ADDITIONAL ENERGY RECOVERY AT SWRO PLANT USING ITS LOCATION

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Abstract

The location of SWRO Valdelentisco plant at 46 m above the sea level requires a 55 m pressure to deliver the seawater to the plant's pre-treatment system, increasing the plant's specific energy consumption by 0.25 kWh/m3.

At the design stage was planned to implement all the necessary actions based on renewable energies at the site not only to optimize the energy consumption but to contribute to improve the carbon footprint of the desalination process.

The plant is equipped with thermal solar energy for heat water, photovoltaic solar panels and the most innovative solution: a Francis turbine to recover the potential energy incorporated into the brine prior to sea discharge using the height elevation of the site. During the last year of operation the turbine has saved approximately 2 % of the energy consumed by the plant what is equivalent to the consumption of one of the intake pumps the plant is equipped with.

The present paper presents all the technical and economic aspects of the installation so as the difficulties found out from the design to the operation phases.

I. INTRODUCTION

Valdelentisco The desalination plant is located in Cartagena, in the region of Murcia in southeastern Spain. This plant has been in operation since 2008 producing desalinated water for supply to the population and for use in irrigation.

In spite of being conceived from the beginning has been during the last years once the plant was in operation, when an important actions have been implemented through the use of renewable energies, which have contributed to reduce the energy bill and CO2 emissions.

One such improvement has been the installation of a Francis turbine to harness the potential energy available to the brine before discharge into the sea, due to the location of the plant at elevation 40 on the sea level.

Described below are the principals in the plant energy recovery potential of the brine and the savings achieved in the last years.

II. VALDELENTISCO SWRO PLANT

The desalination plant was put into service on the first quarter of 2008 and since then has been producing water for irrigation and drinking. The main characteristics of the project are shown in table 1 below.

Table 1: Plant details

Current status	In service
Maximum production	Current: 50 Hm3/year. Extensible: 70 Hm3/year
Benefited population	60,000 people in Cartagena
Irrigated land in hectares	7,577 hectares surface
Desalination process	Reverse osmosis. Stages: 2 Passes: 1
Number of RO racks	Current: 11. Extensible: 16
Number of HPP	Current: 11. Extensible: 16
Type of intake	Open intake tower: height: 5 m Depth: - 25 m
Desalinated water pump	Current irrigation: (QN): 2 × 1500 m3/h. H: 278 mWC. Supply: (MCT) (QT): 5400 m3/h (3+1). H: (MCT) 100 mWC
Intake piping	On shore: 800 m GRP ø1800. Marine: 500 m Polycrete ø2000. 950 m HDPE ø1800
Outfall pipe	On shore: 800 m GRP ø1400. Marine: 1,250 m HDPE ø1600
Regulator tank	Irrigation: 20,000 m3. Supply: 4,000 m3
Total installed capacity	Desalination Plant: 23,200 kVA. Distribution pipeline pumps 6,300 kVA

Concession period	3+22 years
Investment	Desalination Plant: 122.45 M euro (excluding VAT) for: Civil construction: 70 hm3/year. Electromechanical equipment: 50 hm3/year
Distribution capacity	180,000 m3/day 63 hm3/year
Energy data	
Electric power (kW)	50,000 kW (2×25 MW) GIS substation.
Voltage (kV)	132/6 kV. /690/400/230 V
Energy consumption	3.6 at 3.9 kW/m3 including intake, pre and post treatment and RO process
Energy recovery device	Pelton Turbine

The tender specifications dated from 2001 specifying for Pelton turbines for energy recovery devices for each of the 12340 m3/day capacity per rack. The actual specific consumption of the plant that is located at 46 m above the sea level and 1,5 km from the shore line varies between 3,62 and 3.98 kwh per m3 based on the season and the number of racks in operation. The operation of the plant at full capacity will drop these values off once the production of desalinated water is increased.

III. FRANCIS TURBINE

Although the Francis turbine was originally included in the scope of supply, some problems made the installation at site not possible till 2010, two years after the commissioning. The power generated by the turbine depends on the flow as per the curse shown in Figure 1. The minimum power produced by the alternator is 80 kW and the maximum 500 kW.

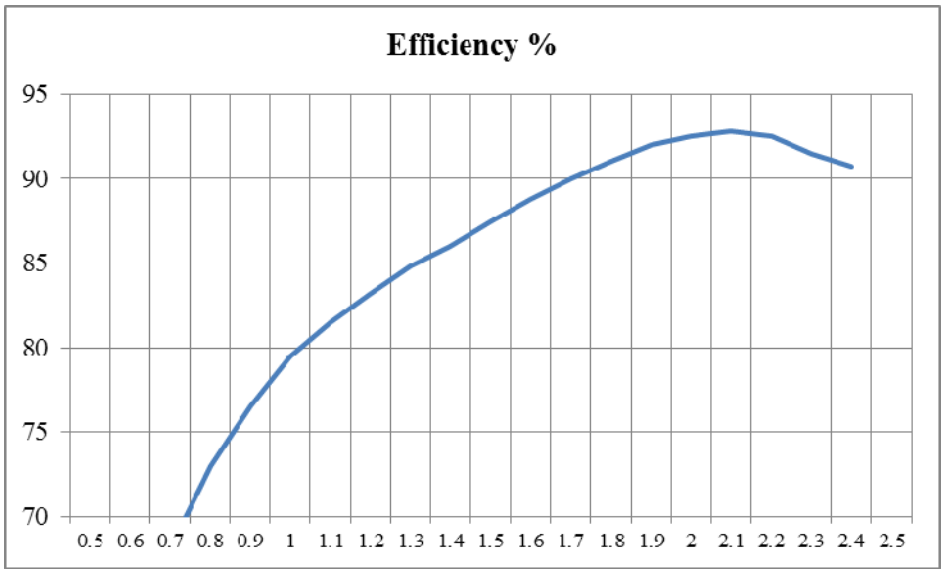

Figure 1

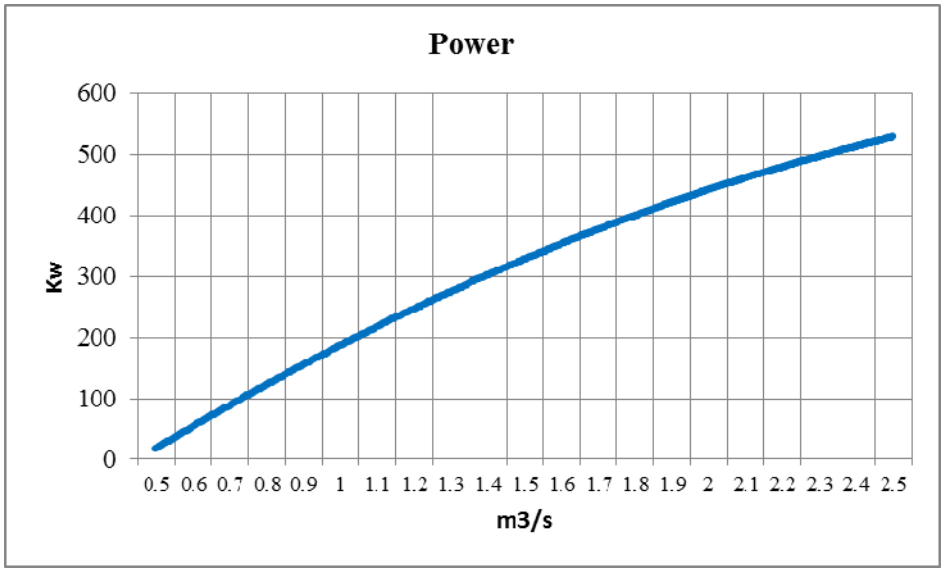

Figure 2

The turbine was manufactured in Spain by Baliño for a maximum nominal flow of 8530 m3 per hour and a differential head of 24.3 m working with brine with a specific gravity of 1,045 kg/cm3. The table 2 shows the main specifications of the Francis turbine.

Table 2: Main specifications

Technical specs		
Type		Francis
Configuration		Horizontal
Impeller number / diameter	- / mm	1 / 670
Design temperature	ºC	40
Flow	m³/h	8530
Net height	m	24.3
Efficiency	%	91
Hydraulic power	kW	513.7
Net power	kW	488
Velocity	rpm	500
Max velocity	rpm	1040
Hydraulic axial load	kN	21
Acceleration axial load	kN	-17
Suction head	m	2
Inlet diameter	mm	1000

One of the main problems for the manufacturer selection was the availability of materials suitable to resist the brine corrosion potential as most of the previous applications of this kind of turbines were for fresh water, mainly in hydro power installations. There was a delay in the project as a consequence of the use of no standards materials during the manufacturing process.

Table 3: Materials

Impeller	SS2387
Conical bearing	S355J0
End bearing	1.4462
Disc	1.4462
Driving blades	Aluminum bronze
Control ring	S355J2G3
Side cover	Aluminum bronze
Top cover	Aluminum bronze
Shaft	Bronze/strontium
Spiral case	1.4462
Draft tube	1.4462
Dry bearings	Bronze

With a maximum nominal power of 500 kW, the alternator selection was very important to maximize the energy production. The figure 2 shows the power generated by the alternator related to the brine flow and is important to point out that below 0.7 m3/s of brine (2500 m3/h) the turbine can not operate in order to avoid cavitation problems.

Table 4: Alternator specifications

Alternator		
Type		B5G 500 LC12
Units		1
Nominal power	kW	500
Nominal velocity	rpm	500
Acceleration		1040 rpm by 10 minutes
Voltage	V	690
Frequency	Hz	50
Cos φ		0.8
Efficiency	%	95
Protection		Class F
Heating		Type B
Service		S-1
Max ambient temperature	ºC	40
Height	m	<1000
Protection		IP 55
Cooling		IC-411

IV. RESULTS

The Figure 3 shows the payback period based on the number of racks in operation, considering the additional extra savings of the CO2 gas emissions at selling price [2] of 35 USD per Ton of CO2. The electricity price for the analysis is 7,5 cts Euro per kWh[3].

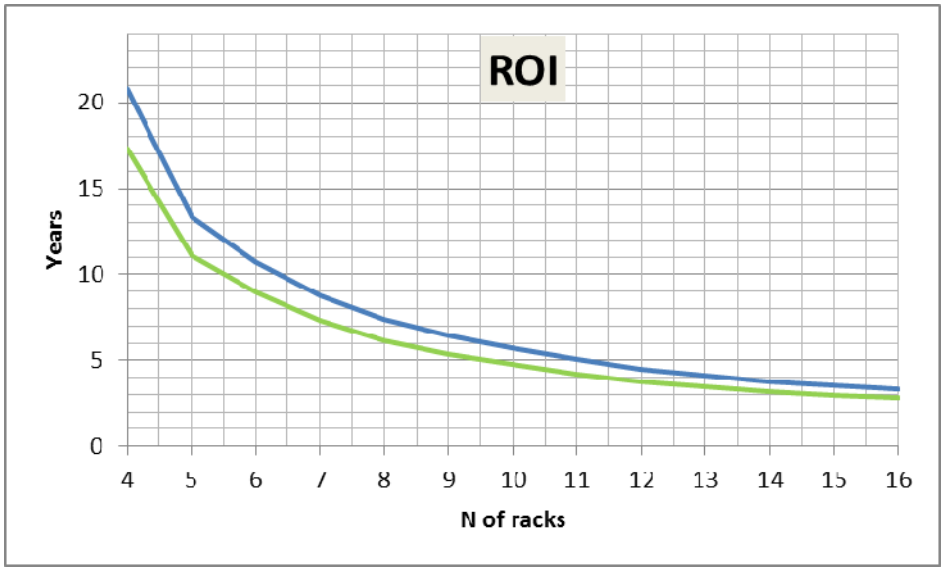

Figure 3

Based on the original design of the plants working at full capacity with 12 racks the payback of the investment is around 4 years, but the reality has been different with just 6 racks in operation increasing the payback period up to 10 years.

The installation of the Francis Turbine has avoided the emissions of 500 Tn of CO2 per year during the first two years of operation just due to the fact that the plant has been in operation at 40% of the total capacity. If the operation would have been based on 80% capacity the estimated CO2 emissions savings could have reach up to 1400 Tn. Figure 3.

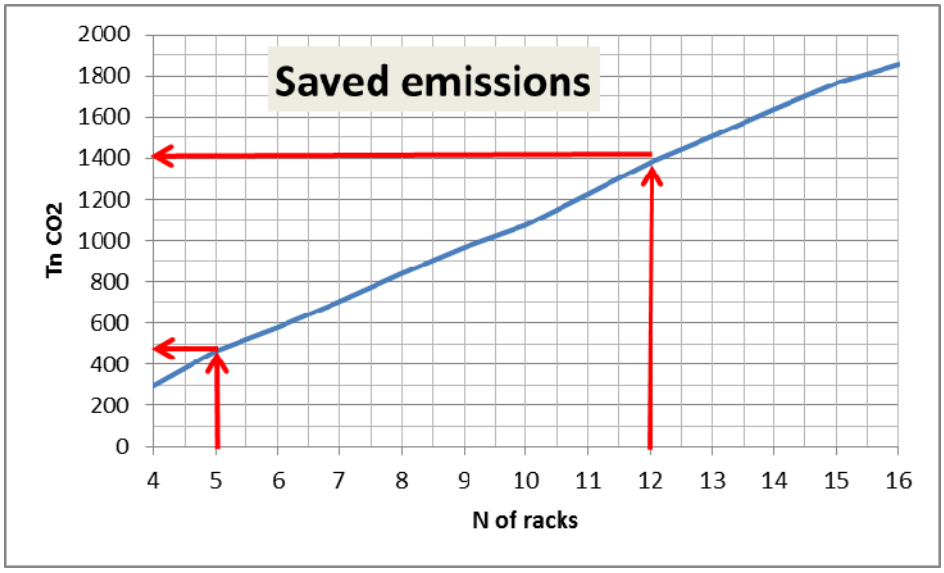

Figure 4

When the plant will be operating at 100 % of the capacity, 16 racks, the estimated savings in CO2 emissions will be close to 2000 Tons per year, what is equivalent to the production of 2,000,000 m3 of desalinated water or the emissions produced by the Valdelentisco plant. This carbon footprint is the same as 400,000 vehicles making 25,000 km per year.

Considering a 25 years operation life at 60% capacity the estimated savings will be of 21.000 Tn of CO2.

V. CONCLUSIONS

The expected savings in emissions estimated in 1400 Tn CO2 approximately have been reduced into a third due to the few racks in operation during the last years as a consequence of the operation of the plant at 40% due to the high rains.

Although the plant has not operated for the number of racks for which originally was conceived, there has been important energy and environmental savings, which offset the increase in the return on investment beyond 5 years.

However environmental improvements and the need to promote alternative energy by the administration led to the decision to install the turbine in Valdelentisco, saving more than 500 Tn of CO2 emissions per year since the turbine installation in 2010.

VI. REFERENCES

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2. Power prices report 2012. Observatorio de la Electricidad WWF España Diciembre 2012