.7	5.25 – 13.13	1.9
10 000 efficient fridge-freezers	1.2	4.6%			2.125	5.25	
Energy saving behaviour	0.425	1.6%			0	1.86	
Bioclimatic design & efficient air-conditioning	0.72	2.8%			?	4.9	
750 solar systems	0.80	3.1%			2.625	3.5	

46 Excluding saving on initial investment for electric system purchasing

47 Assuming that energy efficient fridges and freezers reduce electricity generation from HFO at Pte Monnier

TOTAL	3.75 – 5.5	14.5% - 21.3%	0.6 – 2.4	9 % - 37%	5.5	15.86 Excl. bioclimatic	1.9

Other energy saving solutions for the domestic and commercial sectors could be listed. All other sectors (industry, public lighting, irrigation) should be audited therefore additional energy saving solutions could be listed.

From the currently identified saving potential, one could venture a hypothesis for the global saving potential. ARER considers that energy saving solutions could reduce final electricity consumptions as well as peak load by 20 to 30%.

For 2006, it represents 5 to 7.5 GWh and 1.3 to 2 MW. If no action is taken to save electricity and consumption continues to be based on the same current appliances and behaviour, then the energy saving potential will remain from 20 to 30% applied on a larger basis. This potential will be used, in the following chapters, to establish an energy scenario with RUE.

Table 30: Global RUE potential - electricity saving and peak load reduction - according to ARER

Global electricity saving potential		Peak load reduction potential	
2006 gross value (GWh)	Ratio to total consumption (%)	2006 gross value (MW)	Ratio to peak load (%)
5 – 7.5 GWh	20 – 30 %	1.3 – 2 MW	20 - 30 %

Given the 20% ratio of loss from production to consumption, 5 – 7.5 GWh (20-30%) of electricity saving at the end-user side represents 6.2 – 9.4 GWh of production reduction (still 20-30%).

Renewable electricity generation

This chapter investigates electricity generation with renewable energy sources. The following sources were investigated:

- biomass: biogas or wood-fired power stations
- solar energy: photovoltaic systems
- wind-power: wind farms
- marine energy: wave, tide,...

Those sources and the associated technologies will be analysed and compared to the current means of production.

Wood-fired power station and gasification

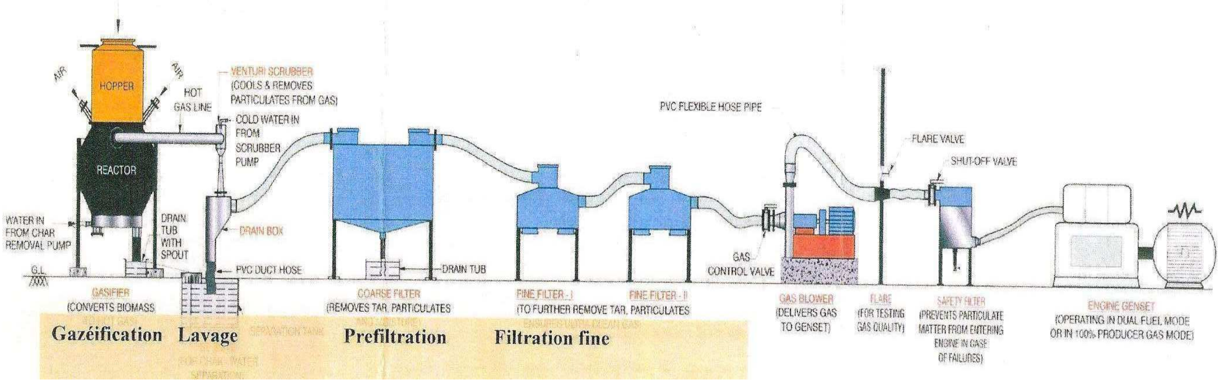
Besides economic development and climate change issues which are part of deforestation, the wood-fired power station could also participate in reducing greenhouse gaz emissions. The technology of biogas is very reliable. They both offer the advantage of being able to provide the base of the CEB load curb and are not intermittent energies like as windpower or solar panels.

In the Indian Ocean, bioenergy is implemented in Madagascar through a robust and well adapted Indian technology which is used by the company 'Bionerr'. These operations are being developed throughout the world, particularly in India. They are sustainable as long as the ressources come from wood or vegetal waste or from controlled wood production organisations in forestry or agriculture.

Technology presentation - Source BIONERR :

« Gasification is the chemical process that transforms solid biomass into a combustible gas. It is possible to produce biogas from all sorts of biomass: wood, corn cobs, rice bales, nutshells, etc. This could be used for thermal or electrical energy. 3, 5 kg of wood transformed into biogas is equivalent to 1 litre of diesel oil or 1 kg of gas. » It is possible to set up a power station ranging from 9kW to 1 MW.

Figure 24: gasification synoptic - source BIONERR



The advantages of biogas are: high productivity, green energy, no smoke emissions. Biomass is a source of renewable energy.

- Thermal energy: gas is produced in a reactor and passes through a coarse filter before being used in a burner. Possible usage: heaters, ovens, dryers.
- Electricity in dual fuel mode: the bio gas is produced in a reactor. It then goes through fine filters. It is injected to a standard diesel generator through a T pipe. This technology saves up to 70% of diesel use. It is a flexible solution which usually provides ROI in less than one year.
- Electricity in 100% biogas mode: the biogas is produced in a generator. It then goes through fine filters. It is then used in an engine which has been specially designed for this purpose. Advantage: diesel is no

longer needed therefore it is very economical. Disadvantage: investment is higher as these engins are manufactured in small numbers. This solution is less flexible as the consumption needs to be as high as 50% of the nominal power.

Technical features for a 1Mw unit (source : BIONERR)

- Wood consumption is on average 1.3 kg per kWh
- Yearly operating time is 8140 hours. (Switched off : 2 hours every two days for cleaning, 12 hours per month for maintenance, 5 days a year for maintenance)
- Effective Electrical Power is 800 kW.
- Total electrical generation is 6.5 GWh per year
- Total heat generation is 12 GWh per year.
- Wood consumption for such production is 8450 tons.
- Equipment life-length is about 20 years.
- Yearly maintenance and operation costs are 5% of investment.
- Maintenance: easy, as complex maintenance concerns only the engines.

Global electricity generation potential

Concerning the biomass ressources, an assessment must be carried out in association with the Forest and Water Boards to establish production capacity from the available forests.

In Madagascar, for example, Eucalyptus tree forests produce between 5 and 25 tons per year and per hectare depending on their situation. In India, high density and irrigated Eucalyptus tree plantations can produce up to 100 tons per hectare per year!

On the basis of a 10 ton per year and per hectare production, **845 hectares are needed to supply the 1MW unit in Rodrigues.**

In order to reach the 20% humidity rate necessary for the production of biogas, a 3 month stock must be set up in order to prepare and dry out the wood. In other words: 3,000 tons of wood or 10 000 steres. A 2 hectares area is sufficient to install both the necessary biomass stock and the plant itself.

Set up and operating costs depend on local costs and the chosen level of automation in biomass preparation process. A detailled survey should be carried out at a later stage.

Note that the current forest surface availble for exploitation is 3500 hectares. Reforestation could generate an increase to 4,500 hectares.

Gasification potential could be estimated at 3 MW by exploiting around 50% of this surface area. Choosing one specific variety of wood for energy could eventually triple this potential outcome.

Furthermore, there is potentially an extra source of energy for 1MW by using organic waste, such as vegetal waste and animal manure.

Implementation cost – Economic and environmental impacts

The initial investment cost is around 1M€.

Fuel cost could be closer to 1000 Rs/Ton than 2000Rs/ton. All calculations use 2000Rs/Ton to be sure not to under-estimate costs.

Operation and maintenance costs should be around 5% of initial investment.

Table 31: cost and environmental impact for a 1MW wood gasification power system

Biomass system	Wood gasification power system
Installed capacity	1 MW
Effective capacity	800 kW
Initial investment	42 MRs
Life length	20 years
Depreciation time	15 years

Yearly depreciation cost	**2.8 MRs**
Yearly electricity generation	6.5 GWh
Yearly heat generation	12 GWh
Fuel consumption	8 450 Tons
Fuel cost (assuming 2000 Rs/Ton)	**19 MRs**
Operation & maintenance costs	**2.1 MRs**
Total costs, depreciation incl.	**24 MRs**
Generation cost per unit	**3.7 Rs/kWh**
Yearly GHG emissions	0
Yearly saving on fuel bill for CEB (HFO)	**21 MRs**
Yearly GHG emissions reduction	4 250 Ton CO2 eq
Yearly GHG emissions cost saving (1TCO2 = 840 Rs)	**3.6 MRs**

Schedule and partnership

All forest and agricultural sectors must be involved in the reforestation programme and in the collection of agricultural waste such as corn cobs. Is it possible to envisage local fishermen becoming involved in the reforestation campaign as well as forest maintenance and wood collection during their low season.

For electricity production: CEB

For a general feasibility study: Consultancy Firm

For land reservation (2 hectares per MW unit) : inscription in the Global Territory Plan by the local authority

Schedule:

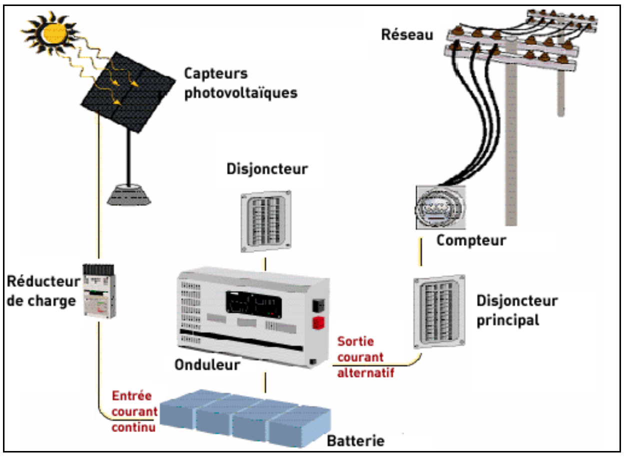
- 2008: detailled study and localization of 2 units according to wood collection and connection to the CEB Medium voltage network
- 2009-2010: technical study and detailed set up of the first 1 MW unit
- 2011-2015: technical study and detailed set up of the second 1MW unit
- 2016-2025: study and detailed set up of the third 1MW unit
- 2026-2050: study and set up of the fourth 1MW unit

Solar electricity – photovoltaic systems

Technology presentation

Numerous technologies exploit solar energy to produce electricity. Only photovoltaic systems were investigated as they have the lowest impact on land-use. Actual local solar radiation data are needed to establish photovoltaic systems production. A PV system is constituted of PV panels producing DC and a DC to AC converter. A 1kWe system needs 8 m² panels: i.e. current PV output to input ratio is 12.5%. A 1kWe system is defined as a system capable of providing 1kW with an optimal solar radiation (1kW of solar radiation per m² and perpendicular to panel). Given Réunion Island and Mauritius solar radiations, the production of a 1kWe PV system varies from 1500 to 2000 kWh. PV systems can be connected to the electricity grid. They can also be used for off-grid applications with electricity storage system like batteries.

Figure 25: PV system



Global electricity generation potential

Rodrigues PV potential with large buildings is at least **1MWe** if you consider the main building:

- The market and the bus station of Port Mathurin
- The office buildings of Rodrigues Regional Assembly
- The power stations and the administrative office of CEB
- The port's dock building / the airport
- The new police station / Schools and high-schools The swimming pool building
- Hotels / the welcome centre of "François Léguat Reserve"

The PV potential can be extended to at least **10MWe** if PV systems are installed on individual houses, considering an average 1kWe per household.

However, renewable electricity from photovoltaic systems is still expensive. Until cost reduction or public incentive, this solution cannot be widely spread in Rodrigues Island as a priority. **Cost could reduce dramatically from 2015: a 1kWe PV system could reach 160 kRs for small sizes and 120kRs per kWe for sizes superior to 200kW.**

However on a long term perspective, these technologies must be considered as efficient, simple and sustainable against climate change.

Meanwhile, PV could be used in cases where electric grid extension is too expensive: in these cases, a comparative analysis should be done between PV system and fossil electricity generation plus grid extension. Currently, PV activated water pumps as well as PV-supplied communication transmitters are in use in Rodrigues.

Another niche market for PV would be communication safeguarding in administrations and hotels: to prevent communication breakdowns after tropical storms caused by electric grid breakdown, a PV system could be used to provide the necessary power.

For a widespread option, it is more preferable to develop biomass and wind-power. PV could be widespread after 2015 and this will most probably be the case in 2025.

Implementation cost – Economic and environmental impacts

Table 32: PV system data for Rodrigues

Photovoltaic system	**1kWe PV – 8 m²**
Power	1 kW
Yearly electricity generation	1500 – 2000 kWh
Cost	252 - 336 kRs
Life length	20 years
Generation cost per unit	**6 - 11 Rs/kWh**
Yearly GHG emissions reduction	981 – 1308 kgCO2eq
GHG emissions reduction over life length	**19.8 – 26.2 Ton CO2 eq**
GHG emissions reduction benefit over life length	**16.6 – 22 kRs**

Forecasts on future prices show a reduction by 60% by 2015.

Schedule and partnership

PV systems could be implemented in two phases:

- large systems – 1MWe: 2016-2025
- small systems and new large systems – 10MWe: 2026-2050.

Wind-power – wind farms

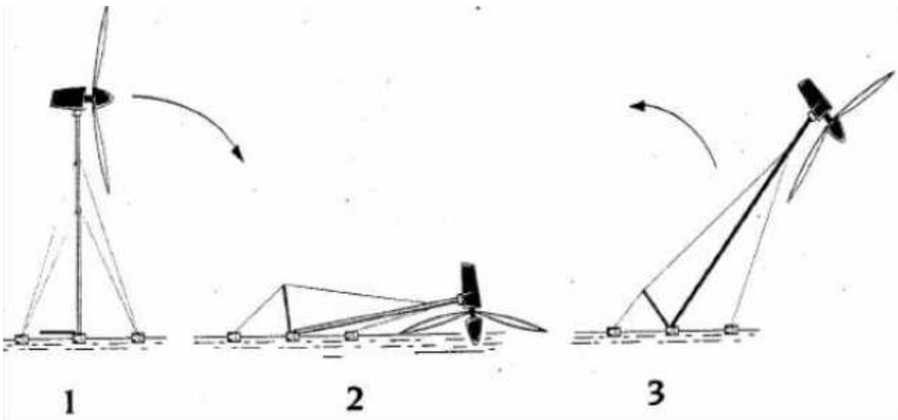
Technology presentation

Rodrigues Island has a high potential for wind-powered electricity.

Figure 26: Satellite view of eastern Rodrigues with multiple windfarm sites

Due to damage and saftey risks during cyclones, the selected wind-turbine aerogenerators must be able to be lowered to the ground.

Table 33: Tilting system for VERGNET aeogenerotors



The aerogenerators from VERGNET offer this possibility. The range of power is up to 275 kW. The company is currently developing a 1MW aerogenerator with an added feature: the possibility to be lowered and anchored to the ground during cyclones.

Currently, 3 aerogenerators are in operation in Trèfles. The technical features are the following:

- power : 3 x 60 kW
- yearly electricity generation : 400 MWh

These aerogenerators need to be stopped for a 3-day maintenance check-over once every 3 months, that is to say 12 days per year. Up to now, the main problems encountered have concerned:

- electronical controls
- corrosion

The windiest locations on Rodrigues are mainly situated to the east and south-east of the island. Thus, on both sites, Trèfles and Grenade, the average annual wind speed has been measured at about 8mps.

Table 34: average annual wind speed at Trèfles at 30 m high

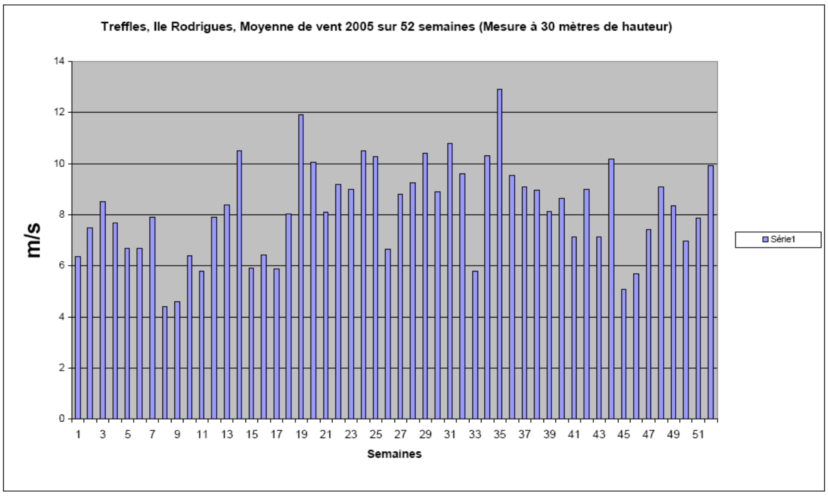
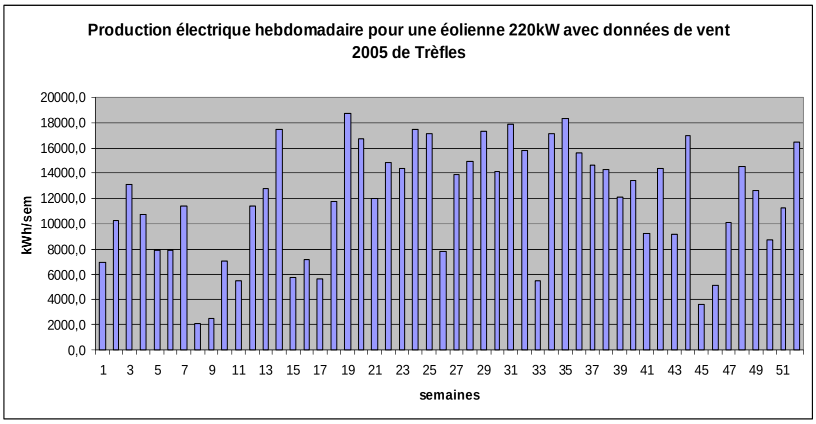


Table 35: weekly electricity production with a 220 kW aerogenerator based on the Trèfles winds



The simulation of electricity production by a 220 kW aerogenerator with the 2005 wind data from Trèfles shows a annual production of an estimated 614 Mwh which is evenly distributed over a week.

The CEB is planning to install a VERGNET aerogenerator on the Grenade site:

- power : 200 kW
- electricity production : 700 MWh
- initial investment cost: 25 000 000 Rs

- life length : 20 years / ROI/depreciation: 15 years

Global electricity generation potential

It is possible to install ten (10) 200kW Vergnet wind generators on the Grenade site. It is possible to find 5 similar sites in Rodrigues. Therefore the global wind-power potential with current technologies could be estimated at:

- **capacity: 10 MW**
- **yearly electricity generation: 32.5 GWh** (assuming 650MWh/200kW)

Future technologies will improve power density for wind-power (installable capacity per area). This development will allow increasing wind-power potential without increasing land-use and with same wind speeds. ARER's information on current Vergnet research activities indicate that density could be doubled in the next few years. It is reasonable to plan that this new equipment will be operational around 2010-2012. The global wind-power potential with future technologies with the same land-use could be estimated at: 20 MW / 65GWh.

Implementation cost – Economic and environmental impacts

Table 36: Implementation cost of ten wind turbines - 10*200kw

Five 10x200kW wind farms	
Cost	1 250 MRs
Life-length	20 years
Depreciation time	15 years
Yearly depreciation cost	84 MRs
Yearly maintenance costs	32 MRs
Yearly electricity generation	32.5 GWh
Total electricity generation over life-length	650 GWh
Generation cost per unit	3.5 Rs/kWh
Yearly saving on fuel bill for CEB = all fuel bill	87 MRs
Yearly GHG emissions reduction	19 620 Ton CO2 eq
Yearly GHG emissions cost saving (1TCO2 = 840 Rs)	16.48 MRs

Penetration Rate of intermittent energies within the electrical network

Note that with the current electricity system, direct injection of intermitent energy supply cannot exceed 30% of load. 30% of the minimal load in Rodrigues is 750 kW for Rodrigues. It is therefore impossible to set up a further 2 or 3 aerogenerators without regulation and storage equipement.

In other words, the set up of the whole wind farm in Grenade and, later on, the exploitation of all Rodrigues wind-power potential requires the implementation of an energy storage device.

Planning and involved actor

This project should be put into place up to 2025:

- 2008-2010: 200kW per year (1 "200kW" wind generator)
- 2011-2015: 400kW per year (2 "200kW" wind generators)
- 2016-2020: 1000 kW (1 new wind generators with doubled power density)
- 2021-2025: 2000 kW (2 new wind generators with doubled power density)
- 2026-2050: replacement of wind-turbines by new equipment with doubled power density

A detailed Wind Energy Resource Atlas needs to be established. This Atlas will identify wind power potential for Rodrigues as well as all possible land for wind farms (good wind, close to grid, far from inhabited areas).

From thereon, it will be possible to identify areas for future wind farms and launch detailed measurements of wind speed for these areas. It will then be necessary to implement the Global Territory Plan to reserve these locations.

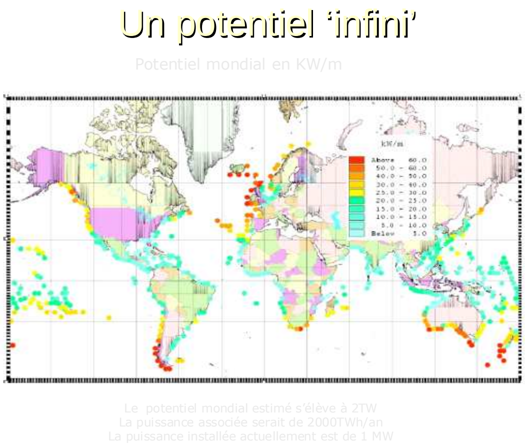
CEB could be the project leader as it has done it before and it is the electric system manager.

Marine energy

Technology presentation

Marine energy has a high potential through:

- Wave Energy (Wave Energy Convertors - WEC)
- Current Energy
- Ocean Thermal Energy



These technologies are under development. They could be available on an industrial scale in 2012-2015.

To begin with, in 2008 and 2009, data purchase is required in order to plan the appropriate systems and to stock data which is likely to be of interest for developers.

Wave energy potential

Relevant technologies can be divided into two groups:

On-SHORE systems

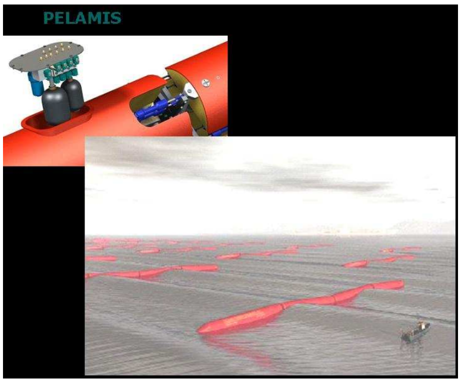
- less expensive
- energy efficient
- not applicable in the case of Rodrigues except in harbours

Figure 27: Onshore Wave Energy Convertor

Off-SHORE systems

- possibility to set up WEC farms
- flat sea bed needed between 30m and 100m deep for perfomant anchorage
- favorable location in Rodrigues : off shore from Mont Cabri

Figure 28: Offshore Wave Energy Convertor



The targeted location for the off-shore systems is just off the coast of Mont Cabri, being very exposed to swell with a favorable bathymetry and with close access to land (no lagoon).

- Available data : bathymetry, googleearth satellite image
- data to be reserched : set up of a 'houlographe' (to calculate swells), or simulate the swell propagation
- Cost : 400 kRs
- Schedule : (2008/2009) gathering of documentation, measurements tender, (2010) measurements to be carried out (2011) technologies and economic feasability studies
- Partnership: to be decided

Current energy potential

HYDrogenerators: there has to be currents stronger than or equivalent to 3 kt (1 kt = 0.5 m/s)

- lagoon pass (Port South East, Saint François....)
- the vast areas of flat sea bed for example, off the cost of Mont Cabri

Figure 29: marine current energy technologies

The targeted area is just off the « Grand Passe » at Port South East. To begin with, an exact simulation of the currents in this pass is needed.

Figure 30 : Biopowers system, australian current technologie under developement

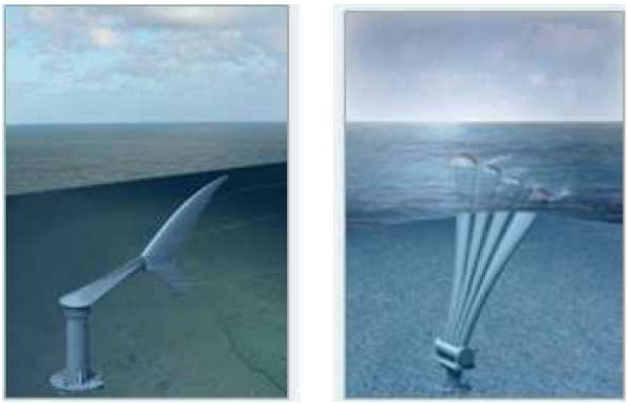


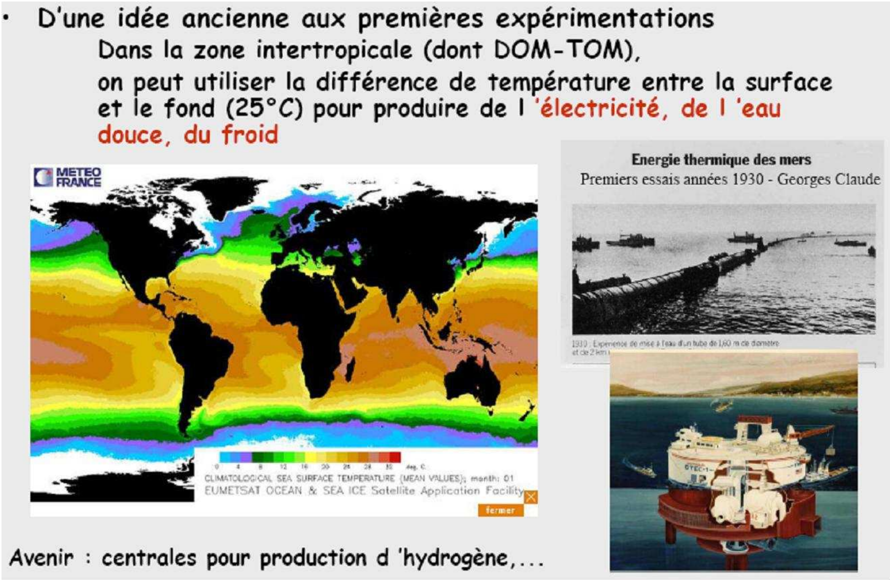
Figure 31: satellite view of Port Sud-Est "Grand passe"

- available data : bathymetry of « Grand Passe », googleearth satellite image
- data to research : measurements of currents taken at different sea depths
- Cost : 400 kRs
- Schedule : (2008) gathering of documentation, measurements tender, (2010) measurements to be carried out
- Partnership: to be decided

<u>Ocean Thermal Energy Potential (ETM/OTEC)</u>

This system was devised by J. Verne and invented by J. d'Arsonval at the end of the XIXth century and set up in Cuba by G. Claude in the 1930s. It is an energy source that can only be used in tropical areas (Sea surface temperature must be at a minimum of 20°C) . All tropical European waters are currently unexploited!

Figure 32 : Global average temperature of the surface of the see



The operating process is as follows: For a ETM power station of 1 MW:

- Water is pumped up at 4°C from 1000m deep: at a typical rate of 2.5m3/s. This means a 20mW electrical consumption.
- A thermal cycle between cold water and warmer surface water (↑20-25°C) pumped at 5 m3/s produces more or less 21 MW, that is to say an extra 1 MW i.e. 5%
- It's BASE producible!
- The cold water at the end of the process is 6-7°C and can be used in diverse industrial or economic processes. This cold deep sea water production containing nutritional qualities is generated without energy consumption.

Several products can be manufactured from the use of this deep sea water: for example the « by-products » from ETM under study in Mauritius. With regards to climate change this technology could become very useful on several different aspects.

Figure 33: land base oceanic industry, example of Mauritius

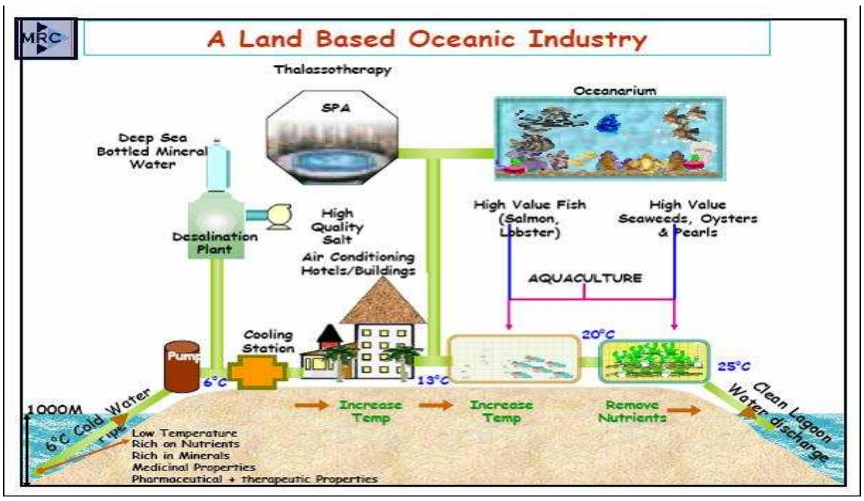


Figure 34: bathymetric data in Rodrigues Island

The targeted seabeds can be found between 500 and 1000 meters below sea level. The bathymetry results have revealed an area which is not too far from the island, situated to the East North East

- Available data : bathymetry of Rodrigues Island
- Data to be researched: water quality measurements taken at different depths.
- Schedule: (2008) opportunity study, (2008). Technical requirements, measurement tenders, (2009) measurements to be carried out.
- Partnership : MRC

Implementation of marine energy will only start from 2016 and is due to take off on a larger scale after 2026

Summary for RES

Renewable electricity generation potential in Rodrigues has been estimated for biomass, PV and wind-power. The future potential of marine energy was not given. It is due to be developed after 2015.

Table 37: RES operations, installed capacity and yearly electricity production at end of period

	today	2008-2010	2011-2015	2016-2025	2026-2050
Biomass	0	1MW – 6.5GWh	2MW – 13GWh	3MW – 19.5GWh	4MW – 26GWh
PV	0	0	0	1MWe – 1.5GWh	10MWe – 15GWh
Wind-power	0	0.6MW – 1.8GWh	2.6MW – 8.3GWh	17.6MW – 57GWh	20MW – 65GWh
Marine energy	0	0	0	?	?
TOTAL	**0**	**1.6MW – 8.3GWh**	**4.6MW – 19.8GWh**	**21.6MW – 78GWh**	**34MW – 106GWh**

Control and storage of intermittent RES

This chapter investigates technological solution for control and storage of intermittent electricity generation with intermittent renewable energy sources such as solar, wind and marine energy.

As a matter of facts, management of electric system as well as expectations of final consumers needs reliable electricity generation that cannot directly provided by intermittent RES.

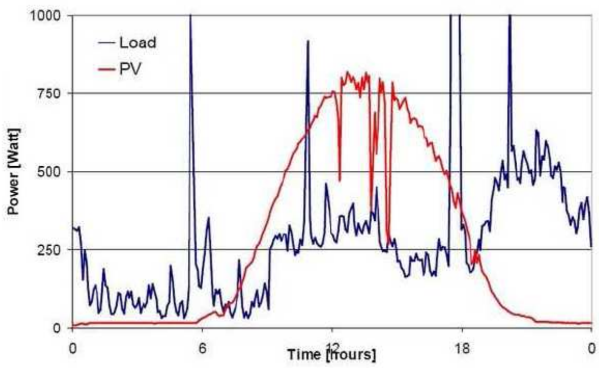
Electric system equilibrium

Technical presentation

The electrical system is based on an operating principle which continously matches up electricity production to electricity consumption. For this, it uses a control loop that sets the signal frequency at a 50Hz.

The following diagram simply explains the issue of intermittent energy in the case of an isolated site equipped with solar panels. The energy production (in red), which runs solely on sunlight, and the energy consumptions are independant.

Figure 35 : issue of intermittent energy in the case of an isolated site equipped with solar panels



Electricity production from biomass is not intermittent: it is guaranteed energy.

Limit of 30% for direct injection of renewable energy

In the case of an electrical system using several means of production, the variations of intermittent energy can be compensated by other installations. Thus, the instantly available power should be able to take over from a windpower or photovoltaic farm, should they suddenly shut down. This requires that the maximum intermittent power injected into the network should not exceed a certain rate in order to allow the other power station to react in time. Scientific documentation establishes that maximum penetration at 30% of the instantaneous power lo ezavinpy@hotmail.com ad of the whole system.

Therefore, if the setting up of an intermittent energy exceeding 30% of the power load is planned, it is necessary to implement a storage solution which will be used as a buffer between the excess power and the network. This will be the case with the 10 aerogenerator windfarms to be set up in Grenade (2 Mw for a minimal power of 2.5MW)

This is all the more true if energy self-sufficiency is targeted through a range of mainly intermittent energies.

Storage technologies

In terms of energy storage, numerous technologies already exist. Some of them are presented in the table below:

Table 38: Storage technologies

	Hydraulique gravitaire	Air comprimé	Batteries électrochimiques (Pb)	Batteries à circulation	volant d'inertie	supercapacité	SMES	H2
Puissance	10MW - 2GW	100MW - 1GW	1kW - 10MW	100kW- 10MW	1kW - 1 MW	1kW - 100kW	~ 100kW	1kW - 200kW
Capacité	100MWh - ...	100 à 10000 Mwh	0,1 à 40 MWh	10 à 100MWh	~ kWh	~ 100Wh	~ 500Wh	?
Rendement	0,6 à 0,8	0,50	0,75	0,7 - 0,8	0,80	>0,9	>0,9	0,25
Cycles admis	>10000	?	100 - 1500	2500 - 10000	>10000	>10000	>10000	?

Energy storage for Rodrigues' energy self-sufficiency

Regarding Rodrigues' energy self-sufficiency, a detailled comparative analysis on the different applications is necessary, in order to determine the most appropriate technology.

The information which must be taken into account is the potential for the following intermittent renewable energies:

	today	2008-2010	2011-2015	2016-2025	2026-2050
Biomass	0	1MW – 6.5GWh	2MW – 13GWh	3MW – 19.5GWh	4MW – 26GWh
PV	0	0	0	1MWe – 1.5GWh	10MWe – 15GWh
Wind-power	0	0.6MW – 1.8GWh	2.6MW – 8.3GWh	17.6MW – 57GWh	20MW – 65GWh
TOTAL	**0**	**1.6MW – 8.3GWh**	**4.6MW – 19.8GWh**	**21.6MW – 78GWh**	**34MW – 106GWh**

A schedule of the penetration of intermittent renewable energies and energy storage will be planned with regards to electricity consumption trends. During a future trend analysis, energy storage will be presented with dimensions in accordance with the intermittent renewable energies power shown above: a total of 18.6 MW and 58.5 GWh in 2025 and 30 MW and 80GWh in 2050.

Given the electrical power and quantities forecasted, two storage technologies seem appropriate:

- Hydraulic storage with 60% output
- Vanadium batteries with 70 to 80% output

Vanadium batteries

Technology presentation[48]

"The **vanadium redox** (and redox flow) **battery** in its present form (with sulphuric acid electrolytes) was patented by the University of New South Wales in Australia in 1986[49]. It is a type of rechargeable flow battery that employs vanadium redox couples in both half-cells, thereby eliminating the problem of cross contamination by diffusion of ions across the membrane. Although the use of vanadium redox couples in flow batteries had been suggested earlier by Pissoort[50], by NASA researchers and by Pellegri and Spaziante in 1978[51], the first successful demonstration and commercial development was by Maria Skyllas-Kazacos and co-workers at the University of

48 http://en.wikipedia.org/wiki/Vanadium_redox_battery

49 M. Skyllas-Kazacos, M. Rychcik and R. Robins, in AU Patent 575247 (1986), to Unisearch Ltd.

50 P. A. Pissoort, in FR Patent 754065 (1933)

51 A. Pelligri and P. M. Spaziante, in GB Patent 2030349 (1978), to Oronzio de Nori Impianti Elettrochimici S.p.A.

New South Wales in the 1980's[52]. The Vanadium redox battery exploits the ability of vanadium to exist in 4 different oxidation states, and uses this property to make a battery that has just one electroactive element instead of two.

The main advantages of the vanadium redox battery is that it can offer almost unlimited capacity simply by using larger and larger storage tanks, it can be left completely discharged for long periods with no ill effects, it can be recharged simply by replacing the electrolyte if no power source is available to charge it, and if the electrolytes are accidentally mixed, the battery suffers no permanent damage.

The main disadvantages with vanadium redox technology are a relatively poor energy-to-volume ratio, and the system complexity in comparison with standard storage batteries."

"Currently installed vanadium batteries include:

- A 1.5MW UPS system in a semiconductor fabrication plant in Japan
- A 275 kW output balancer in use on a wind power project in the Tomari Wind Hills of Hokkaido
- A 200 kW, 800kWh (daily) output leveler in use at the Huxley Hill Wind Farm on King Island, Tasmania
- A 250 kW, 2MWh (daily) load leveler in use at Castle Valley, Utah
- A 2MW (3 MW pulse), 12 MWh (daily) flow battery is also to be installed at the Sorne Hill wind farm, Ireland."

Global electricity storage potential

The global storage potential for Rodrigues with vanadium batteries is much higher than needed as there is no constraint on space use.

As a matter of fact, the 800kWh storage facility in King Island represents a volume of 55m3 of electrolytes in four tanks[53]. 80MWh storage would require 5,500m3 of reservoirs.

Implementation cost – Economic and environmental impacts

The 2MW (3 MW pulse), 12 MWh (daily) storage facility at Sorne Hill wind farm costs 9.4 M$ (US)[54].

A 6MW (9MW pulse), 36MWh (daily) storage facility would cost 30 M$ (US) i.e. approximately 1000 MRs.

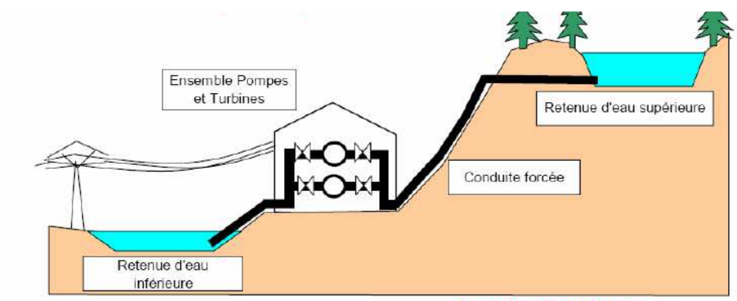
Assuming a 30 year life-length and an effective use of 10GWh yearly, the cost of storage per delivered unit is 3.3Rs/kWh.

Hydraulic storage

Technology presentation

The following diagram shows the principle of this storage system.

Table 39: principle of hydraulic storage



52 M. Rychcik and M. Skyllas-Kazacos, J. Power Sources, 22 (1988) 59-67

53 http://www.hydro.com.au/Documents/Renewables%20Development/5882Roaring40s.pdf

54 http://www.theengineer.co.uk/Articles/298818/Irish+energy+storage.htm

The energy output for this type of storage is more than 60%: 1kWh pumped then turbined supplies more than 0.6 kWh.

Therefore the storage system proposed for Rodrigues Island is a combination of one or more hydraulic energy storage systems through:

- high reservoirs and low reservoirs
- pump and turbine systems
- pump and turbin pipe networks
- electronical control systems

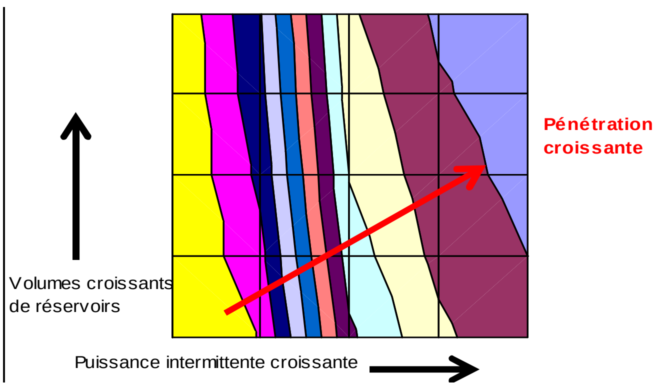
This system will regulate the intermittent photovoltaic and windpower electrical systems. The complementary necessary production will be supplied by a biomass power station and eventually by a fuel power station for the residual need.

The dimensions of this system depend on the targeted intermittent energy level:

- the higher the penetration, the more powerful the intermittent power should be
- the higher the penetration, the more powerful the pumps and turbines should be
- the higher the penetration, the larger the reservoirs should be

For a given penetration, the pumps and turbines power are directly in proportion to the intermittent energy power. On the other hand, for a given penetration, the size of the reservoirs and the intermittent energy powers are inversely linked: the more powerful the installed intermittent energy, the smaller the reservoirs will be.

Figure 36: link between reservoir size, intermittent energy power and penetration on the network.



In addition, the power and energy supplied by hydraulic storage are directly in proportion to the height between high and low reservoirs:

- Power = k x H x Q where k is a constant and Q the turbined water flow rate
- Energy = k x H x V where V is the turbined water volume

k is calculated from turbines output (80%), from the constant g (9.81 m/s^2) and the water density (1m/l).

Global electricity storage potential

Based on the 2006 electrical balance, the daily electricity consumption in Rodrigues, including energy savings, is 72 Mwh of which 18Mwh minimum would come from biomass. This allows us to imagine that the approximate size needed for the storage of 54MWh is about :

- a water volume of **100 000 m3** falling from **250m**
- **or** a water volume of **125 000 m3** falling from **200m**
- **or** a water volume of **168 000 m3** falling from **150m**

Rodrigues' annual estimated water needs: 3 650 000 m3

Figure 37: A recently built resevoir in Rodrigues, southern area of the island

Given the above mentionned large volumes, it is crucial to use the existing water storage equipements, dams for low reservoirs, small and extra systems.

The study « THE RATIONALIZATION, REHABILITATION, UPGRADING AND EXTENSION OF THE WATER TRANSMISSION/DISTRIBUTION NETWORK OF RODRIGUES ISLAND » carried out in 2000 by Luxconsult for the Mauritian governement should be put into use.

Therefore, it seems that **water issues and energy self-sufficiency** in Rodrigues could be linked together to obtain a more efficient and economical management.

Implementation cost – Economic and environmental impacts

The storage option of 125 000 m3 of water falling from 200m seems realistic. This option is compatible with a windpower farm of 10MW:

- 54MWh supplied daily after storage = 90MWh produced before storage (60%)
- 32.5 GWh annual windpower = 89 MWh daily windpower

The slight difference can be compensated by an electricity production from biomass which will be higher than the base limit which has been identified as 6.5 GWh.

The pumps are sized with an output of 70% from water flow and height
⇨ 10 MW
The pumps engins must be sized to operate at 85% of their maximum power
⇨ 12 MW
The turbines must be sized with a margin of 20% of the maximum supplied power
⇨ 6 MW
The pipes must allow for transportation of a total section of 4 m² of water.

This information allow us to examine two cases

Case 1:

- 2 low dams 80 000 m3 + 67 000 m3
- 13 high reservoirs of 10 000 m3
- 13 double pipeworks of 1km and 640mm in diametre (total section = 4.18m²)
- Pumps 12 MW + Turbines 6 MW
- Electronical control panel to simultaneously deal with the renewable energy production – network injection – storage and supply

Case 2:

- 13 high reservoirs of 10 000 m3
- 13 low reservoirs of 10 000 m3
- 13 double pipeworks of 1 km and 640mm in diametre (total section = 4.18m²)
- Pumps 12 MW + Turbines 6 MW
- Electronical control panel to simultaneouslydeal with the renewable energy production – network injection – storage and supply

These two cases only differ by the choice of low storage: 2 dams of a total of 147 000 m3 or 13 reservoirs of a total of 130 000 m3.

It is not necessary to have one centralised system: these reservoirs, pipeworks, pumps and turbines can be distributed throughout several local systems.

Table 40: cost/kwh stored - case1

Case 1: 2 lower dams	
Lower dams costs	300 MRs
Life-length for Dams	30 years
Yearly cost of dams if spread over life-length	10 MRs
Higher reservoirs costs	845 MRs
Life-length for reservoirs	30 years
Yearly cost of reservoirs if spread over life-length	28 MRs
Pumps costs	750 MRs
Life-length for pumps	30 years
Yearly cost of pumps if spread over life-length	25 MRs
Turbine costs	750 MRs
Life-length for turbines	30 years
Yearly cost of turbines if spread over life-length	25 MRs
Piping costs	30 MRs
Life-length for piping	30 years
Yearly cost of piping if spread over life-length	1 MRs
Electronic command system	50 MRs
Life-length for electronic command system	5 years
Yearly cost of command system if spread over life-length	10 MRs
TOTAL COSTS for 30 years	2 975 MRs
TOTAL YEARLY COSTS OVER LIFE-LENGTH	99 MRs
TOTAL COST PER UNIT (30 GWh yearly)	3.3 Rs/kWh

The cost per unit is quite high in both cases: 3 and 4 Rs/kWh.

To reduce the cost, it will be necessary to optimize the combination of energy storage strategy and water strategy by using the energy storage system for improving the water system.

It is also possible to reduce the costs by reducing the amount of stored energy (thus reducing dams and reservoirs sizes). This implies an optimization study of the electric system by allowing HFO electricity generation during low wind season.

Table 41: cost/kwh stored – case2

Case 2: 13 lower reservoirs	
Higher and lower reservoirs costs	1 690 MRs
Life-length for reservoirs	30 years
Yearly cost of reservoirs if spread over life-length	56 MRs
Pumps costs	750 MRs
Life-length for pumps	30 years
Yearly cost of pumps if spread over life-length	25 MRs
Turbine costs	750 MRs

Life-length for turbines	30 years
Yearly cost of turbines if spread over life-length	**25 MRs**
Piping costs	**30 MRs**
Life-length for piping	30 years
Yearly cost of piping if spread over life-length	**1 MRs**
Electronic command system	**50 MRs**
Life-length for electronic command system	5 years
Yearly cost of command system if spread over life-length	**10 MRs**
TOTAL COSTS	**3 520 MRs**
TOTAL YEARLY COSTS OVER LIFE-LENGTH	**117 MRs**
TOTAL COST PER UNIT (30 GWh yearly)	**3.9 Rs/kWh**

Summary for storage technologies - Schedule and partnership

For both surveyed technologies, the storage costs per delivered unit are similar: 3.3 to 3.9 Rs/kWh.

Primary energy production cost should be added to the storage cost to obtain the global cost per delivered unit:

- wind-power: 1.79 – 3.03 Rs/kWh
- vanadium: 70-80% efficiency
  - vanadium primary energy production cost = 2.24 – 4.33 Rs/kWh
  - global cost per unit delivered from wind-power through vanadium = 5.54 – 7.23 Rs/kWh
- hydraulic: 60% efficiency
  - hydraulic primary energy production cost = 2.98 – 5.05 Rs/kWh
  - global cost per unit delivered from wind-power through vanadium = 6.28 – 8.35 Rs/kWh

On the one hand, vanadium batteries require less space than hydraulic storage. On the other hand, hydraulic storage could improve Rodrigues' water situation.

Nevertheless, storage applications should be implemented according to the forecast of intermittent RES production. First storage solutions to be implemented could be hydraulic storage in order to:

- improve the water management system
- wait for an improvement in vanadium batteries cost, efficiency and reliability

However, studies are required and there is a possibility that these studies will be carried out during 2008-2010. The aim of these studies may be:

- optimization study of the electric system including energy storage system
- optimization study of the combination of energy storage strategy & water strategy

The first storage facilities could be implemented from 2011 as the Grenade wind farm would exceed 30% of minimum load.

CEB and RRA could jointly lead the project as energy and water are simultaneously concerned.

Storage of intermittent RES impacts actual renewable electricity injection:

- no impact on biomass
- impacts on PV and wind-power:
  - use of hydraulic storage up to 32GWh with 60% efficiency
  - use of vanadium batteries afterwards with 70% efficiency

Table 42: effective renewable electricity injection to the grid

	today	2008-2010	2011-2015	2016-2025	2026-2050
Biomass	0	1MW – 6.5GWh	2MW – 13GWh	3MW – 19.5GWh	4MW – 26GWh
PV stored via vanadium	0	0	0	1MWe – 1GWh	10MWe – 10.5GWh
Wind-power stored via hydraulic then vanadium	0	0.6MW – 1.8GWh	2.6MW – 5GWh	17.6MW – 36.7GWh	20MW – 48.75GWh
Marine energy	0	0	0	?	?
TOTAL	**0**	**1.6MW – 8.3GWh**	**4.6MW – 18GWh**	**21.6MW – 57.2GWh**	**34MW – 78.75GWh**

Important interaction between energy, water and agricultural/forestry issues

Windpower production, seawater desalination and water distribution management

The strategy of energy self-sufficiency discussed during technical meetings is directly linked to water and reforestation issues. Joint decisions will have to be made on these different subjects. The next step is to situate the different proposed equipment. It is clear that the setting up of added dam would minimise the need formulation desalination and save on electricity for water production.

An ecological and environmental industrial park in Grenade

The Grenadesite already features:

- a building materials quarry where the materials are processed
- the Roche Bon Dieu waste dump,
- potential site for a large water dam,
- potential site for a windpower farm,
- potential site for a seawater desalination station .

For land planning purposes, it is proposed that this ecological and environmental industrial park should offer a combination of activities linked to water, energy, waste and building materials.

VI / Energy scenarios

Basic energy demand forecast is based on prospective methodologies taking into account:

- population growth and improvement of access to energy
- economic sector growth and evolution of the sector energy intensity[55]
    - GDP growth and evolution of energy intensity
- introduction of new and major infrastructures/consumers

This methodology provides forecast of energy demand and does not consider the change in energy attitudes and technologies.

The forecast of energy supply is based on the demand forecast, taking into account energy losses and the consumption of the energy sector itself. It also defines the production means that will provide the necessary energy.

A sustainable energy strategy introduces an energy-saving and efficiency plan that will reduce energy demand. It also considers RES for energy supply. In the previous chapter, "Potential for sustainable energy technologies", we have considered a sustainable energy strategy that will introduce an energy policy based on Rational Use of Energy and Renewable Energy Sources.

In the case of Rodrigues Island, the CEB did a forecast analysis in 2003. The actual data for years 2003 to 2007 show a difference between the CEB's forecast and reality. Therefore ARER will present a new forecast for energy demand and supply.

Scenarios of the Integrated Electricity Plan 2003-2012

In the Integrated Electricity Plan 2003-2012, the CEB has presented a forecast analysis, carried out during 2003, of demand and supply. The following data are extracted from this document. However, actual electricity demand and supply for years 2003 to 2006 show a different pattern than forecast by the CEB.

Table 7-4. Summary of Forecast Elements With Desalination Project

YEAR	SALES		GROSS GENERATION REQUIREMENTS		SYSTEM CAPACITY REQUIREMENTS	
	GWh	Growth Rate (%)	GWh	Growth Rate (%)	kW	Growth Rate (%)
2002	18.2	–	22.6	–	4,400	–
2007	33.8	13.2	40.7	12.5	7,195	10.3
2012	41.8	4.3	49.6	4.0	8,525	3.5

Note: Growth rates shown are average cumulative annual growth over the next 5 and following 5 years.

Table 7-5. Summary of Forecast Elements Without Desalination Project

YEAR	SALES		GROSS GENERATION REQUIREMENTS		SYSTEM CAPACITY REQUIREMENTS	
	GWh	Growth Rate (%)	GWh	Growth Rate (%)	kW	Growth Rate (%)
2002	18.2	–	22.6	–	4,400	–
2007	27.5	8.6	33.1	7.9	6,045	6.6
2012	35.6	5.3	42.2	5.0	7,425	4.2

Note: Growth rates shown are average cumulative annual growth over the next 5 and following 5 years.

[55] Energy intensity = energy consumption per GDP unit

Figure 7-2. Forecast of Gross Energy Generation Requirements

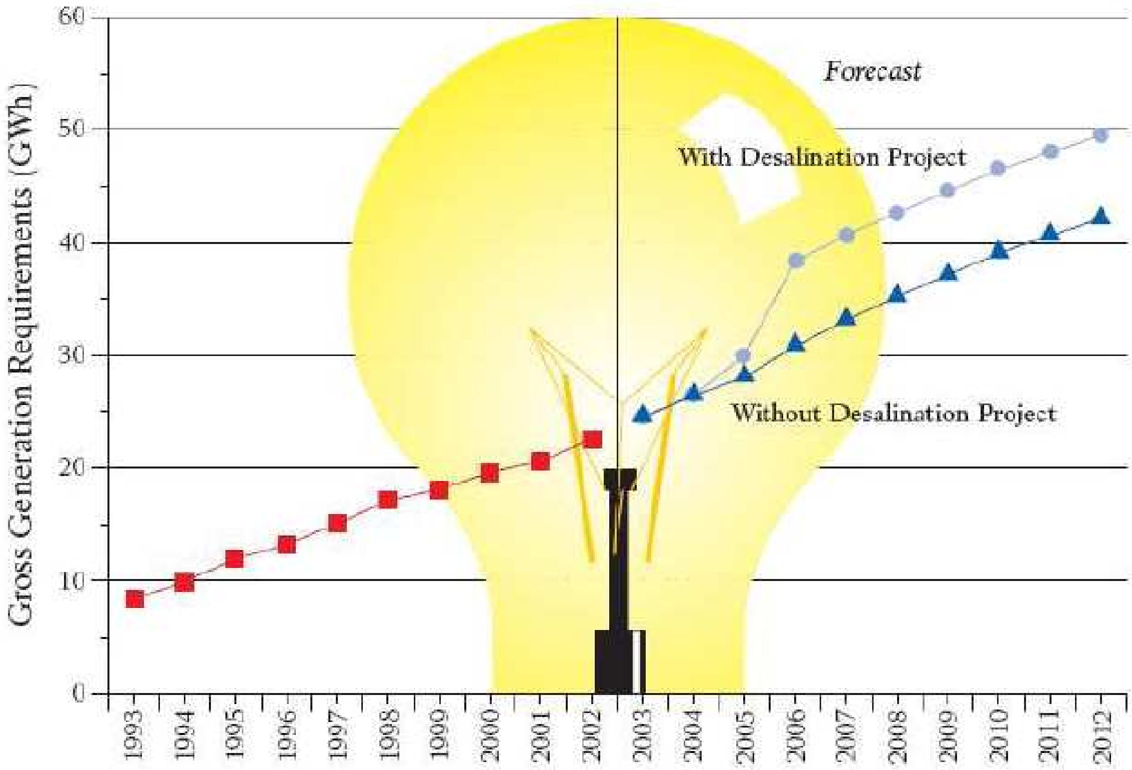


Figure 7-3. Forecast of Peak Capacity Requirements

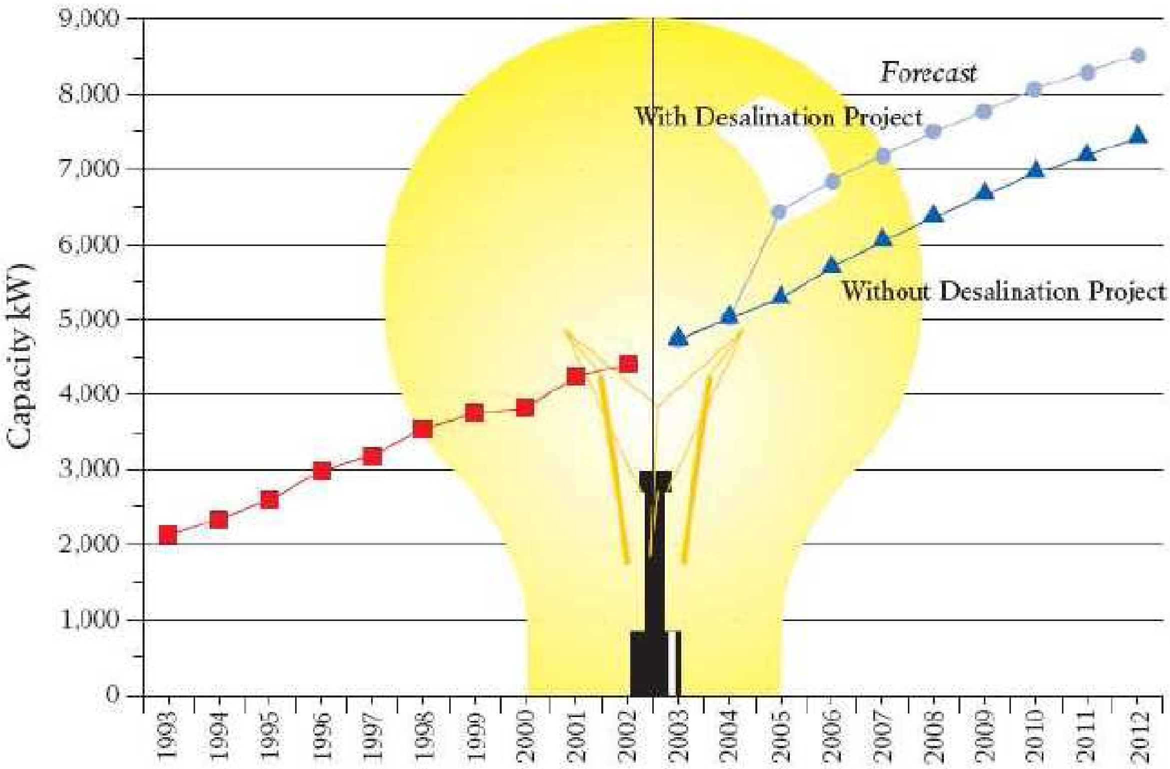


Figure 7-6. Rodrigues Capacity Balance Without Desalination Project

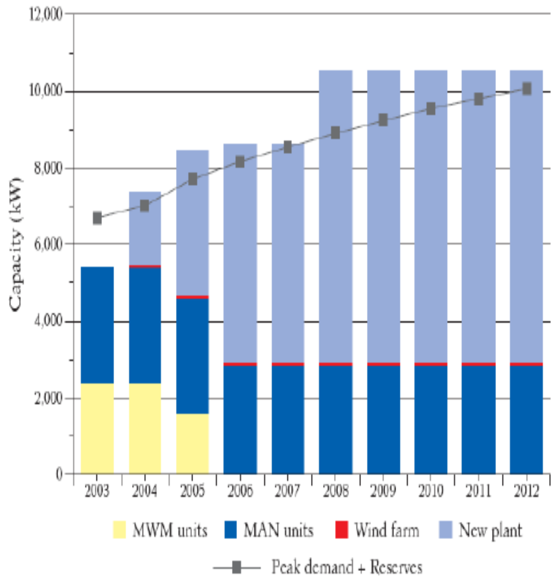
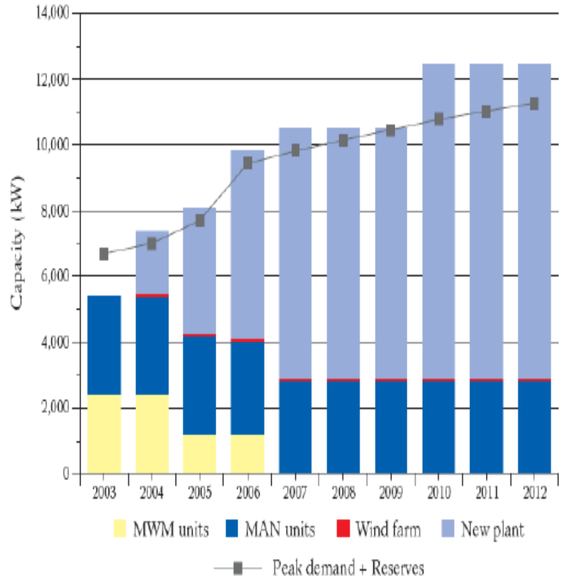


Figure 7-5. Rodrigues Capacity Balance With Desalination Project in Early 2006



Demand forecasts for 2007-2015-2025-2050 according to present analysis

Energy demand forecasts consider each customer category and plan the progress in the number of customers as well as the progress in energy demand.

Therefore, demand forecasts must mainly consider:

- population growth and improvement of access to energy
- economic sector growth and evolution of sector energy intensity
    - o GDP growth and evolution of energy intensity
- introduction of new and major infrastructures/consumers

Table 43: Average Consumption per Customer Category 1994-2005

Average Consumption Per Customer Per Category						
Year	*Domestic*		*Commercial*		*Industrial*	
	Gross value (kWh)	*Growth n/n-1 (%)*	*Gross value (kWh)*	*Growth n/n-1 (%)*	*Gross value (kWh)*	*Growth n/n-1 (%)*
1994	*751*		*3 458*		*9 587*	
1995	*833*	*10,9%*	*3 683*	*6,5%*	*11 765*	*22,7%*
1996	*890*	*6,8%*	*3 599*	*-2,3%*	*13 204*	*12,2%*
1997	*963*	*8,2%*	*3 713*	*3,2%*	*13 104*	*-0,8%*
1998	*1 082*	*12,4%*	*4 519*	*21,7%*	*16 017*	*22,2%*
1999	*1 127*	*4,2%*	*4 352*	*-3,7%*	*13 958*	*-12,9%*
2000	*1 130*	*0,3%*	*4 793*	*10,1%*	*9 546*	*-31,6%*
2001	*1 242*	*9,9%*	*4 860*	*1,4%*	*8 192*	*-14,2%*
2002	*1 269*	*2,2%*	*5 315*	*9,4%*	*9 670*	*18,0%*
2003	*1 303*	*2,7%*	*6 193*	*16,5%*	*8 707*	*-10,0%*
2004	*1 339*	*2,8%*	*6 948*	*12,2%*	*9 265*	*6,4%*
2005	*1 482*	*10,7%*	*8 047*	*15,8%*	*11 973*	*29,2%*
Yearly Average 2005/2001		*4,5%*	*-*	*13,5%*	*-*	*10,0%*

Source: CEB

Domestic demand forecast

The Central Statistics Office (CSO) publishes, on a yearly basis, a digest of demographic statistics. The 2006 digest provides population projections for Rodrigues up to 2046.

Table 44: Population – historic data & 2006 CSO projections

Year	Population
1983	33082
1990	34204
2000	35779
2006	37079
2011	37910
2016	38799
2021	39903
2026	41318
2031	43234
2036	45130
2041	46974
2046	48640

From the CSO projections, ARER has estimated a population of 50,000 persons for 2050.

One should notice that the CSO projections are useful data that could be discussed. As a matter of fact, the CSO projections differ from year to year:

- in 1997, CSO projected a population of 50,001 in 2037
- in 2005, CSO projected a population of 49,219 in 2045
- in 2006, CSO projected a population of 48,640 in 2046

The typical Rodriguan family was made up of 5 persons in 1983, 4.8 persons in 1990 and 4.2 persons in 2000. The ARER projections on household size and number are based on population projections and on the decrease rate of the household size from 1990 to 2000. Projections show an average household size of 2.3 persons in 2046 which is the current household size in France. This seems to be coherent.

Table 45: Household size and number – historic data and 2007 ARER projections

Year	Household size	Household number
1983	5	6 616
1990	4.8	7 126
2000	4.2	8 519
2006	3.9	9 565
2011	3.6	10 454
2016	3.4	11 438
2021	3.2	12 576
2026	3.0	13 921
2031	2.8	15 572
2036	2.6	17 377
2041	2.4	19 336
2046	2.3	21 405
2050	2.3	21 739

Forecast for electricity demand per household

Access of households to electricity increased from 19% in 1983 to 68.3% in 1990 and to 92.2% in 2000. In 2006, it was estimated that all households had access to electricity. Average household consumption for 2005 was 1482 kWh per customer representing an average yearly growth of 4.5% compared to 2001.

ARER assumes that there will be:

- 2007-2010: 4% yearly growth of average consumption per customer
- 2011-2015: 3% yearly growth of average consumption per customer
- 2016-2025: 2% yearly growth of average consumption per customer

- 2026-2035: 1% yearly growth of average consumption per customer
- 2036-2045: 0% yearly growth of average consumption per customer
- 2046-2050: 0% yearly growth of average consumption per customer

As from 2036, the average consumption per household should reach 3000kWh/yr and stay stable.

The assumed growth rates include normal energy efficiency improvement of domestic electrical appliances, which means an improvement of the access of households to energy without any increase in energy consumption. Besides, the average household size will decrease. Therefore, stable energy consumption per household means growing energy consumption per person.

This analysis does not consider RUE. Energy consumption reduction, thanks to RUE, will introduce an average 25% saving as from 2011.

Table 46: Domestic electricity demand forecasts 2007-2025-2050

Year	*household number*	*average consumption (kWh)*	*yearly growth of average consumption (%)*	*global domestic consumption without RUE (MWh)*	*global domestic consumption with RUE (MWh)*
2006	*9 565*	*1 541*	*4%*	*14 740*	*14 740*
2011	*10 454*	*1 875*	*4%*	*19 601*	*14 701*
2016	*11 438*	*2 174*	*3%*	*24 861*	*18 646*
2021	*12 576*	*2 400*	*2%*	*30 179*	*22 634*
2026	*13 921*	*2 650*	*2%*	*36 884*	*27 663*
2031	*15 572*	*2 785*	*1%*	*43 364*	*32 523*
2036	*17 377*	*2 927*	*1%*	*50 859*	*38 145*
2041	*19 336*	*2 927*	*0%*	*56 593*	*42 444*
2046	*21 405*	*2 927*	*0%*	*62 646*	*46 984*
2050	*21 739*	*2 927*	*0%*	*63 624*	*47 718*

Forecast of the economic sector demand

A sectorial and sub-sectorial approach to GDP growth and evolution of energy intensity is required. However, given the lack of information concerning economic growth, ARER will consider all economic sectors together and assume global GDP growth.

Energy intensity is supposed to improve thanks to basic technology improvement and to more efficient energy behaviour: energy intensity should therefore decrease, which means that less energy is needed per GDP unit generated. However, energy intensity will be considered stable so that electricity saving actions are not accounted for twice: RUE will be introduced in the next chapter.

ARER assumes that there will be:

- 2007-2010: 10% yearly growth of GDP
- 2011-2015: 7% yearly growth of average consumption per customer
- 2016-2025: 5% yearly growth of average consumption per customer
- 2026-2035: 3% yearly growth of average consumption per customer
- 2036-2045: 2% yearly growth of average consumption per customer
- 2046-2050: 2% yearly growth of average consumption per customer

Table 47: Professional electricity demand forecasts 2007-2025-2050

Year	*global professional consumptions without RUE (MWh)*	*yearly growth (%)*	*global professional consumptions with RUE (MWh)*
2006	*12 047*	*10*	*12 047*
2011	*19 402*	*10*	*14 551*
2016	*27 212*	*7*	*20 409*
2021	*34 730*	*5*	*26 048*
2026	*44 325*	*5*	*33 244*

2031	*51 385*	*3*	*38 539*
2036	*59 570*	*3*	*44 677*
2041	*65 770*	*2*	*49 327*
2046	*71 191*	*2*	*53 393*
2050	*78 601*	*2*	*58 951*

Demand forecast for new and major infrastructures/consumers

The desalination plant will be a major electricity consumer in the future: 9 – 16 GWh / year (including the energy required for pumping). ARER will consider an extra-demand of 16GWh use as from 2016.

Total demand forecast

Demand forecasts for total electricity consumption are presented in the following table and figures.

RUE actions are considered to save 25% of the final electricity consumptions, excluding desalination electricity consumption.

Table 48: Total demand forecast according to ARER

Year	*Comment*	*Without RUE (GWh)*	*With 25% RUE (GWh)*
2015	*excluding desalination*	*51*	*38*
2025	*including desalination*	*96*	*76*
2050	*including desalination*	*158*	*122*

Figure 38: demand forecast without RUE 2007-2025-2050

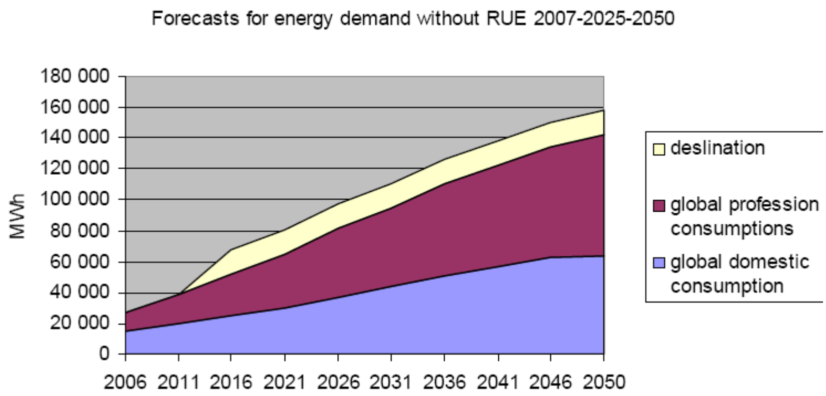
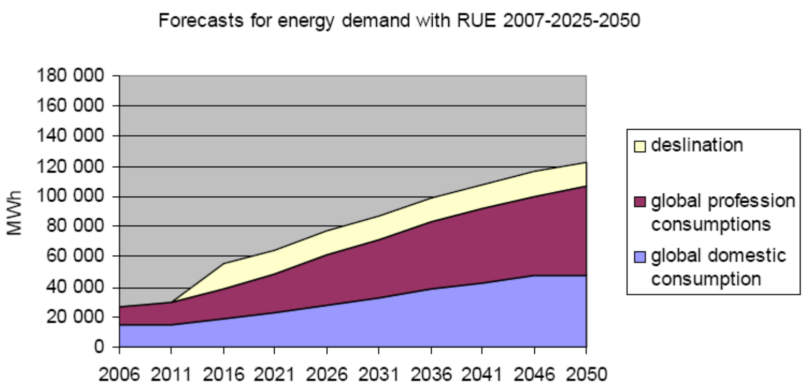


Figure 39: demand forecast with RUE 2007-2025-2050



Possible supply scenario for 2007-2025-2050 according to present analysis

Provided the previously established demand forecast, it is necessary to plan the introduction of the RES production. ARER will only consider the demand forecast with RUE.

Currently, there are about 20% of losses and including the use of the energy sector itself from production to consumption. There should be an objective process to reduce these losses to 10%, like in Mauritius and in Reunion Island. This would be another saving action, from the producer's side.

The necessary electricity generation needed to provide the final consumption is presented in the following table.

Table 49: Total demand and corresponding supply forecast according to ARER

Year	*comment*	*Demand with 25% RUE (GWh)*	*Necessary Supply (GWh)*
2015	*excluding desalination*	*38*	*42*
2025	*including desalination*	*76*	*85*
2050	*including desalination*	*122*	*136*

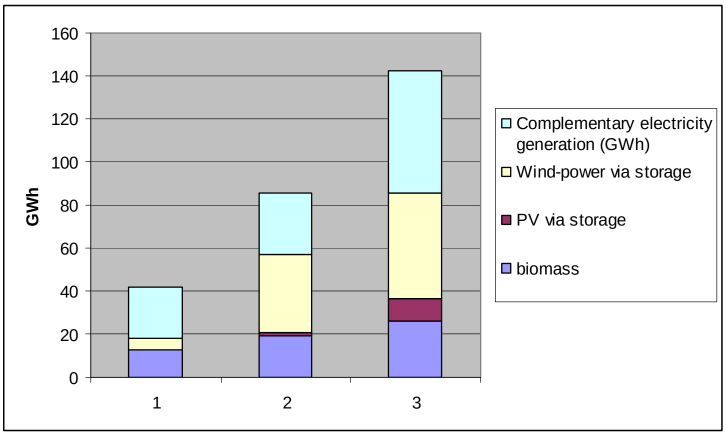
The effective renewable electricity injection potential is presented in table 42. This potential, excluding marine energy, was estimated at 18GWh for 2015, 57GWh for 2025 and 79GWh for 2050.

The complementary electricity generation could come from marine energy or from fossil fuel power system.

Table 50: necessary supply, biomass/PV/wind-power generation and complementary generation 2015 - 2025 - 2050

Year	*Necessary Supply (GWh)*	*Effective generation from biomass, PV and wind-power (GWh)*	*Complementary electricity generation (GWh)*	*Ratio of biomass, PV and wind-power generation to total supply (%)*
2015	*42*	*18*	*24*	*43%*
2025	*85*	*57*	*28*	*67%*
2050	*136*	*79*	*57*	*58%*

Figure 40: supply forecast 2015-2025-2050



VII / Integration solutions for land management, building, agriculture and forest management

Frequent information actions, sensitization and communication with citizens and key players on the running policy and its progress

- Education in primary and secondary schools
- Sensitizing consumers
- Sensitizing tourists
- Using the local mass media
- Sensitizing tourist customers

Building and Regulation

Building adapted, comfortable, energy and water—saving houses

Housing Stock

Source: "THE RATIONALIZATION, REHABILITATION, UPGRADING AND EXTENSION OF THE WATER TRANSMISSION/DISTRIBUTION NETWORK OF RODRIGUES ISLAND – 2000"

"The 1990 census showed that there were 7,810 housing units in Rodrigues at the date of census. The figures show that out of the 7,810 housing units, 7,221 were occupied and provided accommodation for a population of 33,883, grouped into 7,268 households."

Building Characteristics

Out of the 9,283 buildings existing in Rodrigues at the 1990 census, 8,743 were classified as residential buildings inclusive of dwellings under construction, of which 273 were partly residential. The number of units used wholly as one housing unit stood at 7,391, representing 84.5% of the total number of residential buildings. There were 15 blocks of flats or semi-detached houses containing more than one housing unit. 33 other units were buildings designed as individual housing units but crudely subdivided into smaller dwelling units. An amount of 562 dwellings, representing 6.5% of the existing stock, were under construction and not yet inhabited at the time of the 1990 census.

Table 51 : Population, Housing Units and Households by Zones

	Population		Housing Units		Households	
	No.	%	No.	%	No.	%
Piments-B. Topaze	1511	4.5	336	4.3	314	4.3
La Ferme	1112	3.3	300	3.8	272	3.7
B. Malgache	702	2.1	169	2.2	144	2.0
Baie aux Huitres	2308	6.8	603	7.7	565	7.8
Port Mathurin	5484	16.2	1462	18.7	1334	18.4
G. Baie-Mt Goyaves	802	2.4	198	2.5	177	2.4
R. Bon Dieu-Trèfles	2057	6.1	403	5.2	383	5.3
Lataniers-Mont Lubin	3418	10.1	763	9.8	724	10.0

Pt. Gabriel	3731	11.0	817	10.5	755	10.4
Mangues-Quatre Vents	3017	8.9	697	8.9	645	8.9
Plaine. Corail-La Fourche C	2640	7.8	531	6.8	527	7.3
Rivière Cocos	2778	8.2	595	7.6	566	7.8
Port Sud Est	2446	7.2	499	6.4	471	6.5
Coromandel Graviers	1877	5.5	437	5.6	390	5.4
Island of Rodrigues	**33833**	**100.0**	**7810**	**100.0**	**7268**	**100.0**

As it is the case for the island of Mauritius, most of the residential buildings (including partly residential ones) were constructed on one floor. One-floor buildings accounted for 98.8% of the total. No residential building in Rodrigues exceeded two storeys (ground floor plus two).

These building characteristics, namely two storeys (maximum height 10 metres), block of flats or subdivided into smaller dwelling units, bear on the way water needs to be distributed (residual pressure and flow required)."

Elaboration and distribution of the Guide to the ecological, convenient, economical and strong house for Rodrigues

Assessment through pictures on the house-building

Figure 41: Typical constructions of Rodrigues Island

We can note a total lack of vegetation around the houses, except the famous « piquant loulou». The water tanks are scattered and not integrated, either on the plot of land or on the roofs. Waste waters flow to nature, without being treated.

The houses are concrete-made and are very resistant to cyclones. Building on a slope enables the integration of tanks in the bases and the collecting of rain water.

The proposed measures:

- The creation of a regional tree nursery for the production of young plants for bioecological treatment of waste waters, using various plants: bambous, Neem, Baton Mourong (See Chapter on Biomass),
- Systematic cultivation of these young plants on each house of the island for various ecological functions exposed ahead, and encouraging the cultivation of banana trees
- Systematizing the issue of building licences including the stockage of rain waters integrated into the bases of the house
- Imposing that the outside of houses should be terminated (in the name of the landscape and the beauty of the island) as well as gardens (windbreak, growing back the plant coverage)
- Recommending minimal surface areas for the rooms

The agents share the idea of producing a good-building practices guide.

Potential of Rainwater Harvesting

Source: "THE RATIONALIZATION, REHABILITATION, UPGRADING AND EXTENSION OF THE WATER TRANSMISSION/DISTRIBUTION NETWORK OF RODRIGUES ISLAND – 2000"

Figure 42 : example of rain collectors on Rodrigues Island

"Rodrigues has an annual average rainfall of above 1,000 mm, given the tanks mentioned earlier. Its limited rainfall means that less rain is available to be collected. Significant rainfall occurs mainly during summer, for a period of only four months. This means that a very large quantity of rainwater would need to be collected and stored to ensure supply during the intervening dry spells. The complex rainwater harvesting systems that collect and store large quantities of rainwater, however, are very expensive to install and require ample financial resources.

The simple method, described above, will be used below to obtain the size of the tanks required for a house situated in Rodrigues. The same procedure can be adopted to obtain the size of tanks required in other regions and/or for flat roofs. For a pitched roof with a surface area of 70 m² and using a typical filter unit, a region with an average annual rainfall of 900mm would yield:

- 70 x 0.75 x 0.8 x 900 = 37,800 litres
- This figure is then used to determine the tank size with the following equation:
- 37,800 x 5% = 1,890 litres (for an 18-day supply).

Thus, a common fibreglass tank of a capacity of 2,000 L will provide slightly more than an 18-day supply.

It can be noted that retaining 6% of the roof run-off will provide a storage capacity for a 22-day supply, whereas 7.6% will provide it for 28 days. Still greater percentages of rainfall could be collected, but tank costs steadily increase whereas water savings increase only by a small percentage. Besides the considerable capital costs involved, there is also the energy cost required to pump the stored water up to the water outlets in the house and this energy cost would certainly be higher if the storage tank was placed underground.

As it can be expected, the high capital investment, together with the energy cost, would deter most Rodriguans from adopting rainwater-harvesting systems.

However, it is possible to encourage the adoption of such systems by offering tax credits and financial incentives in the form of low-interest bank loans, given the context of low rainfalls in Rodrigues. There are some 7,000 families in Rodrigues who could probably benefit from such a system. A government subsidy would offer some immediate benefit."

Training in sustainaible building techniques

To regularly organise technical days to promote the good practices guide

Informing citizens and building key players

Planning regular radio programmes on this issue

Management of construction licences

Harmonizing the issue of construction licences and environmental criteria

New criteria for help to families

Help to families could be conditionned to some technical obligations

The setting-up cost/associate partners/Planning

- Editing the guide, training, technical days: the building and civil engineering partners in Rodrigues
- Biomass tree nurseries with bioecological functions : the biomass agents
- Editing partners: ARER, the infrastructure department
- Distribution : the Regional Assemnly of Rodrigues
- Cost : 300 kRs for 1500 units exemplaires
- Deadline : 2008

Hotel/Inn/Gites

Identified priority actions / setting up cost/ Planning/Partners

- Frame of reference: Guide for buildings and tourism buildings (400kRs/2008/building and civi engineering, Infrastructures, ARER, tourism network)
- Existing diagnosis campaign (funded by each hotel). These energy audits on existing buildings lead to financial savings which fund the audits (0 kRs/2008/BTP, Infrastructures, ARER, tourism network, BET)
- Assessing the needs in 100% solar hot water and grouped consultation for a global equipment – solar water heater equipment campaign for all the tourist accommodation network (300*3000Euros*50/1000= 45 000 kRs/2008 à 2009/ building and civil engineering, Infrastructures, ARER, tourism network, BET, Région Réunion, Solarists)
- Future technical obligations for future building structures after recommandation (300 kRs/2008/building ad civil engineering, Infrastructures, ARER, tourism network)
- Mobilization and reinforcement of the tourism partners' capacity through technical days, conferences (500 kRs/2008/building and civil engineering, Infrastructures, ARER, réseau du tourisme)
- Training the cleaning personel (500 kRs/2008/Building ad Civil engineering, Infrastructures, ARER, Tourism network, BET)
- Marketing projects by tourist networks for the solar tourist network of Rodrigues Island (2 000 kRs/2008/building and civil engineering, Infrastructures, ARER, tourist network, BET)

A primary and secondary schools network teaching climate change and the targeted policy

- The creation of pedagogic tools by the existing education networks of Rodrigues (1 000 kRs/2008à 2010/tous les acteurs de l'éducation)
- Campaigns to equip and demonstrate solar system in schools (20*5 000Euros*50/1000= 45 000 kRs/2008 à 2009/ building and civil engineering, Infrastructures, ARER, tourist network, BET, Région Réunion, Solarists)

BIOMASS: reforestation and biomass development, as a mutiple economic sector and a key action to prepare to climate change

The story of reforestation in Rodrigues has implanted a real know-how there, means and a precious wood capital to be sustainably managed, with the assistance of the Rodigues Regional Assembly forestry department

Through time, the island has undergone serious deforestation, which reached a peak in the 1970s. The primary forest was entirely destroyed. A reforestation policy has then been launched, and due to current major droughts, the « Piquant Loulou » wood (Acacia Nilotica) was chosen as it can grow in arid conditions.

Table 52: « Piquant Loulou » (Acacia Nilotica), wind indicator, how to consider the future of this wood

A 1983 FED programme enabled the pursuing of the reforestation policy and the planting of fodder for pastures. Varied species has been used, such as the filaos, on some coastlines, and the coconut tree in other areas.

The eucalyptus has been mostly planted in the upper parts. More recently, a rehabilitation policy has been set up to gradually encourage the reintroduction of endemic species in exotic forests.

This work has been carried out for years by the Forestry Department of the Regional Assembly of Rodrigues. This acquired experience has been beneficial to the project and to adapt this reforestation policy to the issues of climate changes. Finally the aim is to set up a wood sector with a diversified economic vocation.

Table 53: wooded surfaces in Rodrigues – a map of the forest department

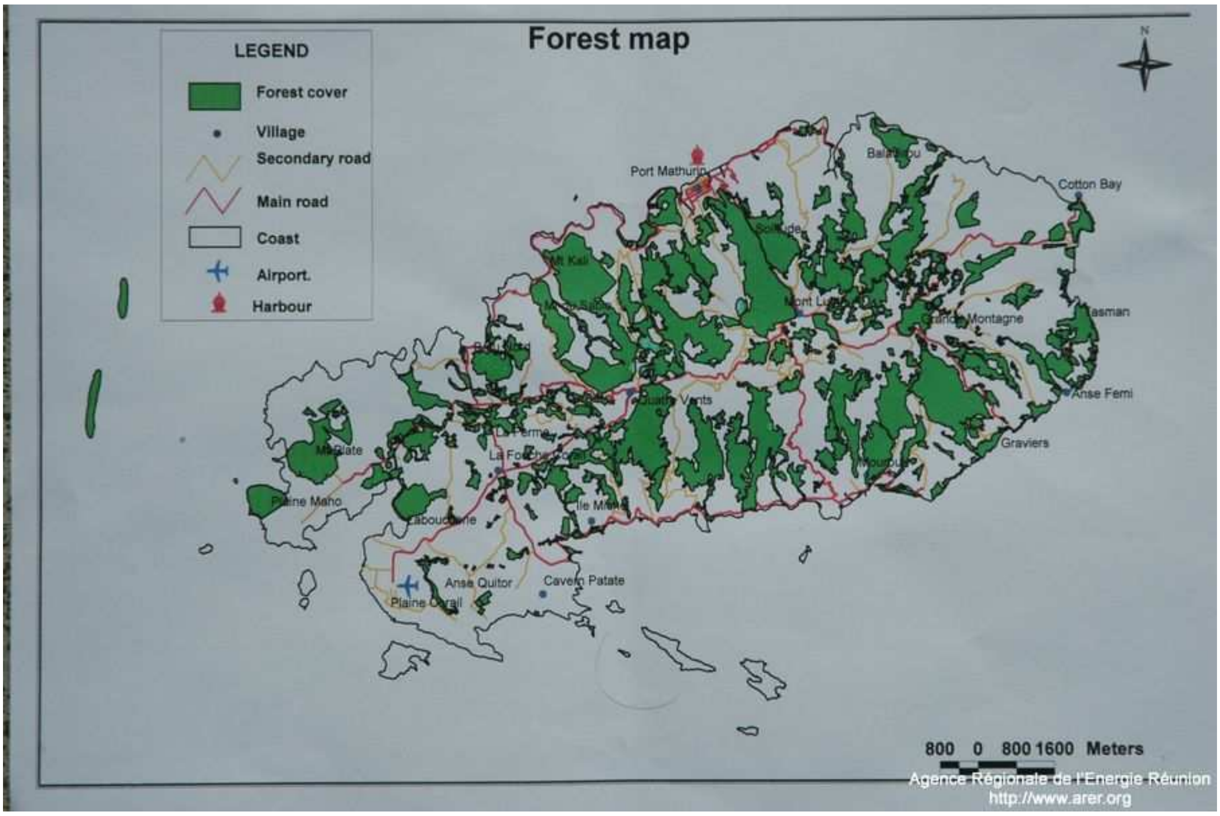
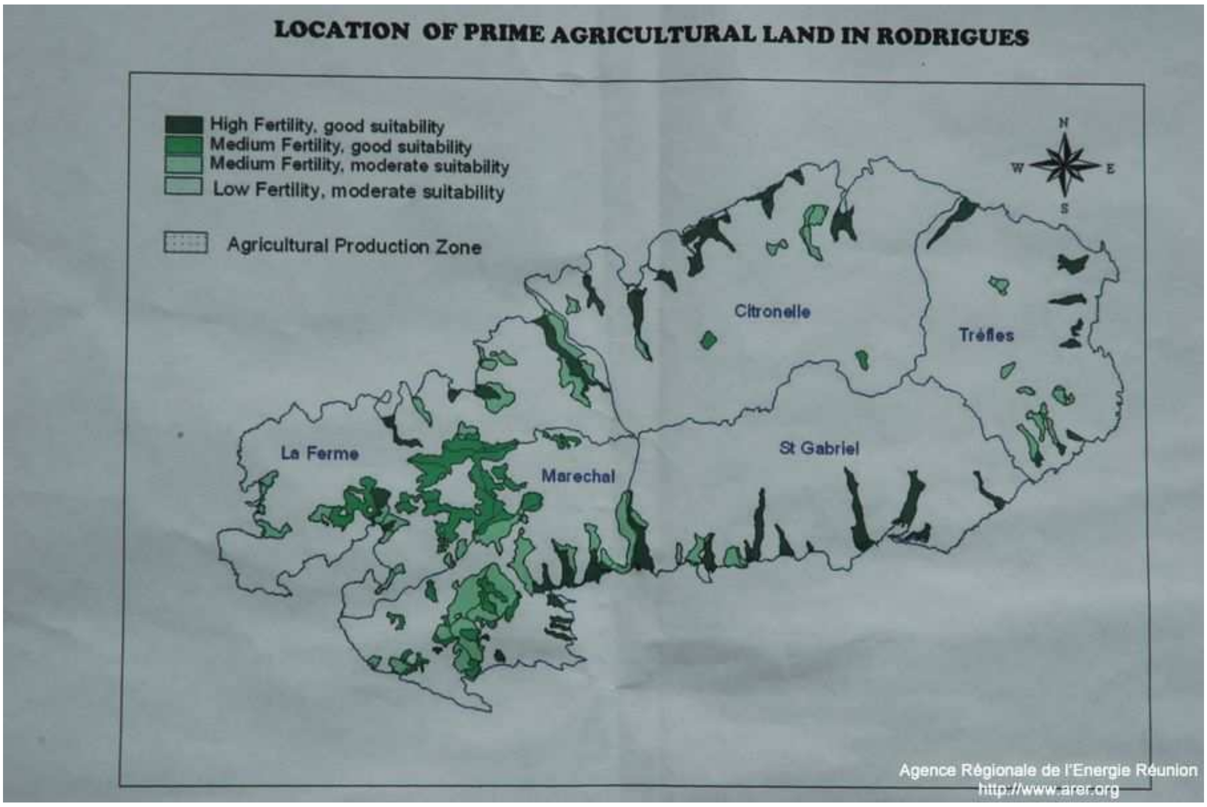


Table 54: A map of the agricultural surface in Rodrigues, from the agricultural department



A private initiative for the reforestation of endemic plants the capitalizes the acquired experience: the anse Quittor tourist park

In the framework of the tourist park" Francois LEGUAT's giant tortoises and grottos reserves " in ANSE QUITOR, an endemic floral rebuilding work has been launched. The aim is to plant primary vegetation again. With the Mauritius Word Wildlife Foundation contest, and the collaboration of a network of key players in Rodrigues, around 106,000 young plants have been reintroduced up to October 2007. A surface area of 16 hectares has been replanted in two years. There is a 90% success rate. We then have to calculate the carbon equivalent. With the experience acquired on the plot, in 5 years, the Reserve will be a totally recreated forest. We can observe that this private project, which can benefit from acquired experiences, has succeeded in good conditions, with a 90%-growth rate of the young plants. Approximately 8 plants per m² have been planted at the beginning if the rainfall period (in November), to give them time to grow before the dry season (in April), with a 14-member team during the planting period.

Table 55: example of replanted endemic plants

Some of the species represent a problem for water resources

The eucalyptus, and other imported stumps, involves environmental problems. The primary forest in Rodrigues is made up of endemic species constituting an « ever green» canopy, which collected and kept the waters. The island was desert but the rivers were permanent. Currently, between exotic trees and the population increase, the water resource is diminishing. The "var" is an endemic species, a perfect wood for ships, for stems, stern-post and marine carpentry. Another example is the Terminalia (Razuna), a huge species which covers an extraordinary surface. The compatibiltity of the consumption of these tree species must be assessed.

There has been a population increase of 12,000 people between 1970 and 2007. The latter have growing water-use habits and this explains the pressure on the water resource.

The surface area at stake, reforestation potential, wood availability, today's means, priorities

In 2007, the wooded surface of Rodrigues Rodrigues island amounts to around 3,500 hectares, on a total surface of 10,000 hectares for the whole island. The quantity of available wood wastes would amount to approximately 150, 000 tons. It is known and we can find an inventory of the existing forests with the different species at Mr Hugo MEUNIER's department. These documents can be taken. Ref. the map of today's forest area, today's agicultural zones. A survey study, the « global survey », is being carried out at the moment.

An approximately extra 1,000 hectares of forests is considered as viable, which would finally lead to a wooded farming surface of 4,500 hectares.

The existing tree nurseries, covering 1.5 hectares, can annually yield up to 200,000 feet. Around 40 men per day are needed to reforest 1 hectare. There are around 26 officers and 150 craftsmen who work at the forest department and around 18 persons from the Mauritius World Wildlife Fondation. The Anse Quitor reserve also works with private local key players to prepare the plans.

Current reforestation capacity is around 100 hectares per year, due to existing means, which comprise the forest areas to be replanted (Progressive removal of exotic plants and replanting endemic ones).

The potential focus is to reforest the south-south-western region. A village forest project is considered. Other specific wood sectors could be considered, such as the cultivation of coconut trees[56], of « Bâton Mourong »[57], of bambous (A purifier and big materials for various products, Neem[58], Jatropha[59], to diversify some economic implementations)

« Priorities must be set for land management policy: particularly reforesting against climate change » - dixit the symposium participants

"These contribute to the prevention of soil erosion, the creation of windbreaks, the provision of wood for furniture and other potential commercial activities, and improvements in the quality of the island's visual physical surroundings. Natural reserves also extend to approximately 64 ha. "

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(56) The coconut tree

Fighting against erosion on the coasts. These coconut plantations could be rationally exploited for the production of raw material and biomass gasification. The whole array of derivatives could be used : roots, trunk, leaves, coprah, nuts, seeds, 'chou', fibre, light and resistant coconut wood planks, coconut oil, coconut-shell jewelleries, kitchen ustensils, palm sugar, refreshments, coconut milk,etc. It is a very important potential economic sector.

(57) Moringa oleifera, alias « baton Mourong »

A multiple-use tree: the 'néverdier' (Moringa oleifera) (also called anamambo, moringa, morongo, or Horseradish-tree, Ben-oil tree, Drumstick-tree in English, Malunggay in the Philippines and saijan in India) is a little tree which can be 10m high. It is a very useful tree species from the north of India and the arid regions which generally looks like the acacia which withstands droughts well and has a rapid growth. The ayurvedic Indian tradition stated that the Moringa leaves cured more than 300 diseases.

Modern science has confirmed this belief and has added that this plant has an extra nutritive value: in India, the Moringa is a food-producing plant cultivated for its fruits, which are eaten cooked and, exported fresh or canned. In the Sahel, the Moringa oleifera leaves are eaten as vegetables while the Moringa stenopetala leaves are a basic dish of the Konso people in Ethiopia. Nutritional tests have shown that the Moringa oleifera leaves are richer in vitamins, minerals and proteins than other vegetables. They can be a whole food as they contain twice as much proteins and calcium as milk, as much potassium as a banana, as much vitamin A as a carrot, as much iron as beef or lentils and twice as much vitamin C as an orange. Many programmes use the Moringa oleifera leaves against malnutrition and its related diseases (blindness, etc). Moreover, the Moringa seeds contain cationic polyelectrolyte which has proved its efficiency in the treatment of waters (eliminating turbidity), by replacing alumina sulfate or other floculants. These leaves have two advantages: substituting imported floculants by a local product, which is easily accessible, enables an important saving of the currencies of developing countries. This floculant, contrarily to alumina sulfate, is totally biodegradable.

We can also extract from these seeds an interesting vegetable oil mstly in Africa where a lot of countries lack vegetable oils, an dit is also an interesting raw material for the beauty industry (soap, perfume). A mixed use of moringa, for the production of oil and floculant agent, is possible as the oil cake coming from the extraction of oil keeps its floculants capacities. Its roots are used to produce a seasoning ingredient. Other potential used of the moringa, such as in animal food, as a plant growth hormone, as geen manure, in herbal medicine or as paper paste are all the subjects of various researchers.

The Moringa can be found in very arid zones such as the Sahara, but it also likes wet sub-tropical climates. Its very deep-growing roots enable it to withstand lack of water for months. In Senegal, it is called "Nébédaye", which would come from English : "Never die". When it is cut or when the young plants are burnt by the sun, they grow again as soon as the first rainfalls resume. It can be sown, planted from pricking outs or planted in the field, or from cuttings. It can be cultivated extensively for the production of seeds (seeds or oil production) or intensively irrigated for an optimal production of leaves (very nutritive) with a harvest every 6 weeks! This tree grows very quickly, up to 1 metre per month! It is easily planted, the '"Ananambo", very much present in the six provinces of Madagascar (Fianarantsoa, Toliara, Mahajanga, Antsiranana and Toamasina), is planted from cuttings. Its mass replanting contributes to the preservation of the environment and this tree is an efficient fire-wall. Several organisations have isolated the active protein of the Moringa floculant to easen up its use in water-treatment plants but also for alguae aquaculture, paper paste plants, wine caves and the mining sector. The production and use of the Moringa in real economic conditions are being set up. (Source Wikipedia)

(58)Neem, a tree to be planted in your garden

Neem is an insecticide whose active matter, azadirachtine, is isolated from a tree seed, the Neem. If the leaves are used as medicine to cure malaria, its fruits are a perfect natural insecticide, not harmful to men and animals. It could become a biological solution for the fight against Aèdes Albopictus, the vector to several diseases such as malaria and Chikungunya. Neem oil is used to make all sorts of products such as pesticides and insect repellents. Its oil is famous for its efficiency to fight mosquitoes and flies, mites, nematodes, mushrooms and bacterials. Among them, there is Aèdes. Its active substances radically eliminate mosquito larvas, blocking the metamorphosis from the larva status to that of an adult. This tree is found in great quantites on Reunion Island, mostly in Saint Paul, and Etang Salé, where the ONF and the CIRAD have planted millions of items.

(59) Jatropha Curcas, a plant with various uses

Jatropha curcas L. (Euphorbiaceae) - Pignon d'Inde– from the Barbados. The Jatropha type comprises 170 species and most of them come from tropical America (MABBERLEY, 1993). The name was coined from 'iatros' = medical and 'trophe' = nutrrent. It is an herbaceous plant of 50 to 70 cm high which can also reach 3 m high under good conditions. Its leaves are palmate and are yellowish green. The bear three-shelled fruits. The seeds are 1 to 2 cm long and are black stripped. They are very toxic seeds: 17 to 40 % oil. emeto-cathartic oil. Toxalbumine (Curcine). Purgative, drastic, venemous. Posology: 3 to 5 shelled and lightly grilled seeds. Root barks: rubefiant. Stem juice against Laffe (venomous fish) bites. Leaves used in cataplasm on engorged breasts. This oil is used as ointment for haemorrhoids, rhumatisms, scabies; herpes, hydropisy (DARUTY, 1911). - Source: Medicinal plants sheet of Madagascar by Pierre Boiteau and Lucile Allorge-Boiteau.

The production of green fuel, as considered by the malagasy government, from the Jatropha will lead to a green fuel which is available for generators, vehicules and boats, and this would greatly reduce the territory's energetic dependence on fossil fuel. It would also ensure the emergence of a renewed rural economy and would save the country's finances regarding the increased cost of oil. This plant has other qualities and is present amost everywhere in Madagascar: in soap production, to cure insect bites, urticant caterpillars and itching powder, furuncle, in paper production with bark and fibres ...)

The replanting a natural layer on the island is a major issue for the resistance of Rodrigues Island against climate change, on the economic level, which can greatly create employment. It can also fight against land erosion, recreate the water and soil conditions, and encourage the creation of wood resource which could be used with various objectives: wood energy and craft wood, medical wood, plants for perfume, etc.

The choice of endemic species which are more adapted to the arid and windy conditions of the island can enable a better «preparation » of the ecosystem to the climatic changes on a short-term forecast by the IPCC. The coming thirty years will be the last phase of the reafforestation project and will thus prepare the natural layer to adapt to climate change.

Rodrigues Island now entails political, technical and land management choices: « How can some order be brought and how can the sharing process be carried out regarding pastures, forests and agricultural lands? »

One of the main problems underlined by the agents in Rodrigues is: Rodrigues is covered with «pastures everywhere, villages everywhere, forests everwhere". An educational and training programme for the citizens and farmers has been set up, and it aims at changing attitudes and introducing good practices by the Forestry Commissioner. But it is not enough.

It is very important to be able to manage the allocation of the lands and share them between forests, pasture and farming. To do this, the livestock farming conditions, the production of fodder, and the allocation of lands for these activities must be analyzed. It is clear that the lack of incentives in this field will make this situation last. But how can livestock farming practices evolve to rationalize the use of lands? Cows are mainly bred for the production of meat, and this is also the case of sheep and goats. The milk industry is inexistanr.

Various scenarios are standing out, the functions of the decisions to be taken

Scenario 1: current conditions are lingering. The reforestation policy as an adaptation procedure to climatic changes is not possible. The island is exposed to strong difficulties regarding climatic changes, as there is still a strong part of the natural cover which has been eroded, and this is made worst by present pasture techniques.

Scenario 2: Meat production is still the main aim. Pasture surfaces are allocated per village and in this framework, cattle, cows, sheep, she-goats develop freely. A balance must be managed between the number of animals and the surface area of the pastures. The amount of plots to be afforested is planned and the various reforestation programmes are part of a general biomass programme for Rodrigues Island. It is supervised by the forestry department, WWF Mauritius, and the various economic and social partners in Rodrigues.

Scenario 3: A diversification of this industry has been set up to produce milk, after meat which is already done. Scenario 2 is enriched by the setting up of meadows meant for the production of fodder. Livestock breeding and the animals are grouped and the meadows produce hay to feed the animals. The reforestation programme is done in parallel with diversification of milk products for the Rodriguan market: to reduce the pressure on the lagoons, thanks to the growth of Biomass on the island.

In case it is scenario 1, Rodrigues Island will definitely not be prepared to climatic changes. If scenario 2 or 3 arises, a minimum of 1,000 extra hectars of reforestation is possible. The National Physical Development Plan is the key to this work. It will have to be done with the help of the population.

This decision will finally be taken by the Regional Assembly of Rodrigues.

Diversifying and reinforcing the means

In the framework of the reafforestation plan, the forestry commission has up to now taken care of forests. So as to accelerate the process, new means must be thought, and the work could be extended to the other partners, that is, to the economic sector. The farming, harvesting, transport, transformation and sales jobs available are profuse.

An economic activity of existing wood cutting and transformation is necessary

If an existing forest management and rehabilitation campaign gradually discards the exotic species to promote endemic ones, an economic activity of the existing wood cutting and transformation will be necessary. A portable sawmill plan would have as objective the production of timber for joinery, woodframework and craftmanship. This would restrict the imported volume of wood (of poor quality). A project leader has proposed to organise and launch this activity. Wood wastes from this activity could be used in the gasification unit. The necessary technological chain is:

Table 56: equipping the portable sawmill

- A mobile unit to square off the land and to reduce the volume until the wood can be carried on man's back up to the road
- A fixed electricity unit
- Costs : 450 000 rupees/transformation team
- Project leader: economic key players

(Reference: Logosol in Australie. The start equipment could comprise the Timberjig in a basic version that could evolve towards the Big Mill Basic (the first two ones work with a petrol chain saw and is mainly used to cut the wood in the forest to facilitate the transport) and finally the sawmill Logos l M7 (a fixed place on our carpentry shipyard) equipped with an electric chainsaw for a better yield. All this costs approximately € 9 100.00 including the supplier's hauling in Rodrigues.)

Energy wood and gasification

Beyond the reforestation project which aims at economic development and adaptation to climatic changes issues, the energy wood industry can also participate in the decrease of gas emissions leading to green house effects. Biomass gasification technology is very reliable. It has the advantage of being able to function « in base » on the CEB load curb, and does not possess the intermittent characteristic of wind or solar energy.

In the Indian Ocean, it is used in Madagascar (based on a strong and adapted Indian technology, used for example by the Bionerr Company). These systems are developing everywhere, mainly in India. They have a lasting characteristic, as from the moment that the used resource comes from wood and plant wastes that have been recycled in silviculture and agriculture.

In what ways can the biomass policy become an operational programme fighting against climate change?

Reforestation is simultaneousy a carbon collecting act, the recreation of a viable local climate, a major economic sector, an important source of energy production and a necessary adaptation of the island to climatic changes.

What can slow downte programme:

- Ill-known and not well spread centralised actions
- Few private initiative possibilities
- The length of the plantations growth
- Lack of finance and means
- Lack of political decisions to be taken on the sharing of land use
- Lack of communication with the population on the issues of climate change and the need to act on the economic plan and to adapt to climatic changes

The assets:

- A good experience acquired with very competent key players

- Available fundings in the MDP framework
- A potential of wood for an energy wood sector which is in harmony with the gasifcation system
- The reintroduction of endemic plants has started successfully
- Coconut trees, bambous, Neem and Bâton Mourong grow well and have very diversified economic and environmental potentials
- A strong political drive
- The wood sector, and more globally, the biomass one can contribute to the energetic autonomy of Rodrigues by using gasification, with a electric potential of 1 megawatt

Synthetic presentation of the global action programme to be set up in details in a future specific technical meeting with Rodriguan experts

- Arbitrating the allocation of land among forest, agriculture and livestock farming
- Quantifying and arbitrating the general reforestation programme – this task is to be carried out in a specific workshop grouping the concerned Rodriguan key players :
- Setting up a "Wood" economic branch: General reafforestation of the island with extra minima of 1,000 hectares of endemic plants, 2,000 hectares if possible, for a future total of 4,500 to 5,500 hectares of forest. This includes a constituent which aims at rehabilitating a surface area of exotic plants with endemic plants (1,000 ha), on a total surface area of 10,000 ha all over the island. The aim is also to organize an optimization of the reforestation and acheive a steady pace of 100 ha of reforestation of new areas per year and 100 ha of rehabilitation per year, that is, a reforestation programme spread on ten to fifteen years.
- Sketch of figures to be verified and to be artitrated by Rodriguan experts of the forestry department from the François Léguat reserve:
    - Evaluating the production of young plants for 100 hectares of new reforestation using endemic plants: 100*10 000*8= 8 000 000 plants for 100 ha (base : Evaluation of plant needs per m² : 8 plants/m² from the technique used by the François Léguat reserve).(Nota Bene: according to the communicated figures, 106, 000 plants for 16 ha replanted in two years, with a team of 14 persons, that is, for 100 ha, a need of 106 000*100/16= 662 500 plants.)
    - Evaluating the production of plants per year for the reforestation of 100 hectares by removing exotic plants and using endemic one
    - Taking into account the current capacity of the forestry department tree nursery, this implies that if the figures are confirmed by the rodriguan key players, there will be the creation of several nurseries and the multiplication of the teams working in the nurseries and on reforestation. Assessing the needs
- Setting up a "coconut tree" economic branch: Implantating a coconut tree outline all along the coastline, as far as it is possible, and this is a surface area which has to be quantified. A high hypothesis possible: a strip of land of 30 metres large all around the island (60 000m*30 =180 hectares of coconut tree plantations with an average density of 200 coconut trees per hectare). In a low hypotheis: 30% of the coastline strip could be planted, that is, about 50 ha representing potentially 10,000 coconut trees)
- Setting up a multipurpose ecological sector for the houses and gardens of the island: introduction of a bambou shrub, of two to three bâton Mourong plants, of a banana tree shrub, and of a Neem plant, on the 11,000 houses of Rodrigues, with multipurpose ecological functions.
- Set up a 'village forest' project in each village
- Promoting this reforestation and development programme of the economic sector in greenhouse effect gas and in MDP/CC by quantifying the equivalent of carbon collected by the afforestation project
- Organising a platform of key players (Economic agents, Forestry Commissioner, Mauritus WWF,etc) training, organisation and planning
- Organising reforestation per sector, preparing and setting up the jobs related to collecting and transforming
- Communicating and discussing the plan with the inhabitants and key players and mobilising them on what concerns them

- Investing in a first, then a second biomass gasification units of 1 MW each, for the production of electicity and heat for the energy self-sufficiency of the island

Data to be gathered during detailled technical meetings on this specific topic:

- Cost of the afforrestation teams, assessment of the annual pace of production of necessary plants
- Positionning and booking the necessary nursery areas

Territory management project, the need to organize a programming meeting to integrate this plan into the Rogriguan territory management programme

The issue is to set up the programming and area management of the plan's mechanisms in various leading frameworks and, in particular, in the territory management project.

Biomass and integration in the territory management project, wind, stocking intermittent energy sources and integrating in the territory management programme, the ecological activity zone of the Grenade site: water, energy, materials and wastes, etc

Figure 43 : satellite view of "Grenade ecological activity zone" site

VIII / Tools and human resources: Mobilisation and organisation of the Rodriguan key players

« This global energy plan of Rodrigues is a basis leading to a larger span. This gobal plan must now be set up, its cost must be assessed and it must be planned into details, which could be the start of a climate change plan negociated and financed on an international level. It is also a marketing plan to promote Rodrigues as a « Nature Island », ou "Solar island », or with any other future slogan.

The leading streams of this plan can be studied from the reference plan « Energy Policy 2007-2025 of Mauritius Island" comprising specificities for Rodrigues Island. The consultation session in December 2007 (first week of December) will be preceded by a work exchange between the consultants and ARER, under the supervision of the Regional Assembly of Rodrigues.

English language will be used for the reports. The report must be handed in to the Regional Assembly on the 15th of October for consultation.

The strategic axes and the necessary sites will have to be intergrated in the territory management plan and the Sustainable Plan of Rodrigues: to select all the required sites and to submit the propositions

Project management: the Regional Assembly of Rodrigues

General coordination can be allocated to the Energy Agency of Rodrigues Island or to an integrated department within the Regional Assembly of Rodrigues,

The composition of the management of this local agency: a minimum of Rodriguan key players (te Regional Assembly of Rodrigues, the CEB, the Mauritian government, Economic and tourism partners, Rodrigues and Mauritius Meteo stations,etc)

The operational team of this agency: a Rodriguan team composed of Mr JN PERRINE from the infrastructure department »

A follow-up strategic committee will assist the technical team–Rodrigues Energy Agency

A promotion work and reinforcement of the capacities of the Regional Assembly of Rodrigues is carried out and focuses on training in these jobs, the management of building licences, the setting up of a management device to calculate the flow of for the government and tourism buildings. A major task will be to mobilize the partners and the marketing project on the local, national and international levels

Introducing the project to the IPCC:

- WG3
- Chairman IPC

Presentation to the Mauritian government:

- Ministry of Energy

Presenting the project to the 'Conseil Régional' and actors of Reunion Island

- The department of Sustainable Development
- Cooperation Department
- TEMERGIE
- Group H2 Run Stockage and regulating the intermittent energies

Presentation to key players and citizens of Rodrigues

Mobilizing 'Les Volontaires du progrès'

UrbiFrance, 'Mission Economique' and 'Volontaire export'

Global organizational planning

IX / Strategic, technical and organisational energy politic

Investment costs and exploitation costs compared /100%Renewable

GES assessment

Global Planning

This chapter is the second phase of study to come after concertation between the Rodrigues Regional Assembly and The government of the Republic of Mauritius

X / Speeding up the local, national and international financing

Regional Assembly of Rodigues Funds / Mauritian Government Funds/MPU/CEB

There are multiple local and national sources of financing.

First would be the re-orientation of CEB investments and spending towards local renewable energy sources. Wind-power is economically more interesting than HFO/diesel, until it will become necessary to put in place energy storage systems.

From there, the global economic, social and environmental benefits of production of local RES compared to import of fossil fuels should lead the Mauritian Government and the Ministry of Public Utilities towards local RES.

Rodrigues Regional Assembly could also make use of its budget for orienting the energy situation towards systainable development. This could be done in the form of:

- direct investment to RES production systems
- direct investment to the water system that could be profitable to energy storage as well
- attribution of all grants from RRA to additional environmental and energy conditions
- direct investment in environmental/energy education/sensitization and in guides

Finally, direct investment from the private sector, especially commercial sector, should be oriented towards sustainable energy solutions. This could be achieved thanks to specific rules for building construction licences.

Regional Cooporation from Reunion Island

Regional Cooperation from Réunion Island is mainly carried out by the Regional Council of Reunion Island and the General Secretary Office for Economic Affairs of Reunion Island which is under the control of the Prefecture and is a representative of the French State.

Other cooperation frameworks are carried out by the General Council and the local public authorities of Reunion Island, like city councils.

'Conseil Régional' of Reunion Island

Extracted from http://www.regionreunion.com/fr/spip/spip.php?article1126

Political means

Among the various Work Commissions set up by the Regional assembly, there is a Regional Cooperation Council. It is made up of regional council members. Its role is to present propositions regarding regional cooperation ad give opinions on the reports that it receives in this feld, before their examination and the decision-making by the Permanent Commission or the plenary Assembly of the Regional Council.

Administrative means

Under the control of a Deputy Director, the Regional Cooperation Department is made up of five representatives (including one in Madagascar). The department can, when needed, ask for the help of other functional directions of the Regional Council.

Financial means

To set up its regional cooperation policy, the regional council focuses first on its own budget potentials:

- Either those linked to “regional cooperation”

- Or those from the various sectorial policies of the local government (culture, sports, travelling ...) and which have the potential to also co-finance cooperation actions.

The regional council (the co-financer) can also, in the framework of a state and local government partnership, use other financing means:

- Either of the State: 'Contrat de Plan et Fonds de Coopération Régional' (Regional Cooperation Plan and Funds Contract) of the law on overseas development
- Or those of the European Union: DOCUP and INTERREG

General Secretary Office for Economic Affairs in Reunion Island

The Officer in charge, as Permanent Liaison Officer for the Indian Ocean Commission (Commission de l'Océan Indien-COI) represents France/Reunion Island in the framework of current works of this institution; moreover, it must work with the Ministry of Foreign Affairs, the French Ministry of Overseas, the local government and the concerned operators towards the elaboration of the positions of the French parties in the COI programmes.

Globally, the Regional Cooperation Mission:

- Ensures the follow-up of bilateral cooperation actions in the countries of the zone and promotes necessary relations with the French diplomatic representatives who are present in the geographical environment of Reunion Island ;
- Mobilises and supervises teams working on sectorial needs and associates when needed the heads of the poles, the representatives of the territorial local government, the consular chambers, the University, etc;
- contributes to research and elaboration of new regional coorperation projects in needed fields (economy, public health, training, education, fisheries, agriculture, environment, research, culture)
- participates in mobilizing State (regional cooperation Funds) and European (FEDER) funds, with the participation of financial partners ;
- organises the official programmes of the Prefect of the zone, for instance, during the annual session of the COI Council and the foreign ministers' travels to Reunion Island.

State to State Cooperation between Mauritius and France

The bilateral cooperation policy between Mauritius and France is defined at the levels of the governements and is carried out by the respective Ministries of Foreign Affairs. It is described in the Framework document of the French partnership - Mauritius - DCP - (2007-2011).

Two important instruments of the French bilateral cooperation concerning environment protection are the 'Agence Française de Développement' (AFD) (French Development Agency) and the Fonds Français pour l'Environnement Mondial (FFEM) (French Fund for Global Environment).

Other action frameworks go back to the regional cooperation with the SGAR, introduced in the preceeding chapter.

Agence Française de Développement – French Development Agency

Extracted from http://www.afd.fr/jahia/Jahia/lang/en/home

Presentation

The French Development Agency (AFD) is a financial institution which is at the heart of the French Development Assistance policy. Its mission is to finance development.

Thanks to the broad line of financial tools that it has been able to engineer and enhance, AFD supports public authorities, the private sector and local associate networks, to implement a wide range of social and economic projects. AFD is thus present on five continents and in Overseas France.

AFD's actions in favour of economic growth and preservation of the environment fall directly within the framework of the Millennium Development Goals (MDGs). These priority development objectives were set out in the year 2000 by the United Nations and seek to reduce poverty by half by 2015.

AFD also contributes to the preservation of Global Public Goods and can react to situations of crisis. The Agency is also developing financial and intellectual partnerships with other donors and strives to increase French influence in the area of development.

AFD is involved in Africa, Asia, the Mediterranean Basin, in the Middle East, and in Overseas France, thanks to its network of agencies and its different subsidiaries. The AFD Group brings together more than a thousand agents who, each day, use their abilities and their know-how to underpin their commitment to development.

Energy

Development is closely linked to energy. The provision of energy is a condition for economic growth. The organisation of the supply system structures the balance between rural and urban areas and strengthens social cohesion. Today, moderating energy consumption is necessary for the climatic equilibrium of the planet, which has been knocked off-kilter by a century of "over-consumption" of fossil fuels.

After 15 years of being relatively forgotten because of the oil crisis, energy is now back in the international limelight: the price per barrel of oil and the volatility of oil prices are becoming increasingly worrisome for developing economies; the tension around oil supply has re-opened discussions on energy security; the destabilization of the climate has also called into question the energy-hungry models in both developed and developing countries. Strong increases in demand by emerging countries have changed the energy equation. **Energy is now seen as a Global Public Good, one which the international community must learn to manage in the long run.**

Within this context, the AFD is stepping up its involvement in the area of energy along three lines:

- High-performance, economically competitive energy;
- Energy accessible to the greatest number;
- Sustainable energy, i.e. production of "clean" energy that emits little greenhouse gases, and the promotion of energy efficiency in terms of how it is used.

Project funding

Applications for project funding are submitted by the local contracting authorities to the AFD offices that identify the project. Together with the contractor, the AFD then undertakes a preliminary appraisal of the project idea. The next step is a feasibility study, often AFD-funded, which is carried out by a consulting firm hired on the initiative of the contracting authorities. A technical study, marketing survey and financial projections are all part of the feasibility study.

If the study is positive, the local office, in collaboration with the operational departments at AFD headquarters, takes the decision to bring the project development process a step further. A study is then carried out to check that the project is technically, economically and financially viable. At this stage, the financing plan is drawn up with the borrower. Each stage of the project development process is ensured by a "project team" led from the AFD headquarters.

The decision to grant funding is only taken if all the conditions for the project's success seem to be met and are agreed on by the contractor. The funding is then approved by the AFD's appropriate decision-making body (Supervisory Board, States Committee or Overseas Committee). The beneficiary then signs a loan or subsidy agreement with the AFD.

The choice of contractors lies with the contracting authorities, who put out an invitation to tender in compliance with local procurement legislation and approved by the AFD. The AFD does not intervene in the choice of enterprises, as this is entirely up to the local contracting authorities.

The Agency regularly monitors the progress of projects that entail disbursements, following a strict payment cycle. The final stage is the drafting of a project-completion report, with some projects being subject to retrospective evaluation.

Fonds Français pour l'Environnement Mondial – French Fund for Global Environment

Extracted from http://www.ffem.net/jahia/Jahia/site/ffem/lang/en/accueil

Presentation

The FFEM is a bilateral fund which was set up in 1994 by the French government following the Rio Summit. Its aim is to promote the protection of the global environment in developing and transitional countries.

The FFEM was established in order to promote global environment through projects for economic and social development. It subsidises projects in the following areas to help preserve the main factors of global equilibrium:

- biodiversity
- climate change
- international waters
- land degradation
- persistent organic pollutants (POPs)
- the stratospheric ozone layer

Initially established for a period of four years, the FFEM has been extended twice, in 1998 and 2003.

With funding from the State budget, the FFEM contributes to Official Development Assistance with resources amounting to 201 million euros for the years 1994 to 2006.

Its resources add to the French contribution to the Global Environment Fund (GEF), with which it shares the same areas of activity.

Eligibility criteria

Eligible projects must:

- Have a significant impact on the global environment;
- Contribute to the economic and social development of beneficiary countries and populations;
- Innovate and produce effects which can be demonstrated and reproduced;
- Produce social, institutional and economic effects that prevail beyond the project's lifetime;
- Be implemented by an effective organisation;
- Receive a majority share of funding from other agencies (including local agencies), with the FFEM providing complementary funding;
- Demonstrate consistency with the priorities of French policy for cooperation and development.

The following are not eligible:

- Programmes which concern only research and capacity building and are not linked to a development project;
- Recurrent activities and running costs of institutions or organisations.

Countries eligible for the FFEM are all developing countries and countries with transitional economies which are also eligible for Official Development Assistance as defined by the OECD. However, the priority areas for FFEM funding are the countries included in the "Priority Solidarity Zone" (ZSP), so that, in practice, half of its resources are used to the benefit of African countries.

Small Initiatives Programme

The Fonds Français pour l'Environnement Mondial (FFEM) has launched a new programme for small initiatives which aims at mobilizing the civil societies of developing countries on global environment issues through the financing of local projects.

The environmental issues retained are:

- the preservation of biodiversity ;
- fighting against climatic changes ;
- fighting persistant organic pollutants (POPs).

The programme aims at the setting up around forty projects on two years in the zones where French cooperation is active, in particular in french-speaking countries. Five countries come first in the initial phase: Algeria, Benin, Burkina, Gabon and Madagascar.

European Development Fund (EDF)

Extracted from http://europa.eu/scadplus/leg/en/lvb/r12102.htm

Presentation

The European Development Fund (EDF) is the main instrument to provide Community aid for development cooperation in the AFRICAN, CARRIBBEAN AND PACIFIC STATES (ACP) and OVERSEAS COUNTRIES AND TERRITORIES (OCT). The 1957 Treaty of Rome made provision for its creation with a view to granting technical and financial assistance, initially to African countries which at that time were still colonised and with which some Member States had historical links.

Even though a heading has been reserved for the Fund in the Community budget since 1993, following a request by the European Parliament, the EDF does not yet come under the Community's general budget. It is funded by the Member States, is subject to its own financial rules and is managed by a specific committee. The aid granted to ACP States and OCTs will continue to be funded by the EDF, at least, for the 2008-2013 period.

Each EDF is concluded for a period of around five years. Since the conclusion of the first partnership convention in 1964, the EDF cycles have generally followed the partnership agreement/convention cycles.

- First EDF: 1959-1964
- Second EDF: 1964-1970 (Yaoundé I Convention)
- Third EDF: 1970-1975 (Yaoundé II Convention)
- Fourth EDF: 1975-1980 (Lomé I Convention)
- Fifth EDF: 1980-1985 (Lomé II Convention)
- Sixth EDF: 1985-1990 (Lomé III Convention)
- Seventh EDF: 1990-1995 (Lomé IV Convention)
- Eighth EDF: 1995-2000 (Lomé IV Convention and the revised Lomé IV)
- Ninth EDF: 2000-2007 (Cotonou Agreement)
- Tenth EDF: 2008-2013 (Revised Cotonou Agreement)

The tenth EDF covers the period from 2008 to 2013 and provides an overall budget of EUR 22,682 million. Of this amount, EUR 21,966 million is allocated to the ACP countries, EUR 286 million to the OCT and EUR 430 million to the Commission as support expenditure for programming and implementation of the EDF. The amount for the ACP countries is divided accordingly: EUR 17,766 million to the national and regional indicative programmes, EUR 2,700 million to intra-ACP and intra-regional cooperation and EUR 1,500 million to Investment Facilities. An increased share of the budget is devoted to regional programmes, thereby emphasising the importance of regional economic integration as the basic framework for national and local development. An innovation in the tenth EDF is the creation of "incentive amounts" for each country.

ACP-EU Energy Facility

On the 24th of June 2005, the ACP-EU Council approved the creation of an Energy Facility with a total fund amount of EUR 220,000,000. With the unanimous support of the European Development Fund (EDF) Committee, expressed in its meeting on the 28th of April 2006, the European Commission approved, on the 2nd of June, the 220 M€ ACP-EC Energy Facility.

The lion's share of the funds (EUR 198 million) has been allocated to a Call for Proposals which was launched on: 19th of June 2006.

Outside the call, an amount of EUR 10 million has been allocated in support of the forthcoming EU-Africa Partnership on Infrastructure.

The Facility will be available to all eligible ACP countries but access to the funds will be competitive and demand driven. Grants will be offered to co-fund energy-related projects located in ACP countries which would help alleviate poverty in those countries.

All financial commitments must be completed before the 31st of December 2007, the date of expiry of the current European Development Fund (EDF9).

ACP-EU Water Facility

In March 2004, the EU Council decided to consider allocating a total amount of € 500 million for an ACP-EU Water Facility, to be funded from the conditional €1 billion of the 9th EDF. The establishment of the ACP-EU Water Facility and its funding was endorsed by the ACP-EU Council of Ministers at its meetings in Gaborone in May 2004 and Luxemburg in June 2005. The two instalments of € 250 million each have been made available.

United Nations Development Programme UNEP / GEF

Extracted from http://www.undp.org/gef/05/about/gefsec.html

Presentation

The Global Environment Facility (GEF), established in 1991, helps developing countries to fund projects and programmes which protect global environment. GEF grants support projects related to biodiversity, climate change, international waters, land degradation, the ozone layer, and persistent organic pollutants.

The GEF is fundamentally a partnership for mainstreaming global environmental concerns into national sustainable development agendas. Its governance structure is centered around a Council composed of 32 representatives from member states which meet biannually to review GEF projects, future business plans, work programmes, and policies.

The GEF Assembly, composed of all 176 GEF member states, meets every 3 or 4 years to review and approve general policies, operations, and amendments to the founding GEF Instrument. The Conventions provide guidance to the GEF, and the Science and Technology Advisory Panel (STAP) reviews every project and provides advice regarding GEF policies. The GEF Office of Monitoring and Evaluation (GEFME) reports on results and lessons from GEF programmes and projects directly to the GEF Council.

GEF operations are coordinated by a Secretariat in Washington D.C, which is headed by a Chief Executive Officer (CEO). Operations are carried out by a tripartite partnership composed of the United Nations Development Programme, the World Bank, and the United Nations Environment Programme, which are referred to as the three Implementing Agencies. Each Implementing Agency brings its own particular comparative advantage to the GEF. As stated in the GEF Instrument, UNDP will play the primary role in ensuring the development and management of capacity building programs and technical assistance projects. In 1999, the GEF Council expanded opportunities for seven organizations to contribute to the implementation of GEF projects. These organizations are known as Executing Agencies under the GEFÁs expanded opportunities policy, and comprise four regional development banks (AsDB, AfDB, EBRD, IDB) and three UN bodies (FAO, IFAD, UNIDO), some with full access to GEF funding.

The Implementing and Executing Agencies are responsible for project formulation, submission, implementation, and monitoring and evaluation. Projects have to conform to the policies and decisions of the GEF Assembly and Council and are developed through consultation and dialogue with national governments and local stakeholders, the GEF Secretariat, and STAP. NGOs often play a key role in the project identification, formulation and implementation process.

GEF Leadership in Climate Change Mitigation

GEF helps developing countries undertake "win-win" projects to mitigate the effects of climate change by reducing concentrations of greenhouse gases (GHGs) in the atmosphere. These GEF projects also benefit the local economy and help improve local environmental conditions.

GEF programmes take a long-term perspective to reducing GHG emissions by transforming energy markets in developing countries. The goal is to foster economic growth and sustainable development by enabling these markets to operate more efficiently and shift away from carbon-intensive technologies.

GEF's objectives as far as climatic change mitigation is concerned are:

- Removing Barriers for Energy Efficiency
- Promoting Renewable Energy
- Reducing Costs of Low-GHG Emitting Energy Technologies
- Supporting Sustainable Transportation
- Helping Markets to Operate Effectively

GEF funding

GEF funds a variety of project types, ranging from its Small Grants Programme, to Enabling Activities, Medium-Sized Projects (MSPs), and Full-Sized Projects (FSPs), including the use of the Project Preparation Grant (PPG) to prepare them. In addition, the GEF has developed a two-year $5 million programme with the Development Marketplace to fund smaller projects using an expedited procedure.

Small Grants Programme

The GEF Small Grants Programme (SGP) was launched in 1992 to provide support for community-level initiatives that contribute to conserving global biodiversity, mitigating climate change, protecting international waters, reducing impacts of persistent organic pollutants and preventing land degradation while generating sustainable livelihoods.

SGP complements GEF full- and medium-sized project funding, by providing a window for the direct participation of NGOs, local communities, and other grassroots organizations.

Grants are made directly to community-based organizations (CBOs) and non-governmental organizations (NGOs) in recognition of the key role they play as a resource and constituency for environment and development concerns. The maximum grant amount per project is US$50,000, but averages around US$20,000. Grants are channeled directly to CBOs and NGOs.

Enabling Activities

Enabling activity projects provide financing for the preparation of:

A plan, strategy, or program to fulfill commitments under a global environmental convention

A national communication or report to a relevant convention.

The GEF currently finances enabling activities related to the conventions on biodiversity, climate change, and persistent organic pollutants.

Medium-Sized Projects

Given growing support by governments and non-governmental organizations (NGOs) to expedite the implementation of smaller projects, the GEF Council, at its October-1996 meeting, approved procedures to streamline the processing and financing of medium-sized project proposals (MSPs).

MSPs are limited to a maximum of $1 million in GEF funds. The approval is delegated by the Council to the CEO, and is subject to the Project Review Criteria which is similar to full-sized projects.

MSPs should also satisfy the requirements of:

- a Strategic Priority
- either an Operational Programme or a Short-Term Response Measure.

MSPs are submitted to the Secretariat on a rolling basis throughout the year and go through a one-step approval by the CEO of the final project document.

Full-Sized Projects

Full-Sized projects (FSP) are projects receiving more that one million dollars in GEF grants. FSPs must satisfy:

Eligibility requirements under the Conventions

- A strategic priority
- Either an operational programme or a short term response measure.

These projects go through each step of the GEF Project Cycle (a new project cycle paper will be in place in June 2007), first entering the GEF pipeline as project concepts. Proponents may, however, wish to avail of Project Preparation Grants (PPGs) to further the development of the concept into an FSP. (Preparation guidelines for PPGs can be found below.)

These projects are then submitted for Work Program inclusion and approved by the Council during its regular meetings or intersessionally by mail.

Clean Development Mechanism – carbon credits

An outcome of the Kyoto Protocole, le Mécanisme de Développement Propre (MDP) (the Clean Development Mechanism) is a flexibility mechanism enabling industrialized countries (calles partner countries) to achieve their objecties of reducing emissions by investing in clean technologies in developing countries (called host countries).

The process is simple. A project leader receives Certified Emissions Reductions units (CERs) corresponding to the emission reductions thet have been introduced by the projects assessed by a reference scenario. These emissions reductions are assessed for the « investing » country and the project leader can sell it again on the "carbon" market.

The MDP projects can involve:

- **Renewable energy: wind farms, solar water heater**
- **Energy saving: low consumption lamps**

The setting up involves the participation of the Executive Council of the MDP (EC), the Designated National Authority (DNA) of the host countries and the Designated Operational Entity (DOE) (Chosen Operational Body):

File conception: the project leader draws documents describing the real and sustainable advantages of the reduction of climatic changes and prouves that the reductions are additional

Acceptance of the host country: the DNA assesses and approuves the MDP project relying on the Sustainable Develoment criteria that it had defined earlier

Validation and registering: the DOE validates the project as a MDP one and the EC registers it

Supervision plan: the project leader proposes a follow-up of the reuctions to the EC

Verification: the DOE verifies the real reduction and produces a recommendation report for the emission of the certified emissions reduction (CERs)

Issueing: the EC emits the CERs

The verification and emission phases must be renewed each year

100%solar water heaters for Mauritius Island and other islands

Islands of Indian Ocean need to establish strong technical and political relationships, about climate change and mitigation policy. Each proposition of cooperation we could sustain between our teams working on energy is welcomed. For example: the "Solar Water Heater" (SWH) policy in Indian Ocean and on each island:

During our travels and participations in differents meeting about climate change and energy policies, we have got a good opportunity to understand the state of policy and developement of renewable and fossil energy on Mauritius Island and the another islands. We can constate that a lot of people are now aware about interest and necessity of developing renewable technologies at a large scale on our islands, and particulary on Mauritius Island, in order to compet fossil energy. That's a good point. We can also feel the pressure and complexity to make choices for the right policy, combining short, medium and term, which is not simple, but have to be made on a long term vision abour climate change. Peoples on the Indian Ocean islands are talking about global policy and support they need from their governements, to boost the renewable energy sectors, and some of them considere that, in particulary, time is coming now to promote, among all the different technologies known, the Solar Water Heater, technology that our president of La Réunion Régional Council, Paul VERGES, considere as very strategic and promote on La reunion for a long time and a good feet back now. But how could we emphasise a common representation of that question and set up a cognitive platform to exchange knowledge?

In fact, considering our different meetings, we have heard a lot of arguments and good ideas, and joining with our proper experiences we got, thanks to the solar water heater programm on Réunion Island, some clear ideas emerged:

It appears that international financial incentive as credit carbon and clean mechanism developement, could finance a progamm of solar water heater at a large scale in order to reach 100% of the building equiped on Mauritius Island in 2025, and on each island in Indian Ocean

This programm could be very welcomed by mauritian people, as well as by people from others islands, because now, Renewable Energy become more known and very popular all over the world and also on Mauritius, but also because those technologies are now very efficiency, and not so much expensive, if you create a local big market trough the next twenty years. That's to be considered as a global economic plan for the solar technologies, something like «the solar water heater for each people».

This could also be considered as a compensatory measure to the project of 150 MW of charcoal power station. 100% Solar water heater represente in 2025 about the equivalent of 300 MW of electric power Mauritius Island won't need in fossil systems, and that Mauritius economic actors could developpe themselves, step by step, as we do on Reunion island, and a lot of another counties, thank to a global governemental politic support.

All people or enterprises equiped with SWH will make real financial economies.

In term of global cost, you could see trough more detailed calcul we could process together with your technical team, that even at the present price we buy an individual solar water heater in Mauritius, 300 000 SWH will cost half the financial mass you will invest in the 150 MW of Charcoal Power station, without forgeting that you will have also to buy charcoal each years at prices which will increase in the future, because of the tension on petroleum ressources, a lot of nations will buy charcoal in substitution, if governenments don't act to arise a real global policy to promote clean technologies.

This renewable power installed on Mauritius Island will also permit to preserve Charcoal power stations for other needs, as industrial sector needs for example. We considere also that it preserves a better percentage of energetic independance and that you perform your security of supply, by developing local fabrics to build, sell and recycling old SWH. This global economic plan could create ten more local jobs than the equivalent power in charcoal station.

It could help the Governments in the negociations they conduct, with international institutions as Fond Monetaire International, Worl Bank, IPPC, by giving abroad a very positive image of our Islands. We do not forget also this could give a boost in the marketing of tourism sector, if hotels are equiped with SWH, because of the green label more and more tourits are looking for.

So, our technical team could work together and conduct on the next months a more detailled plans and its feasability, about Solar water heater. That means, meeting at the political level through COI, combining a meeting with the prime minister, the ministrery of environnement and of course the minister of public utilities to examine what could be a global and sustain programm of solar water heater which could contibute to the economic, social and environemmental development of our islands.

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TABLES

FIGURES AND PHOTOS

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ARER - Island-NEWS – Project Engineering : Topic : Energy strategy - Sub Topic : Land
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Writers: falshakarchi@arer.org ; christophe.rat@arer.org, **Contributors:** Laurent.gautret@arer.org, ombline.luca@arer.org
Pilots project for the Rodrigues Régional Assembly : JN PERINNE, S MATADEEN from Infrastructure departement
Date: November 2007
Version 1.0: Regional Assembly of Rodrigues – ARER – Web Site ARER.ORG
Key words: Climate change, water and energy security, rural economic development and urban balance, fight against poverty, development and wealth, programme to reduce greenhouse gas emissions, 100% renewable energy.

ARER, Reunion's Regional Energy Agency, a non-profit association under law of 1901

Advice and Project Engineering and Development of Technological sector, Training, Education and Awareness Building, Observatory

Contact our team on 0262 257 257 or http://www.arer.org - http://www.island-news.org, arer@arer.org - Water, energy, waste and construction material management, planning and transports.

Objective: To promote energy management and the use of renewable energy, to preserve local natural resources, within the context of sustainable development and adaptation to climate change

Office : 40 avenue de Soweto * BP 226 * 97456 St-Pierre Cedex – Réunion Island - Indian Ocean – Tél. : +(262) 262 38 39 38 * Fax : +(262) 262 96 86 91 * n° Siret : 43928091800020 – recognised training organisation.