Sun, wind and water
The new El Hierro island's allies

El Hierro has been the first island that has been declared a Biosphere Reserve by the UNESCO in the new millennium. This acknowledgement was basically due to the need to preserve the particular natural and cultural values of the island, but it involved the support to the island's Sustainable Development Plan that had been officially approved in 1997, where an ambitious and innovator strategy of future already endorsed by several sustainable development projects started since the 80's was defined. Both the basic objectives of the island's declaration as a Biosphere Reserve and the Sustainable Development Plan contain the commitment to turn El Hierro into one of the first islands of the world that is completely 100% RES. In fact, it is at present the only case which recognises a strategy in favour of large-scale use of renewables that is contemplated by the sustainable development and conservation forms supported by the United Nations. It is therefore an innovator project sponsored by the local Island Council with the support of the Canary Islands Government.

The Island Government of El Hierro (Cabildo de El Hierro), UNELCO (local utility) and ITC (Technical Institute of the Canary Islands) are collaborating in a project whose objective is to cover the energy demand of the island with 100% RES by 2005. The first phase of the project has been carried out with the support of the Altener Programme.

Actually, it is a very pondered project, whose first works go back to 1986, when a first proposal was elaborated: it was really a pioneer project if we take into account the absolutely different technological conditions. At that time the commercially available aerogenerators were in the rank of 300 kW, and did not obviously exist yet high-power machines with synchronous generators.

Present situation

The island of El Hierro, Canary Islands, has an area of 276 km^2 and a population of approximately 6,500 people. Nowadays the electricity supply is covered through a conventional thermal power station (diesel system). The power installed is 8'285 MW. The contribution of renewable energies was the following (data from 1998):

- 1 wind farm connected to the grid of 280 kW
- Stand alone photovoltaic systems with a total capacity of 6'5 kW
- 362 m^2 of installed solar thermal panels

The evolution of energy consumption and generation are:

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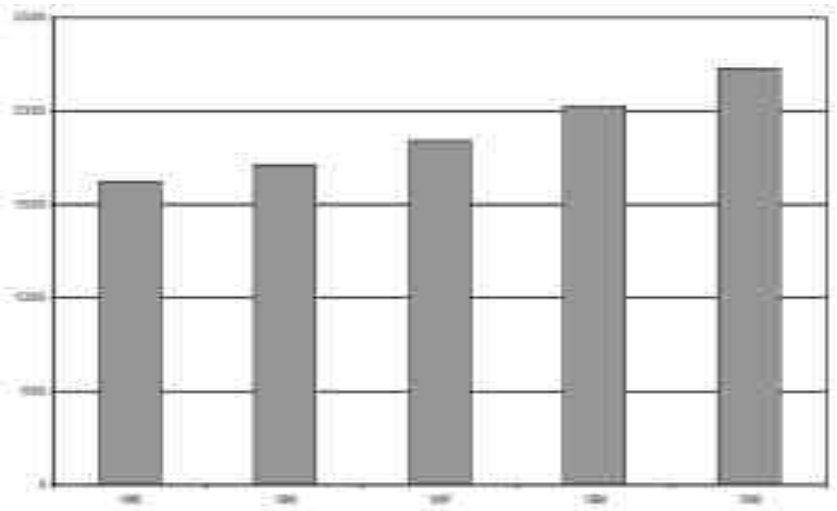
Evolution of Energy Consumption in El Hierro (MWh)



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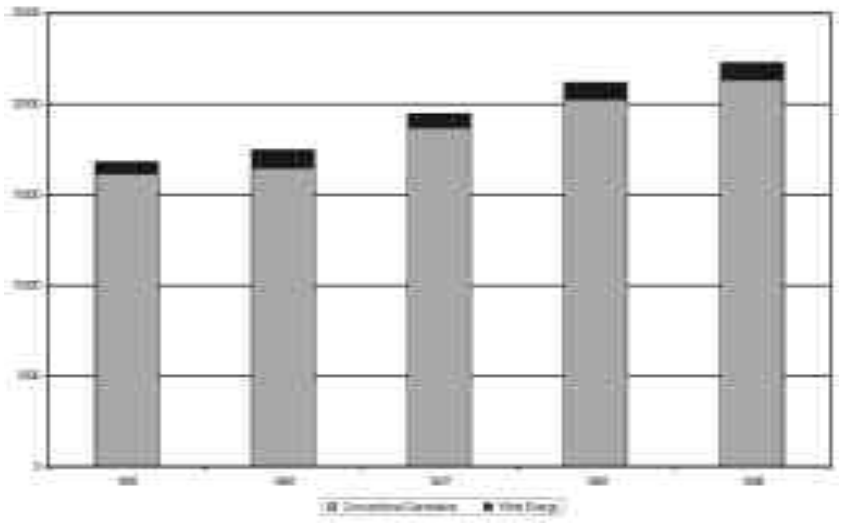


Description of the 100% RES electricity supply project

The Canary Islands Government, through the Industry and Trade Ministry, has a special interest to develop this project on the island of El Hierro as a demonstration case for a 100% RE supplied community, one of the most outstanding initiatives of the Island 100% RES. When successful results and experiences have been obtained it is the objective of the Canary Government to implement such systems in other Canary islands and participate in dissemination and implementation activities in other islands in Europe and if possible in Africa and Latin-America.

As demonstrated with the performance of wind turbines installed in the island for several years, El Hierro has enough wind potential to cover all its electrical demand. However, the Canary Islands' law has established a limit on the penetration of wind energy into the grid of 12% in order to avoid imbalances in the electricity system. Alternatives to increase the RE utilisation are therefore looked at. In this context the following actions to supply 100% of the electricity demand with RE are in focus:

- Implementation of a combined wind energy and hydroelectric power station where water comes from a pump station pumping water from and to levelled artificial lakes;
- High penetration of solar thermal systems for hot water by promotion, dissemination and financing campaigns;
- Introduction of PV systems and hybrid systems (PV-Wind) for houses connected to the grid by promotion, dissemination and financing campaigns;
- Implementation of an energy saving and energy auditing programme;
- Gradual conversion of the transport sector from petrol and oil power;
- Introduction of biomass systems.

The actions will take place in parallel to awareness campaigns, dissemination events and training courses in order to ensure the adaptation of the population to new technologies and organisational structures and to prepare the island population to be responsible for the maintenance of the systems.

Based on the preliminary design already mentioned, the objective is to design, develop and install a wind-hydro system capable of supplying 100% of the island's energy needs. Regarding natural resources, the island has an excellent wind potential. There are two wind turbines installed near the capital (100 and 180 kW rated power). Actually they supply 5% of the energy needs of the island. The consumption in the island is quite reduced (22 GWh per year) due to its low population. Moreover, it has a small and isolated electric system.

When considering storage solutions, the abrupt orography offers advantages for the installation of a hydro plant, due to the height (1500 meters with unevenness of 1200 meters) of this relatively small island. A desalination plant is introduced for filling the reservoirs that will form the hydro plant and replace water losses due to evaporation.

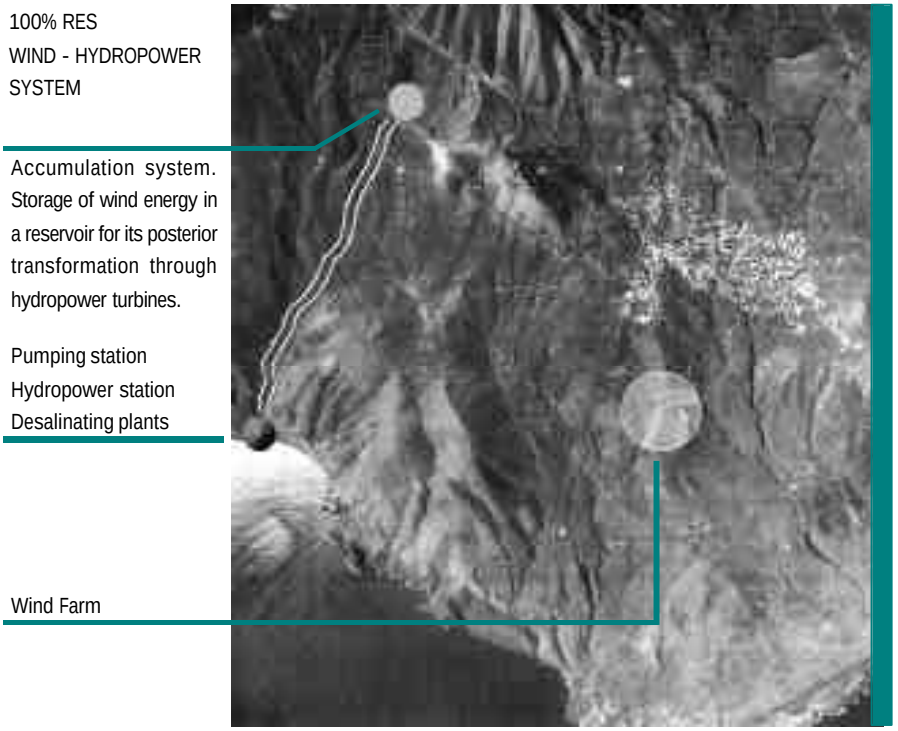
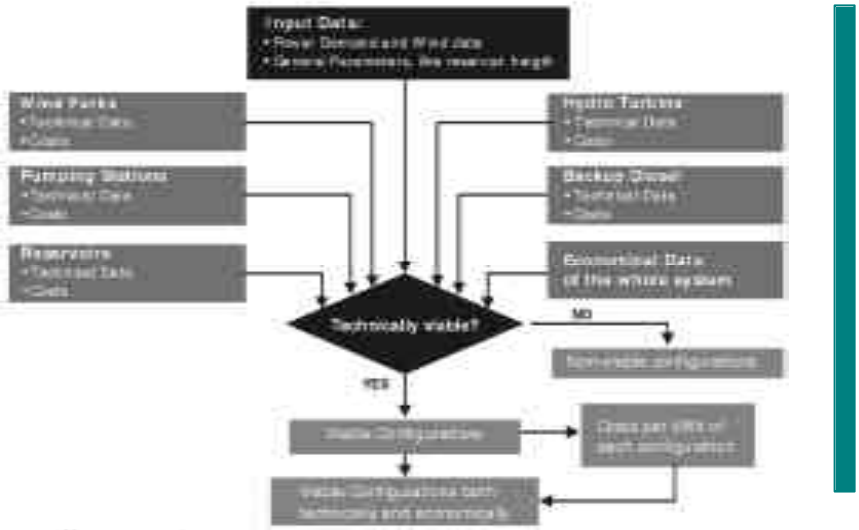


Figure 1 summarily describes the scheme of the system. The wind park supplies energy for consumption, and the energy surplus is used to pump desalinated water from the lower reservoir to the upper one, which is placed at 600m a.s.l. When wind resource is scarce and does not reach consumption levels, the water from the upper reservoir is turbined to the lower one. If a large period without adequate wind has exhausted the water in the upper reservoir, the thermal plant will supply the necessary energy for the island consumption.



Decision-making diagram to choice the most adequate configuration

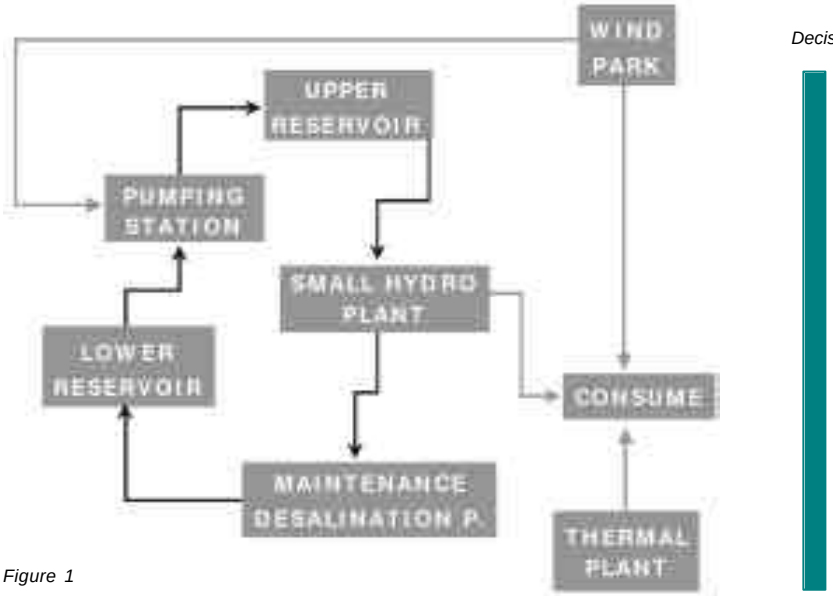


Figure 1

The different performance stages of the system are as follows (Figure 2):

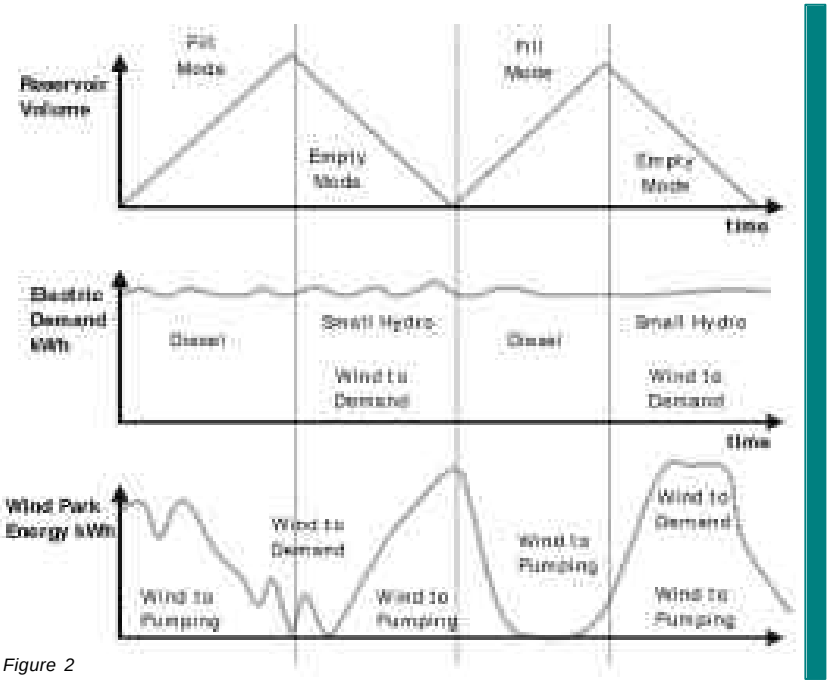
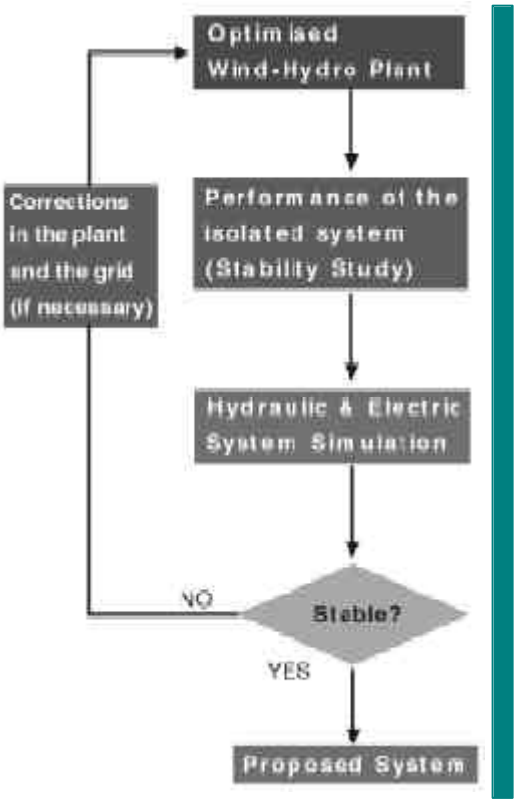


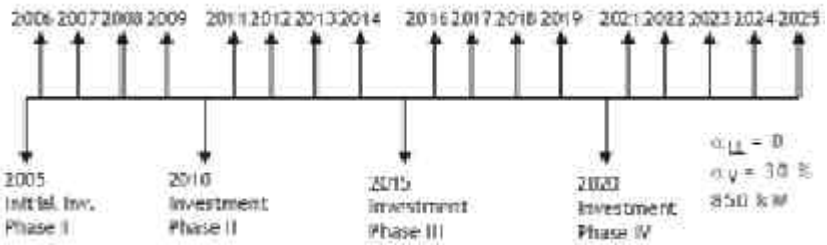
Figure 2

Moreover, there should be confirmed if corrections in the actual electrical grid were needed. Therefore, the most viable configurations were tested in the following scenario:



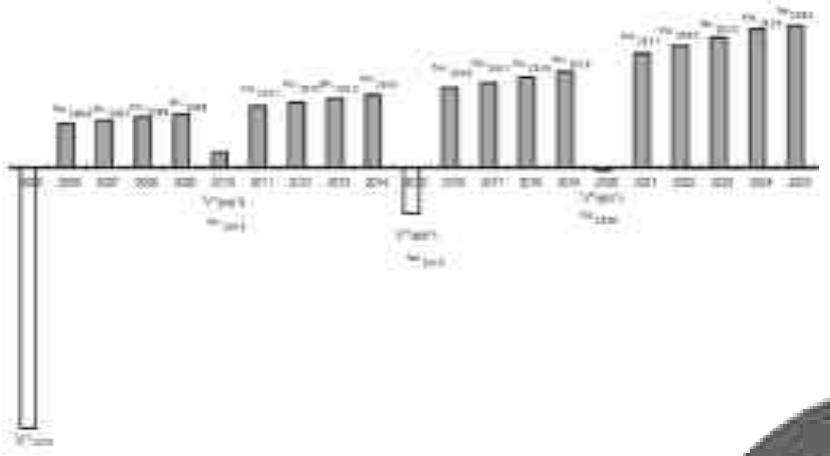
Two different solutions were appropriate, one with 660 kW wind turbines, and another with 850 kW wind turbines. 15 MW of wind power are needed for the system.

The evolution of the investment for both configurations, as well as the technical data are the following:



Phase I	11 [9,350]	7/[5,537]	2/[542]	1	0	19,6	> 70%
Phase II	12 [11,050]	9/[7,119]	2/[542]	2	1 mod 1100	1,9	> 70%
Phase III	15 [11,900]	12/[9,492]	2/[542]	2	2 mod 1100	4,7	> 70%
Phase IV	18 [18,700]	13/[10,283]	2/[542]	3	3 mod 1100	3,2	> 70%

Phase I	13/[8,580]	8/[6,328]	2/[542]	2	0	3,186	> 70%
Phase II	15/[9,900]	9/[7,119]	2/[542]	2	1 mod 1100	364	> 70%
Phase III	19/[12,540]	11/[8,70]	2/[542]	3	2 mod 1100	768	> 70%
Phase IV	26/[17,160]	16/[12,656]	2/[542]	3	3 mod 1100	999	> 70%



The wind turbines will be installed where the actual turbines are installed, considering it the best site after a careful study of wind resources on the island. The reservoirs and generation plants will be placed nearby, as the unevenness of the terrain is also adequate in the area.

Conventional System	Wind-Hydro System
Electric Energy, Mh=58.244	Wind Energy, MWh=43.357
Consumed Fuel, Tm=15,143	Fuel Savings, Tm=11,272
CO_2 Generation, Tm=47,760	CO_2 not produced, Tm=35,552
SO_2 Generation, Tm=272	SO_2 not produced, Tm=203
NO_x Generation, Tm=990	NO_x not produced, Tm=737

Savings expected from the replacement of the conventional system to the wind-hydro plant.

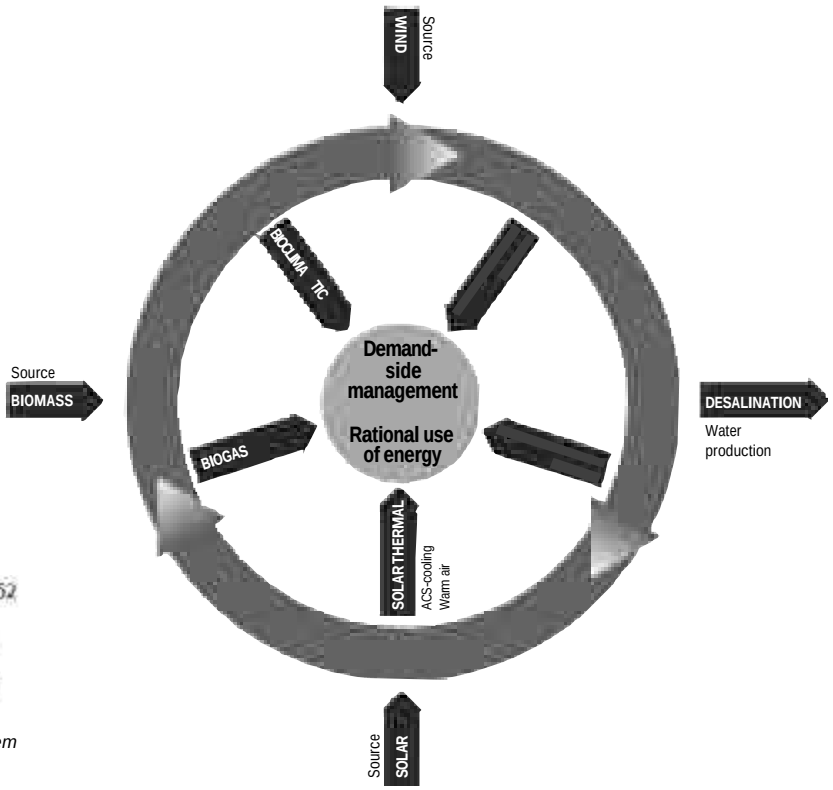
A new alliance to relieve island's thirst

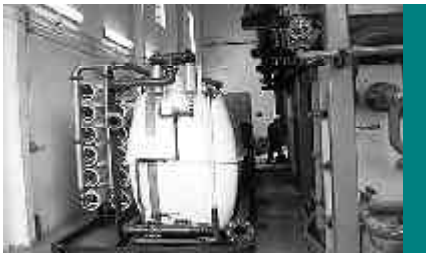
The history of El Hierro has been determined bay water and a fear of water shortage. The geological characteristics of the island are a serious constraint on the island's ability to harness water, forcing the inhabitants to develop a rich and complex culture. Water has always been collected in a thousand different ways on the island, and this is reflected by the fact that Garoe or Holy Tree, which used capture abundant water by distilling the Trade Wind mists, is still a local emblem.

This extreme relationship with water together with the integral character of the Sustainable Development Plan contributed to establish a tight relation between water and energy resources within the framework of the 100% RES project.

Seawater desalination imposes itself as a need to permanently feed the wind-powered hydraulic system, but it is evident that another way to accumulate the wind-generated energy surplus is desalinated water production.

Within this context the final implementation of the 100% RES project includes an





R.O Desalination plant

important increase in the desalination capacity and, as a consequence, a significant increment in irrigation water availability and the local water table upkeep to levels that avoid its deterioration and salinisation. In this way new projects of biological agriculture join up with renewable energy.

Biomass

One of the basic features of the island's sustainable development strategy is the group of actions generated under the slogan "El Hierro - zero waste". Biogas production through valorisation of stockbreeding effluents and sewage by means of methanogen fermentation is an essential part of the outlined strategy based on matter re-utilisation and scarce water resources. Since many years several experiences are being carried out in combined bio-gas production and water bio-recycling systems. Being good islanders, El Hierro people managed to get international cooperation from another island, Cuba. This is an island with enough technical experience and human training and can therefore transfer low-cost technologies to places with similar-featured places like El Hierro. The first phase of this ambitious programme has been concluded when the digesters installed in the experimental farm sponsored by the local Island Council started to be operative.

Visit of the representatives of UNESCO, European Commission and other international organisations to the experimental farm where the methane digesters and sewage biodepuration systems have been installed.

Transport

Transport's energy dimension could not be left out within a sustainable development integrated project that aims to become a working model for other island regions of the world. The Island Council in cooperation with the local transport co-operation started to take the first steps to consolidate an alternative transport system.
The first demonstration projects are based on:

- Incorporation of a hybrid bus to the local fleet. At the beginning its use will be limited to the airport-capital transfer. One among the various options involves the use of biogas as fuel.
- Incorporation of an electric, battery-powered minibus in the El Golfo area, for a mixed tourist-public use. It would rely on a photovoltaic station for its recharge.
- Development and consolidation of an extensive pedestrian network.
- Incorporation of advanced information and management systems within the framework of the sub-programme "El Hierro- Digital Island".
- Development of an ingenious ticketing system for the optimisation of displacements in rural scattered areas, occasionally turning the private vehicle into collective transport, supported by electronic systems for the payment of displacements.

Solar energy perspectives

The solar thermal market was actually decreasing since the 80's in the Canary Islands: that is why the Canary Islands Government promoted the PROCASOL programme (this programme has been defined and managed by ITC). The PROCASOL is a programme for promoting the Solar Thermal Systems for hot water mainly for individual householders.
From the financial point of view this programme provides a subsidy per square meter and a subsidy to the rate of interest. But this programme consists not only on financial measures but also on technical measures in order to assure the quality of the installations. In this sense 3 items have been taken into consideration:

- Guarantees for the installation operation
- Guarantees for the solar collectors
- Guarantees for the installation maintenance

The programme became very effective in almost all the islands. But it was not very effective in some of the small islands, particularly on El Hierro, where in the year 1.999 there were almost no panel installed. Some of the problems were the lack of information and dissemination, the distance to the promoters and that there was no official installer for solar thermal panels in El Hierro (the panels installed under this programme were installed by companies from another island), and that means distance and maintenance problems and lack of trust.
Therefore, thanks to this project, a big effort has been done in order to promote solar thermal systems in the island of El

Solar heating panels used in the greenhouses at El Golfo. The 100% renewables strategy not only concerns electricity production. At the same time, El Hierro has started to develop an ambitious programme to harness solar-thermal energy for producing hot water, and, in the near future, for cooling, and for implementing stand-alone photovoltaic systems in isolated ones and others that are connected to the grid.

Hierro. The financial scheme used was the PROCASOL programme because it has been very effective, but a big effort has been done in promotion, information, awareness campaigns, explanation to the local institution and to the local population and training.
Another big success was the creation of a local company in charge, among other matters, to install solar thermal systems.
Attending to this new situation, a high solar thermal panels demand is expected in the next years.
A study about the estimated market for solar thermal systems on El Hierro has been carried out by ITC. The conclusions of the study are the following:

	Householder	Tourist Sector (Hotels)	Swimming-pool Heating	TOTAL
Estimated market (in m^2)	1.024	115	1.420	2.559

This is of course an estimation that tries to cover all the potential market, the objective, within this project, was to install 500 m^2.
The timetable in order to fulfil this objective is the following:

	2.001	2.002	2.003	2.004	TOTAL
Estimation of m^2 to be installed	90	120	140	150	500

For El Hierro, the benefits of the 100% RES strategy, in quantitative terms, are the following:

- To reach a high independence from imported conventional energy resources (today the Canary Islands are totally dependent on imported oil);
- Energy will be produced and sold by Canary companies like the local power utility;
- Training for local craftsmen;
- New possibilities for employment which is of crucial importance for the island;
- Important local market for thermal systems with new opportunities for the island community;
- New opportunities for sustainable tourism.

In these terms, the model of El Hierro is considered crucial for the establishment of criteria to replicate it in other islands, preferably within the same archipelago. The incorporation of 100% RES in its institutional image, together with the application of best-practice guidelines, allow to strengthen the new way towards a sustainable tourism on which we have been working for several years.

References

Towards 100% Renewable Energy on Small Islands. Development and Implementation of Organisational and Financial Tools in a new Network Collaboration. ALTENER Project 350/99.

First steps. The El Hierro project has been developed on the basis set on the simulation and sizing made in 1986 under the supervision of the researchers Mr. Cardona and Mr. Cendagorta. In the original concept, the configuration was:

- Wind turbines of 300 kW rated power
- Hydro generators of 1,5 MW
- Diesel generators of 3,8 MW
- 250 and 500 kVA water pumps
- Upper & Lower reservoirs.

Landscape conservation has been included as a basic premise in the development of the 100% RES global project. The picure shows the moment when a high-tension cable is taken down because it crossed the El Hierro giant lizards' habitat, one of the most emblematic and endangered species of the Canary Islands. These works started on the same day when the UNESCO officially declared the island a Biosphere Reserve.