A little plant of reverse osmosis fed by an isolated electrical system

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1. Problematic world-wide of the potable water

Around 1,100 million people they do not have access to an improved water provision, and more than 2,600 million people they lack access to improved services of cleaning. The water shortage affects to approximately between 1,000 and 2,000 million people anywhere in the world.
From 1960, the difference between water use and accessible provision have increased in a 20% per decade. The desert ground affects means of subsistence of million people, including a great amount of the poor men of dry earth.[1]
FAO's recent report *World agriculture: towards 2015/30* projects that global food production will need to increase by 60% to close nutrition gaps, cope with the population growth and accommodate changes in diets over the next three decades. Water withdrawals for agriculture are expected increase by some 14% in that period, representing an annual growth rate of 0.6%, down from 1.9% in the period 1963-1999. Much of the increase will take place on arable irrigated land, forecast to expand globally from some 2 million sq. km to 2.42 million sq. km. In a group of 93 developing countries, water use efficiency in irrigation - i.e. the ratio between water consumption by crops and the total amount of water withdrawn - is expected to grow from an average 38% to 42%. The water needs of humans and animals are relatively small - the average human drinks about four litres a day. But producing the same person's daily food can take up to 5,000 litres of water.

2. Problematic Canary of the water

To produce 1m^3 of desalted water requires of 1kg of fuel. Daily in Canary Islands the 550,000 desalt m^3, which represents 26% of the regional consumption and 2% of the world-wide desalination. In the particular case of Lanzarote is more of 72% of the consumed water. The invoice for the Island accounts represents more than 36 million euros/year.[3]
Will have to fulfill the directive frame of the EEC that protects all waters. In this document they are not contemplated like commercial product, but like patrimony to protect. What without a doubt it will limit the well and galleries abuse. In this context denominated the binomial water/energy becomes more present, without energy is not water, is here where the renewable energies open a door to us to the hope.

3. Description of the system

This study analyzes an installation of desalted water production independent, which by means of reverse osmosis, exclusively fed by the sun and the wind is going to provide a production of approximate of 4 m3/día, considering 10 hours daily of operation. What could supply to a population of 80 peoples.

3.1. The reverse Osmosis

After an analysis of all the existing technologies of desalination in the market, determined that in this application the best technology, because its smaller cost, reliability, easy extension, in some cases with heat contribution residual this is not the best option.[2] The proposed system is formed by the following elements:

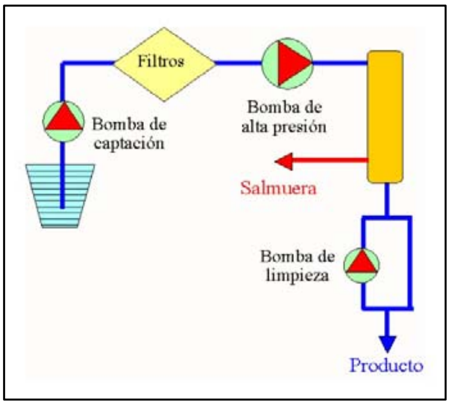

Fig 1. Hydraulic system

- Pump of water pick up sea. 3bar/2.5 m3/h/1kW
- Cartridge filters
- Pump of high pressure to 70bar 1.5 m3/h 2.2 kW
- 12 Membrane module of 2,5"

- Pump of cleaning of membranes 0.37 kW
- Storage of the water product
- Brine expulsion

Connecting to our installation of some recovery system of energy is analyzed.

Since the brine leaves the process to a considerable pressure, are diverse the devices that have been designed for energy recovery from the beginning of these plants about the Seventies. On 1985 the turbines from inverse movement and the Pelton wheels arose. The firts rotatory machin for these systems was made with metallic pieces that often presented corrosion problems, wear out and maintenance when settling in marine surroundings.

In 1990 one second generation arrived at the market new devices for energy recovery that used materials of high alloy, resistant to the wear out, such as the stainless steel 904L. By this time also the hydraulic turbo-charged was developed. These innovations improved the reliability and reduced the necessary maintenance, although still they were limited to recover only between 50 and 80 % of the energy of the brine flow to high pressure of the plants of inverse osmosis due to diverse inherent problems of yield.

During last the 20 years, several scientific have tried to develop advanced commercial devices of recovery energy that allowed to solve the limitations of yield. These devices used combinations of pistons, shovels, valves and timers; some worked well initially, but they presented/displayed many problems of maintenance. Others were equipped with programs of artificial intelligence, with which they disappeared quickly in a sector, in which the predominance of nonqualified workers demands simplicity.

In 1992, it was begun to develop a relatively simple tubular rotor that could directly transfer the energy to pressure from the brine of the inverse osmosis to the feeding flow. The interchanger of Pressure was named (Pressure Exchanger, PE). Devices PE were begun to sell in 1998. The movable and connection parts are made of ceramics, they have shown an exceptionally low wear out, and even null, in the use with brine to high pressure, and the material is not susceptible to the corrosion by punctures and tension that undergo the components of steel and bronze in similar uses. The PE of slow rotation (1,500 rpm) has demonstrated to need little maintenance in commercial desalination plants.

As the PE directly transfers energy of the brine to the flow of feeding without the problems of revolving shaft efficiency of high speed, the PE obtains a real yield of between a 91 and 95 percent with an ample rank of flows. The reduction of the power costs and capital supposes that for the first time it is possible to produce potable water from water of sea with an inferior cost to 1 dollar American by cubic meter in many places worldwide. Nevertheless these devices use for medium and great facilities, reason why they are not had including in our design.

Finally, it discards for the simplicity of the system. The power saving will come from the hand to reduce to the pumping energy selecting the pumps not oversizing, and/or having a variable speed drives.

3.2. Isolated hybrid system of electrical generation

Has been decided on a wind-solar hybrid system because they are two energies that are complemented well, and reached very significant levels in our country.

Both energies, solar and wind are seasonally stronger in summer, it will be there when it is obtained Maxima production agreeing the warmest periods with an increase in the water consumption.

Both present their maximum during the noon, and the minimum at night, so to smooth the daily curve of generation we will count on a small set of storage by batteries, this one increased the running hours and we diminished the energy to dissipate in the resistance of upset, we get more desalinate water . With this system working is more stable, protecting of frequent shutdowns and startings. In addition when it is little energy will stop the plant and the small pump of cleaning will be driven eliminating the salt of membranes, increasing the life utility of all the elements of the hydraulic circuit.

The isolated hybrid systems can have different configurations, we have decided by the configuration series, the following reasons: The required inverter does not have necessarily to be of pure sine wave, because all the generation comes from the C.C bus, in addition for identical reason does not have to be bidirectional. The control is more simple that a parallel configuration. On the other hand the inverter will have to be of the total power of the load, and a rectifier is required for the Wind turbine

(1) Wind turbine of 3-5 kW
(2) Field FV of 4 kW
(3) Dumpload. optional to heat water
(4) Batteries Pb-acid
(5) Osmosis Plant
(6) Inverter 4 kW
(7) Electronic devices

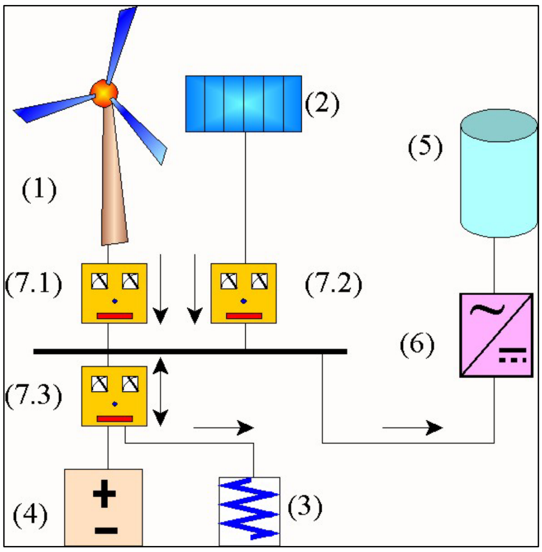

Fig 2. Schematic of the stand-alone system

We have found in market several electronics with which we make the functions of regulator of the batteries, rectifier, follower of the point of Maximum power, controller of the upset one of the remaining energy, that

in addition in the case to a population could be used in heat water, all it integrated, by a side it simplifies and it lowers the price of the installation to us, on the other hand to not being an equipment extended in use, in case of failure would stop the plant completely, having to be replaced by one similar, or to buy three local conventional equipment to replace it.
In the following scheme the electronics has been divided in three, which allows to accede to many manufacturers, as well as to decide which marks can commercialize local, saving the time to us on watch of the spare part, in addition a failure in anyone to the three, would allow remaining continuing another working.
(7.1) Rectifier (7.2) Following of the point of Maximum power (7.3) Regulating of load.
The ways of operation of the system are described in the following diagram. The storage of energy by batteries allows to the system working of more stable, protecting of shutdowns and frequent startings. In addition when it is little energy will stop the plant and the small pump of cleaning will be driven eliminating the salt of membranes, increasing the life to all the elements of the hydraulic circuit. The dumpload will act only when in mode 1, it exists excessive of energy.

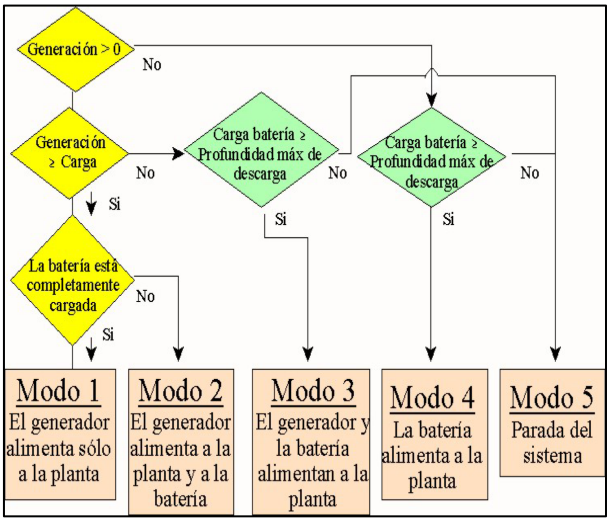

Fig 3 Operation mode

4. Devices selection of the electrical system

4.1. - The wind turbine

Has been made a study of market of mini wind turbines that could be used in this project. It being reflected in the following table a comparative. It is important to emphasize the total unamimity use synchronous permanent magnet generators. The turbines differ enormously, someone have a vertical axis with the advantage of not requiring direction and are stronger, as opposed to a less yield; although it is predominate horizontal axis with two, three and up to twelve blades. Also in the protection against speed up the pitching predominates. The selected rank of power is from 3 to 5 kW. The prices oscillate between 9,800 and 5,945.

Marca	Ropatec	Eshia	Bornay	Sciroco	Windmission	Iskra	Wes technical
Modelo	WRE.030	AERO5000W	INCLIN3000	E5.5-5	Wind Flower	AT5-1	LMW 3600
Potencia	3000	5000	3000	5000	4000	5300	3600
Velocidad d corte	14	15	14	16	15	12	12
Vel. de arranque	3	4	3,5	2,8	4	3	4
Tipo de eje	vertical	H3Palas	H2Palas	H2Palas	H12Palas	H3Palas	H3Palas
Generador	síncrono	síncrono	síncrono	síncrono	síncrono	síncrono	síncrono
País	Italia	España	España	Grecia	Dinamarca	U.K.	Rusia

Tabla 1 Wind Turbines

4.2. - The photovoltaic panels

A market study has been made, outstanding is had that all the selected units are equipped with cells single or multi crystalline, because we have not considered the thin film solar cells, why its smaller eficiency and life utility. This study is less rigorous because the manufacturers of photovoltaic panels in Europe are very numerous. Panels between 100 and 200W will be used, in number so that 2kW is added approximately, we will consider that is a number that allows to its association in series and parallel until reaching an adapted tension of work, in order to diminish the losses and falls of voltage in the side of continuous current.

marca	Atersa	BP	Sun Technics	Aet Albasolar	Isofotón	Siliken
modelo	A-100	BP 3125	STM 200 F	Conergy 123P	I-100/24	SLK36P6
Potencia (W)	100	125	200	175	100	120
Tensión (Pmax) V	16,5	16,5	40	35,4	34,8	18,2
Tipo de célula	poli	poli	mono	mono	mono	poli
Número paneles	20	16	10	12	20	18
País	España	España	Alemania	España	España	España

Tabla 2. FV panels

4.3. - The electronic devices

This installation requires a follower of maximum power point, a regulator of load for the batteries, a rectifier for the wind turbine, as well as of an inverter to feed the loads. Altogether they could be four equipment, or a unique device.
The use of a unique device specially designed has been considered to work with the aerogeneradores supply certain houses of mini turbines like J.Bornay, eoltec and

Sciroco. For it, the regulator goes provided with following bornas of connections:

- Three-phase entrance for wind turbine
- Entrance +/- to PV (Optional)
- Exit +/- to battery
- Exit to resistance (Optional)

The operation of this regulator, is to detect at every moment the state of the battery, controlling the passage of energy produced at every moment, introducing it only the necessary, and dump the rest, thanks to the resistance heating including in the interior of the same regulator (Optionally to warm up water through the exit to resistance). The battery always receives the necessary energy, maintaining it in flotation state when it is loaded, all it thanks to the electronic controller through Moss system. The use of this device lowers the price of and simplifies the installation, but we depend in exclusive right of this manufacturer and a failure in the device could stop all the installation. Another option is to select the equipment of independent form, as it has been reflected in the schemes previously.

The inverter will have to be not grid iteractive, and with a pseudo sinusoidal wave, because one of pure sine wave because he is more expensive and with worse yield; but either of square wave, because he could affect the correct operation of the equipment.

4.4.- Batteries

The use of the storage system allows us to disconnect the production of the consumption, in bad days, with a little wind and sun, , with storing we could give entrance to the plant sometimes, although never the production reaches the nominal plant power. We avoid continuous startings and shutdowns of the plant with the failures and wearing down that supposes, in addition always will have left a small energy of reserve to come to the cleaning of membranes in case of shutdown of the plant. All it entails a greater advantage of the generators and the plant. In return we increase in price the installation, as far as the reliability increases although the batteries are a delicate element, because the storage is arranged in parallel, in case of failure the system could work perfectly without him. A storage has been considered that allows an autonomy of almost four hours, using for it six batteries, in series three to three, of the following characteristics:

SBS- G Series Batteries G12V Gel

Nominal Voltage:	12V
20h Capacity:	150AH
Weight:	115 lbs
Internal Resistance:	3 mOhms

The work tension is of 60V, whichever greater is the tension, minor losses and falls of tension. Using two branches in parallel allows the power us to maintain the system of storage until with three spoiled batteries operative. It's a security voltage in dry place.

4.5. - Selection of devices

Considering the curves of production, the costs and the reliability has reached the conclusion that the optimal configuration is the formed one by the following elements already described.

The wind turbine the Sciroco, to present the curve of power with greater slope and the same speed of starting, using the maximum advantage of the resource. Entering price with respect to the others.

The selected photovoltaic panel has been the I-100/24 of the Isofotón house, being all of approximately the same efficiency and to be this one the one that greater voltage in the point of maximum power, 34.8 V. We do not forget that a greater voltage carried less losses and voltage falls. They will be connected in series two to two, therefore the tension of the bus will go up to around the 70 V.

5. Conclusion

The municipality of Mogán in the southwest of the island of Great Canary has been considered like installation place, known its Wind and radiation resources. The resources of the selected zone, and the production considered with the configuration described is analyzed for the different months.

Media diarias	Radiación kWh/m2/ día	Viento m/s	Paneles kWh	Aerogen. kWh	Agua desalada m3
Enero	3,206	8,19	125,11	2158	209,67
Febre.	3,985	8,04	140,46	1848	182,61
Marzo	5,423	5,27	211,63	595	74,08
Abril	6,441	8,05	243,25	1987	204,82
Mayo	7,664	9,80	299,09	3571	355,42
Junio	7,902	10,04	298,43	3600	358,02
Julio	8,736	10,72	340,92	4166	413,90
Agosto	7,931	9,66	309,51	3497	349,58
Septie.	6,319	5,35	238,64	612	78,12
Octub.	4,828	7,11	188,41	1525	157,35
Novie.	3,219	4,85	121,57	403	48,17
Dicie.	2,771	5,70	108,14	699	74,13
Año	**5,702**	**7,74**	**2625,17**	**24661**	**2505,87**

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