Evolution of production and energy savings in SWRO Plant of Las Palmas III

Authors: *Raul Lemes, Jose Luis Perez Talavera, Raul Falcon, Rafael Arocha, Jacinto Curbelo, Victor Platas, Laura De Lorenzo and Domingo Zarzo*

Presenter: Raul Lemes
O&M Director - Emalsa - Spain

Abstract

This paper aims to show the development and design changes have been done in SWRO Las Palmas III to achieve improvements in energy savings from the start-up in 1996 until today. We want to present the evolution of the different energy recovery systems and new technologies that have been adapted to this facility in operation for the last 20 years.

The plant began working with a production of 36,000 m3/day with 45% recovery and 6 racks in two stages, with 300 ft2- surface membranes and Francis turbine as energy recovery device, getting a specific energy consumption of 6.16 kWh/m3.

In 1999, the plant increased production to 39,000 m3/day maintaining recovery and the number of racks, mainly due to changes of membranes with an area of 315 ft2.. Besides it got a specific consumption decreased to 5.18 kWh/m3 due to the installation of a new energy recovery system, Pelton wheels.

In the year 2000, Emalsa installed for first time in the world interstage pumps (so called booster pumps), increasing production to 44,000 m3/day and recovery to 48%, reducing the specific consumption to 5.10 kWh/m3.

At 2001 and 2002, production is increased to 57,000 m3/day with the installation of a new RO rack and with the addition of a new row of pressure vessels and membranes in all racks that increased recovery to 50% and decreased the specific consumption to 4.95 kWh/m3.

From 2002 to 2007 plant increases production to 81,000 m3/day, adding new more efficient racks increasing global recovery to 52% and reducing specific consumption to 4.6 kWh/m3.

Since 2008 the company began to replace the Pelton turbines for isobaric energy recovery systems, replacing in 2008 the first two Pelton turbines with a single isobaric system from ERI (PX) for two racks, reducing the specific consumption of these two racks more than 20%. In 2009, there were installed two new isobaric systems, one per rack, getting the plant a total of 86,000 m3/day and a total specific consumption of 4.15 kWh/m3.

Currently, the company made a new rack design, which improves the operating conditions when Pelton wheels are replaced for isobaric systems. This project will be operational in November 2010 and it has been predicted a decrease in specific consumption below 4 kWh/m3.

With all this improvements, it can be said that Las Palmas III SWRO plant has been a pioneer in the world of desalination and a lively look at the history of energy recovery in SWRO plants.

I. INTRODUCTION

1.1. Background

The company Emalsa, holding by Valoriza Water, from the Spanish group Sacyr Vallehermoso, operates the most important SWRO plant of the Canary islands, which it supplies to Las Palmas de Gran Canaria City, with a population of 400,000 inhabitants. The above mentioned installation produces a daily average of 86,000 m3 and is considered cutting-edge enterprise in continuous improvements in the design and operation ways.

The SWRO plant of Las Palmas III has been characterized for implementing technological measures that have taken advantage of the shortage of available space to increase the production, to improve the quality of the produced water and to reduce the energy consumption.

1.2. History of the water in the city

The history of Las Palmas de Gran Canaria City has passed parallel with the fight of his inhabitants against the lack of a vital element as the water.

The deficiencies in the supply propitiated that was promulgated, already in 1906, one Law which was declaring of public usefulness the water supply to the city. The topographical and technical difficulties to drive water from the mountains and the need to construct, near the city, a great regulatory storage tank to guarantee a service without disruptions, did precisely to award, in 1912, the concession of the service of supply to the English company "City of Las Palmas Water & Power Company Limited ".

It was necessary to wait until March 30, 1946, in order to sign in London the contract of completion of the concession, in which the Municipal Service of Water supply took charge of the Regulatory Storage Tank of the Llano de Las Brujas (64,000 m3), of more than 30 kms for distribution networks and of 10,000 flow meters renting installed.

Between the period 1960-1975, appears the tourist phenomenon, which does that the population of the city increases, which generated important problems of supply. Before the inability to obtain sufficient flows for the traditional methods, it became necessary the adoption of new technologies: the production of drinking water across the treatment of sea water. So that, in 1970, the SW plant Las Palmas I was opened, with a 20,000 m3/day of production and, in 1980 joined the SW plant Las Palmas II, with a daily production of 18,000 m3/day. And finally, in 1989, SWRO plant of Las Palmas III with a dialy production of 36,000 m3/day was officially opened.

The system of municipal management continued until 1989. With the need to optimize the service of water supply and adapt it to a city in continuous development, the Las Palmas de Gran Canaria Town Hall sold 66 % of his shares, initially to the entities Canaries Electrical Union (33 %) and Societé D'Amenagement Urbain et Rurally (33 %).

In the year 2005, Valoriza Water (Sacyr-Vallehermoso Group) acquired 33 % of the Canaries Electrical Union shares, joining a part of the shareholders of Emalsa.

II. FACILITIES´ DESCRIPTION

2.1. General Comment

Emalsa arranges his SW desalination facilities in the industrial estate of Piedra Santa, Jinamar, in the city of Las Palmas de Gran Canaria.

Fig. 1. Facilities situation.

This facilities began in 1969 with the installation of a SW desalination plant based on a MSF plant Wespoor of low temperature with 4 x 5,000 m3/day, which was named **Las Palmas I**. immediately afterwards, in the year 1981, Emalsa installed a SW desalination plant based on MSF Babcock Wilkox of high temperature with 2 x 10,000 m3/day, named **Las Palmas II**.

In 1989, Emalsa installed a SWRO plant with 4 racks x 6,000 m3/day, which was named **Las Palmas III**. In 1992, Emalsa installed two new racks x 6,000 m3/day, became the large desalination plant in Europe, which designed and built by companies from Canary Islands.

On the other hand, and to replace the first MSF (Las Palmas I) Emalsa built a SW desalination plant based on the last generation of evaporation system (MED) with 2 x 17,500 m3/day, connected to the thermal power station of Las Palmas I, with a maximum power generation of 24 MW.

Emalsa like the concessionaire company to do the operation and maintenance of the facilities, has made a huge modifications that have been improving the performance, suits to the demographic changes of the city, to the new energetic markets, to strict requirements of quality and, especially, optimizing the scanty available space that prevents the growing. So that, Emalsa is required to keep itself in the forefront of new desalination technologies that allow an increase of the production capacity, of the recovery of the plant and an improvement of the specific consumption of the process.

2.2. Evolution of SWRO plant of Las Palmas III

Below, there will be enumerated the different steps that have marked the long history of the SWRO Plant of Las Palmas III, which have allowed substantial improvements in capacity of production, quality of the water, recovery of the plant and specific energy consumption.

2.2.1. The beginning

Between 1989 and 1992, there were installed the first 6 SWRO racks with a daily capacity of 6,000 m3/day each one. Originally these modules had got two stages without intermediate pumping, where the second stage was treating directly the rejection of the first one, obtaining recoveries about the 45 %. This design operated with the same type of membranes as in the first stage as in the second stage, and used as recovery system of the second stage brine, Francis turbines which were connected directly to the axis of the high pressure pump.

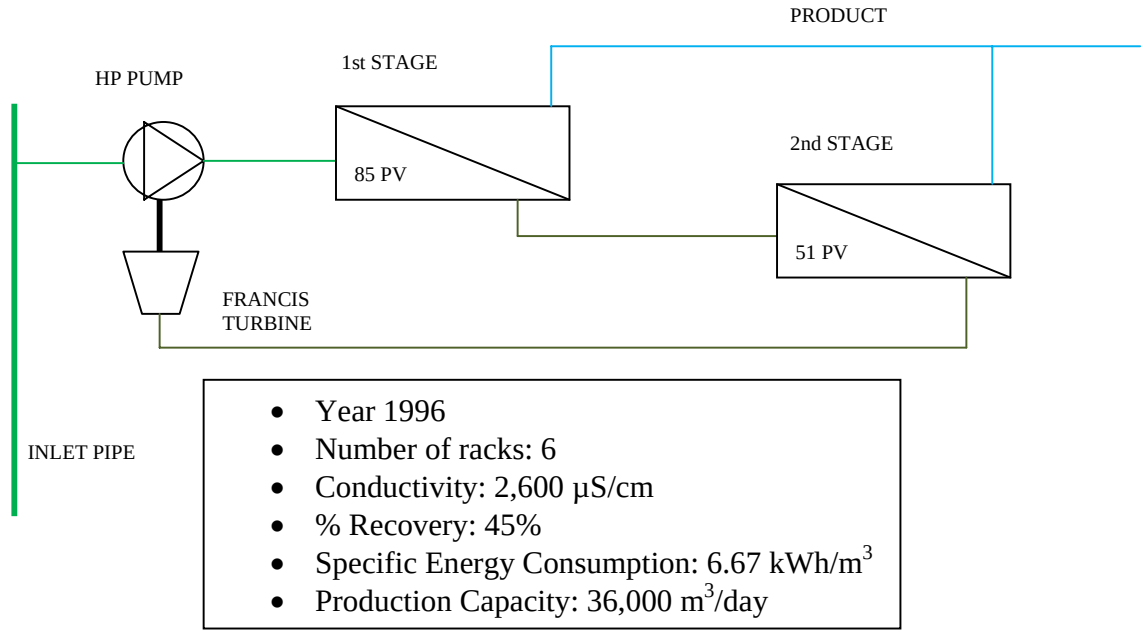


Fig. 2. Hydraulic scheme of the racks with Francis Turbines.

2.2.2. Replacement of Francis turbines

From 1996 to1997, Emalsa began to realize actions aimed to improve the quality of the water. First of all, Emalsa proceed to replace of 4,896 membranes for others from the best available technology and systems.

In 1997, Emalsa began to replace the 6 Francis turbines with Pelton Wheels, a system with a major performance, which produced an improvement in the specific energy consumption (about 12.3 %). This replacement caused the modification of the HP Pump impellers to fit to the system.

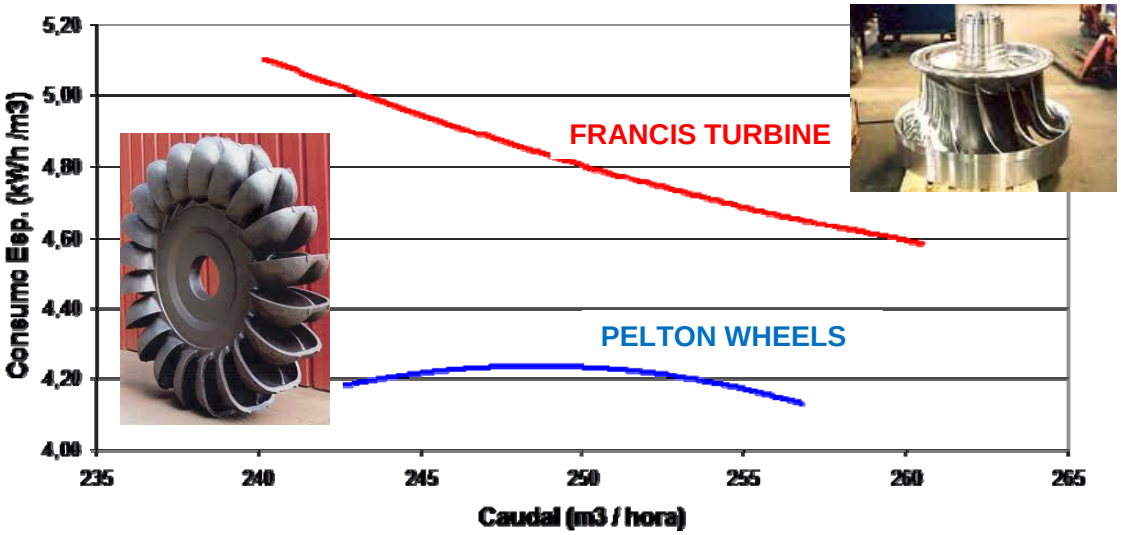


Fig. 3. Improvement of the performance between Francis Turbine vs. Pelton Wheels

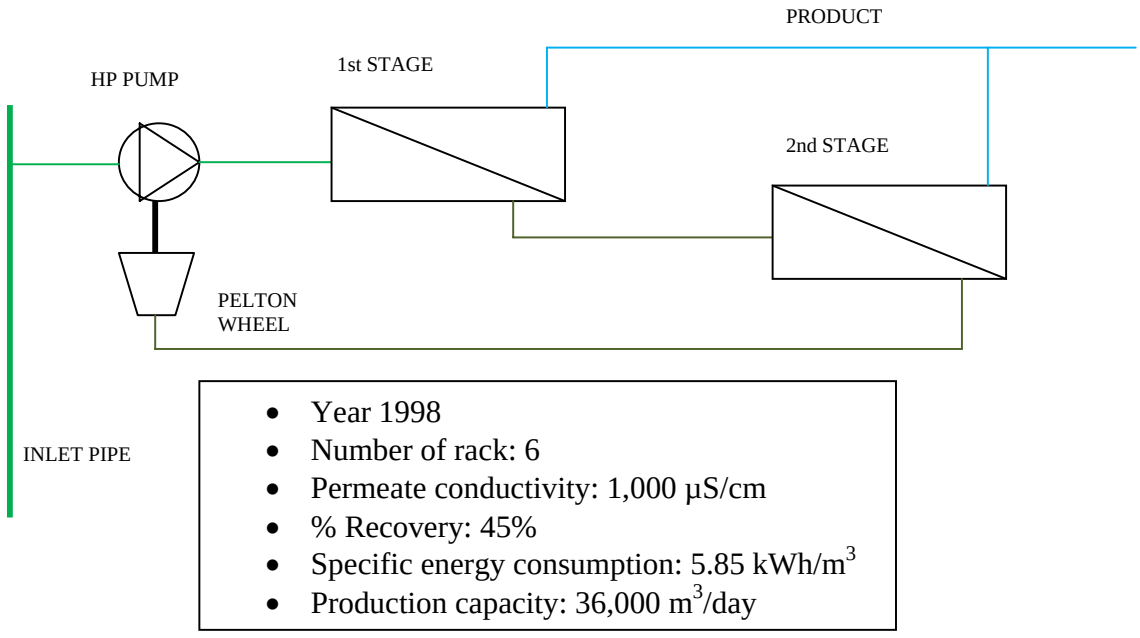


Fig. 4. Hydraulic scheme of the racks with Pelton Wheels.

2.2.3. Booster Pump between stages installation

Until 2001, the RO desalination plants, with standard membranes (82 bars of maximum pressure), were limited to a maximum recovery of 45 %.

The need, already mentioned, of optimizing the sea water, with the purpose of increasing the production capacity of the plant, made the company an effort to looking for technical solutions to improve the limitation in the recovery.

Fruit of this effort emerged the patent **P200102300**, OPTIMIZATION OF RO PLANTS BY MEANS OF INTERMEDIATE BOOSTER PUMPS, granted on October 15, 2001, which was immediately put into practices with satisfactory results, an increase of **8%** in the recovery of the SWRO Plant of Las Palmas III and an improvement of **12.65%** in the specific energy consumption.

Fig. 5. Interstage booster pump

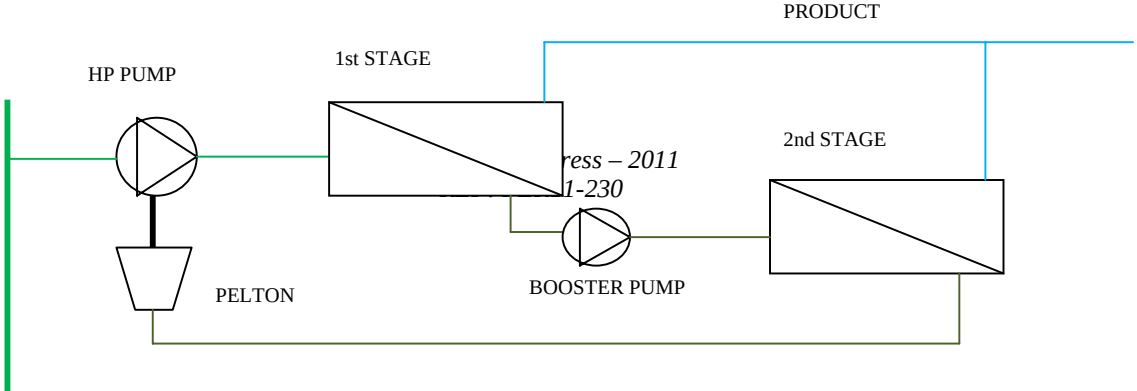


Fig. 6. Hydraulic scheme of the racks with booster pump between stages and Pelton Wheels.

2.2.4. Extension of the number of desalination racks.

The increase in the water demand determined the Emalsa's investments plan, directing the efforts at increasing the production capacity of Las Palmas III.

The first part of the 2000 decade was marked by the installation and starting up of four new RO racks with the same configurations as well as preceding.

The modern technology used in these new racks, as well as the installation of last generation membranes, allowed to obtain an important evolution in the parameters of quality and efficiency of Las Palmas III.

The first extension took place in the year 2001 with the installation of the seventh rack.

Later, in the year 2003, it was installed the eighth rack, in an attached building near the original one of Las Palmas III, reached a global recovery plant of 51.16 %, a specific energy consumption of 4.76 kWh/m3, as well as a production capacity of 65,000 m3/day.

Finally, in the year 2006, it completed the installation of ninth and tenth rack, reaching a production capacity of 79,000 m3/day, recovery of 52.8 % and a specific energy consumption of 4.63 kWh/m3.

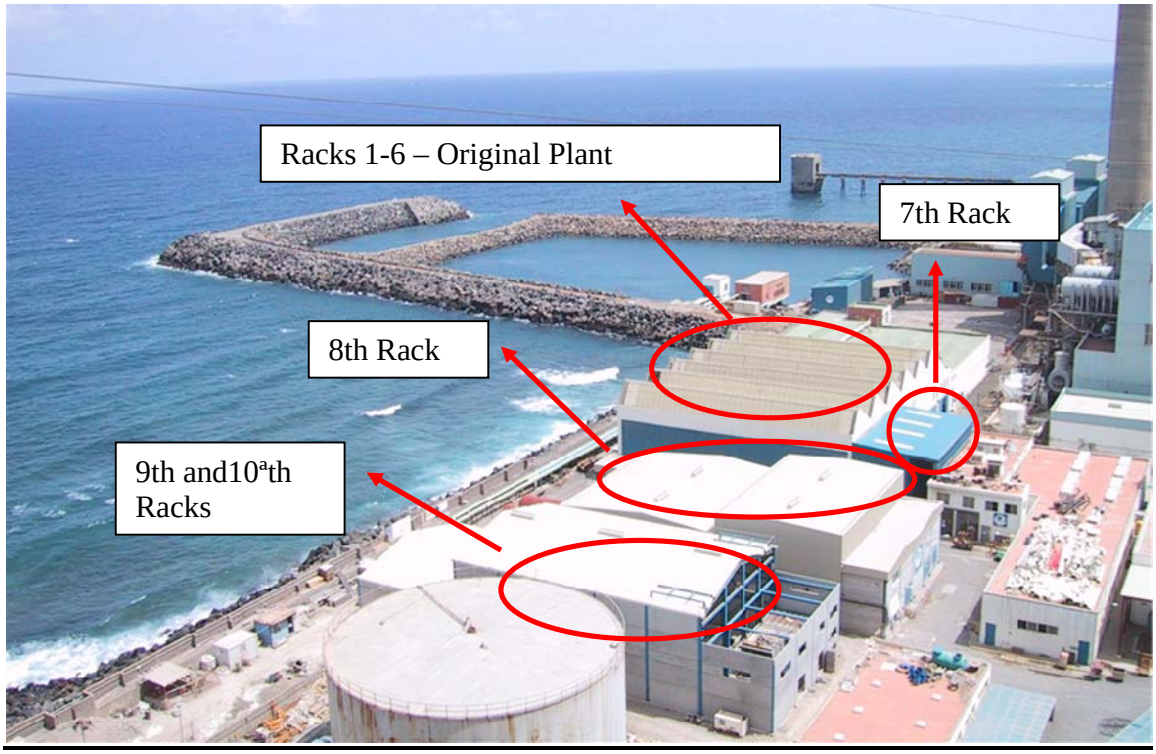


Fig. 7. Location of the facilities.

2.2.5. Installation of energy recovery system (ERS)

Since the year 2001, a pilot plant for research was working in the SWRO Plant of Las Palmas III, where evaluated the possible benefits that might generate the replacement of the Pelton Wheels for energy recovery system based on isobaric chambers with performances that could overcome 90 %.

It was not until the year 2007, coinciding with a improvement of the energy recovery system of the pressure exchangers technology, when SWRO Plant of Las Palmas III embarked in the first installation of this technology.

The above decision, prompted a complete change in the design philosophy of the racks, due to a turbine of recovery, Pelton or Francis, demanded that the whole feed water flow drove to the high pressure pump, whereas in case of the pressure exchangers, only drive the seawater flow equivalent to the production of the rack, while the pressure exchangers pressurize part of the seawater equivalent to the rejection.

This fact required the company to consider two options, the first one, the need to replace the high pressure pumps with others which adapted to the new conditions, this option had the inconvenience of making an expensive new investment, and the second one, the need to modify by means of a retrofitting the high pressure pump, this option has a reduce investment, but has the inconvenience of a reduction of the performance of this high pressure pump.

To avoid this dilemma, since the recovery of the racks was overcoming 50 %, the solution considered to the first installation of pressure exchangers in SWRO Plant of Las Palmas III was joining two racks, so that one high pressure pump and only one pressure exchangers system, will feed the two racks. In this way, Emalsa installed a double rack, with one design in the world, which allowed reaching a reduction in the specific energy consumption of the plant.

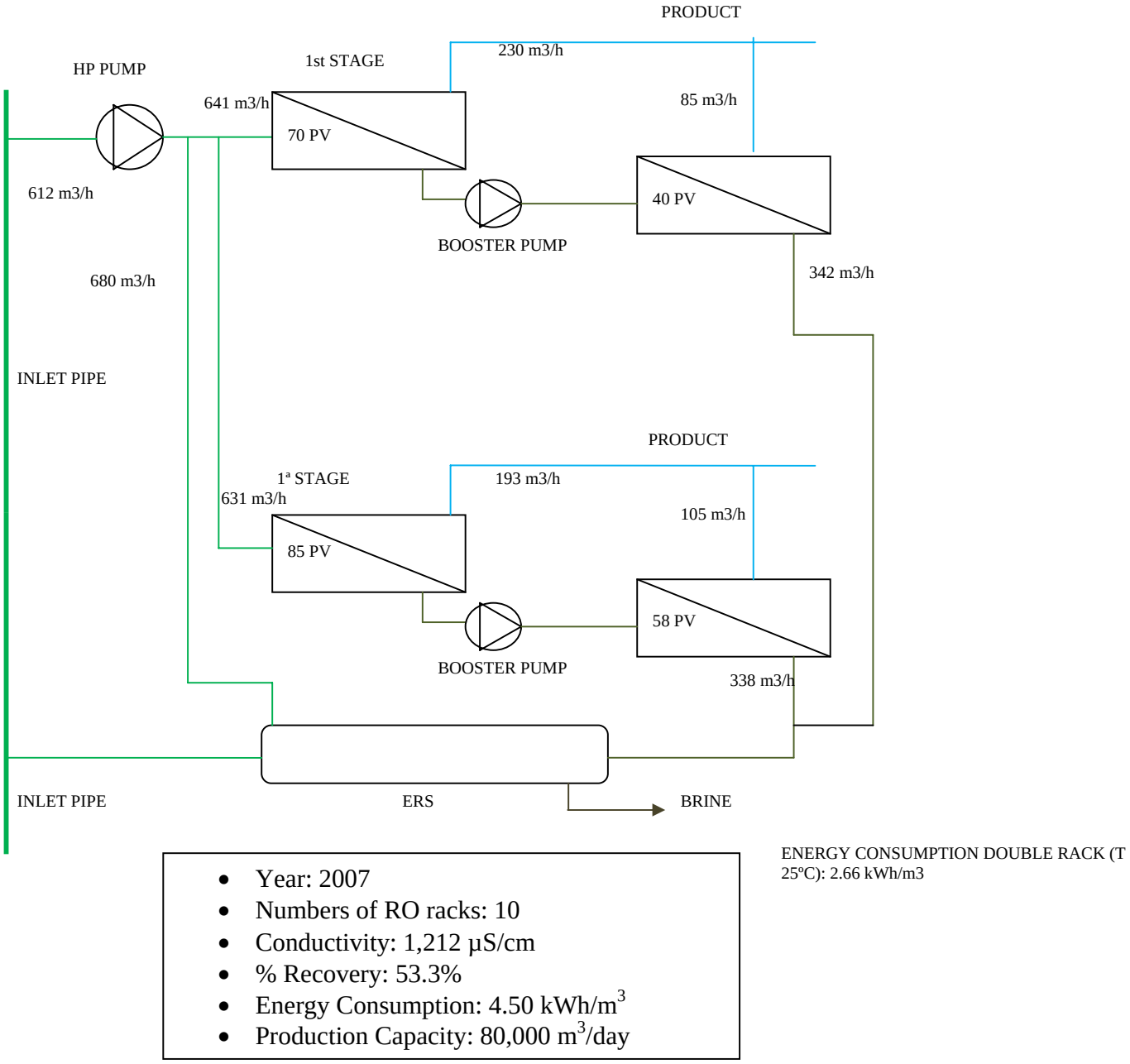


Fig. 8. Hydraulic scheme of the double racks with booster pump between stages and pressure exchangers.

Fig. 9. Installation of the pressure exchangers.

Looking the reliability of this new system, with an improvement in the specific energy consumption of the plant, the company decided to start the replacement the Pelton Wheels with pressure exchangers in SWRO Plant of Las Palmas III.

So, in 2009, other two lines were modified, but in this case, the company decided to install the pressure exchangers in two racks, with an individual way, to improve the flexibility of the desalination plant at the moment of carrying out maintenance works.

This fact came together with an important policy of changing membranes, as well as the installation of end caps, which originated in the plant, not only an improvement of the specific energy consumption, also an important improvement in the quality of the product water, adapted, in this way, to the new regulations of quality.

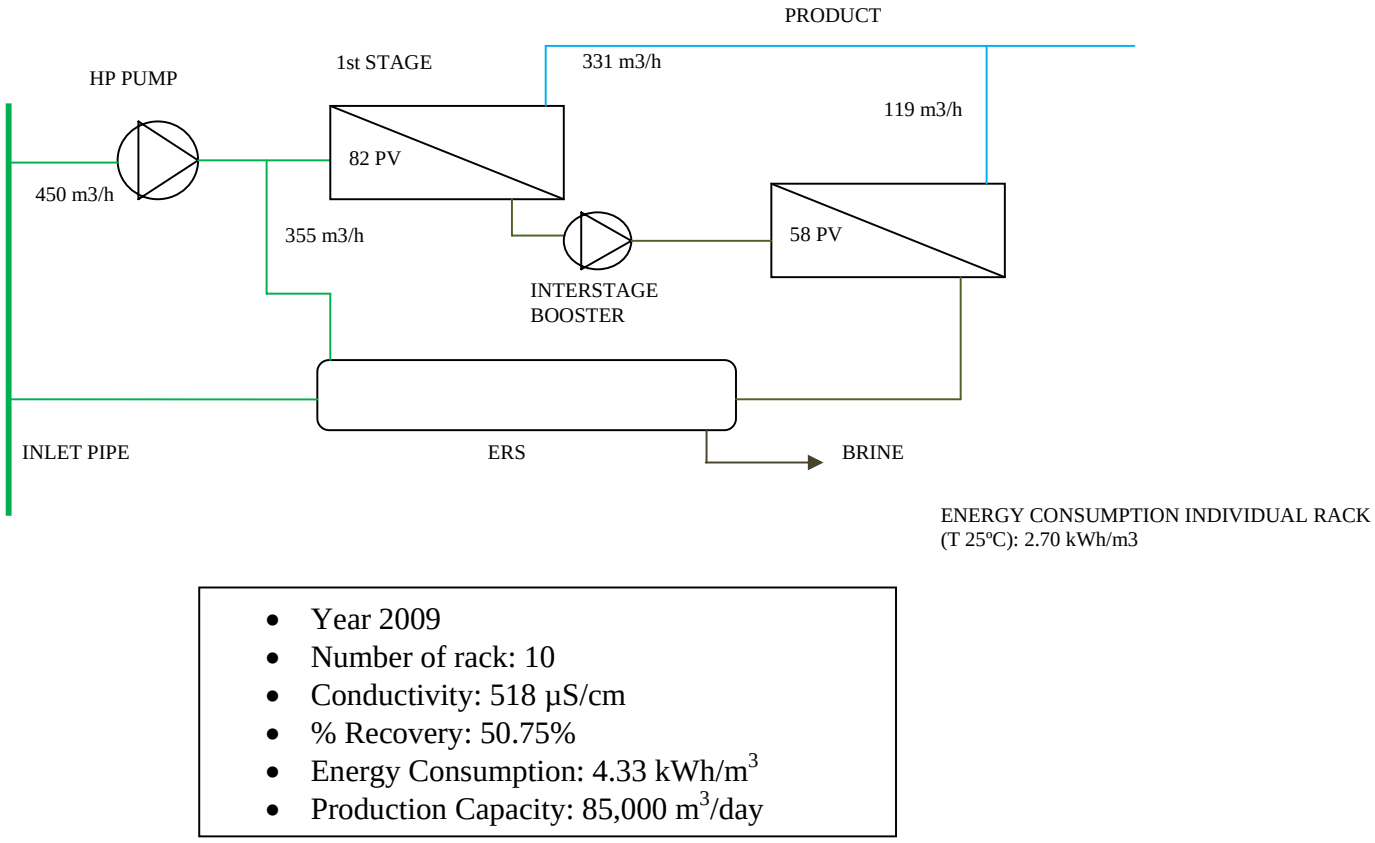


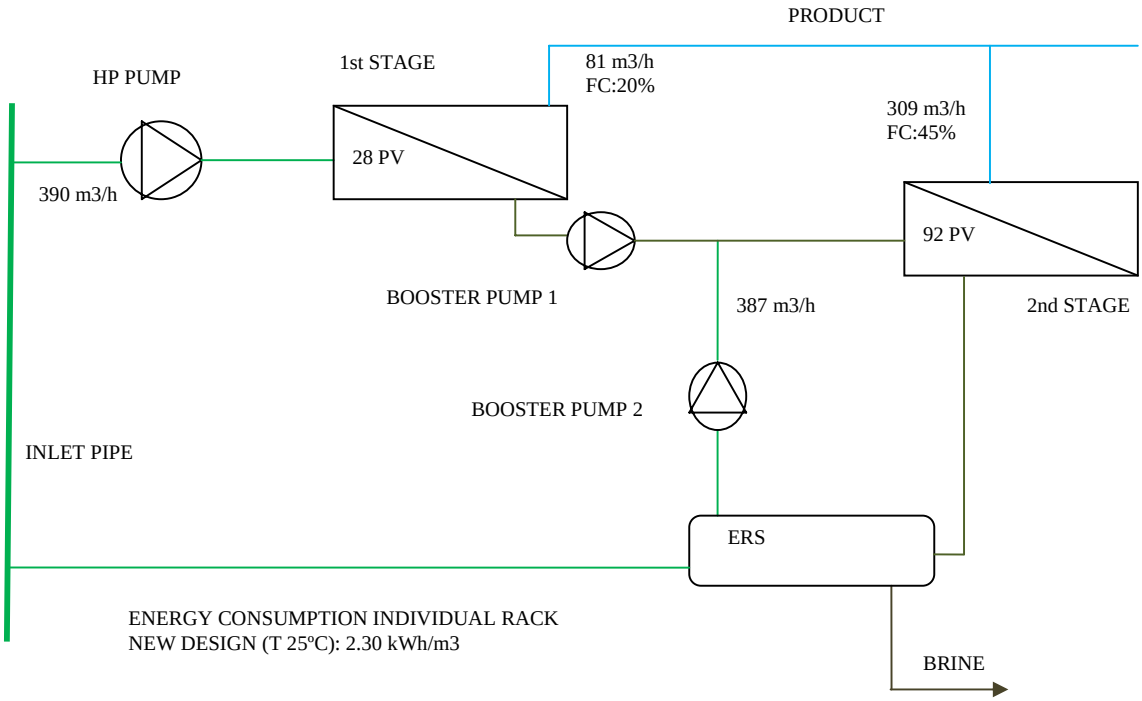
Fig. 10. Hydraulic scheme of the racks with booster pump between stages and pressure exchangers.

2.2.6. New hydraulic design with ERS

In 2010, continuing the same philosophy of the previous years, improving the specific energy consumption of the plant and a constant improvement of the quality standards, the technicians of Emalsa design a new hydraulic scheme in one of the racks of the SWRO Plant of Las Palmas III. This design incorporates a system of energy recovery by pressure exchangers, but optimizing the design to allow a major decrease of the energy consumption of the rack, as well as an improvement in the quality of the product.

The new design connect the pre-treatment seawater, pressurized by the pressure exchangers, directly to the feed of the second stage, mixing with the brine of the first stage, while the first stage only receive the flow of seawater equivalent to the product water of the global rack.

In this way, we have reached to improve the conductivity of the second stage product water, and even with the installation of the second booster pump, the specific energy consumption of the rack has improved, about 36 % if it compares with a classic design with Pelton Wheels and 15 % if it compares with the classic design of pressure exchangers.



This new design has got an international patent by the number of publication **ES200902348** "SWRO Plant with energy recovery system and his procedure",

III. RESUME OF RESULTS

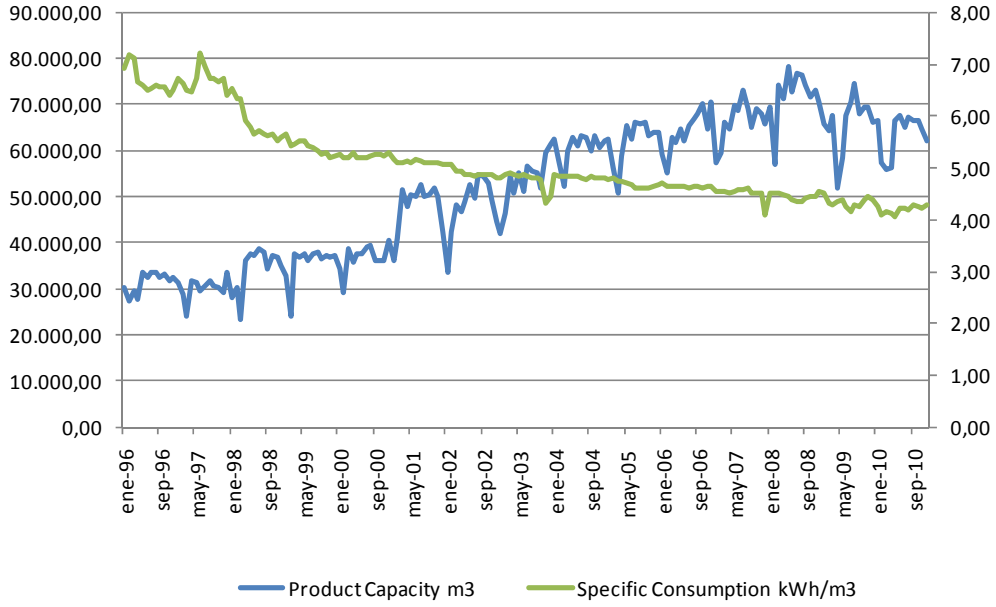
Following we show a summary of the most significant information obtained in every one of the designs installed during the life of the SWRO Plant of Las Palmas III.

DESIGN	YEAR	SWRO PLANT CONDUCTIVITY (µs/cm)	SWRO PLANT % RECOVERY
FRANCIS TURBINE	1996	2,600	45.0
PELTON WHEELS	1998	1,000	47.9
BOOSTER HIGH PRESSURE PUMP	2001	1,234	48.6
SEVENTH TRAIN	2001	1,234	48.6
EIGHT TRAIN	2003	1,498	51.16
TENTH AND ELEVENTH TRAIN	2006	1,100	52.8
TOGETHER TRAINS (5&6), ERD INSTALATION	2007	1,212	53.3
END CAPS	2008	1,027	-
INDIVIDUAL TRAINS (4&7): ERD INSTALATION	2009	518	50.75
BASTIDOR A	Actually	404	50.08

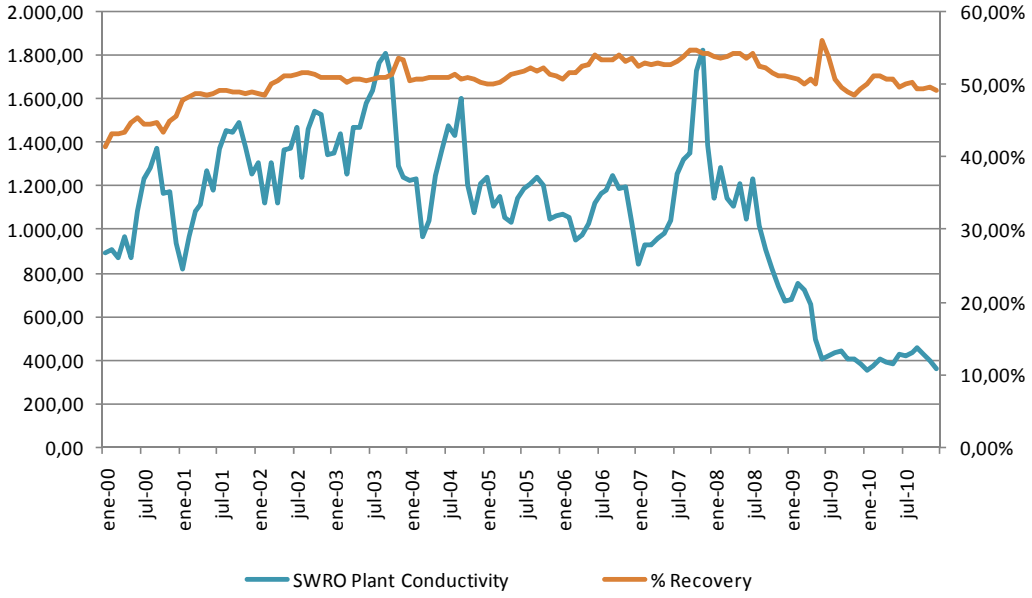
Table 1. Results I

DESIGN	YEAR	SWRO PLANT SPECIFIC CONSUMPTION (kWh/m^3)	SWRO PLANT CAPACITY (m^3/día)
FRANCIS TURBINE	1996	6.67	36,000
PELTON WHEELS	1998	5.85	36,000
BOOSTER HIGH PRESSURE PUMP	2001	5.11	50,000
SEVENTH TRAIN	2001	5.11	57,800
EIGHT TRAIN	2003	4.76	66,000
TENTH AND ELEVENTH TRAIN	2006	4.63	80,000
TOGETHER TRAINS (5&6), ERD INSTALATION	2007	4.5	80,000
END CAPS	2008	-	-
INDIVIDUAL TRAINS (4&7): ERD INSTALATION	2009	4.33	85,000
BASTIDOR A	Actually	4.1	86,500

Table 2. Results II



Graphic1. Evolution of parameter in SWRO Plant of Las Palmas III (1)



Graphic 2. Evolution of parameter in SWRO Plant of Las Palmas III (2)

IV. CONCLUSIONS

Following we show the conclusions summary of the most significant information obtained in every one of the designs installed during the life of the SWRO Plant of Las Palmas III.

- SWRO Plant of Las Palmas III is one of the most benchmark regarding and historical facilities on a worldwide scale, due to the numbers of years that it takes in operation.
- The innovation and the technical advances in SWRO Plant of Las Palmas III have been directed to reduce the operation and maintenance cost, mainly in the energy and chemical consumption.
- SWRO Plant of Las Palmas III has proved his technical and economic feasibility with technical developments and new technical advances that reduce the energy consumption since values of 6.67 kW-h/m^3 in 1996 to values of 4.1 kW-h/m^3 actually.