IS RES POWERED DESALINATION A VIABLE SOLUTION FOR WATER STRESSED REGIONS? A CASE STUDY IN ALGARVE, PORTUGAL

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ABSTRACT

With a severe seasonal concentration of precipitation, unevenly distributed water resources and frequent droughts and floods, the water supply in Portugal is under stress, and the problem is expected to increase with climate change. Water desalination is increasingly becoming the preferred solution to fight water scarcity but, being energy-intensive, the underlying costs and sustainability concerns over the power sources chosen remain a challenge to its implementation. This study aims to assess if the introduction of renewable energy sources (RES) powered seawater desalination in mainland Portugal could allow for the flexibility needed to guarantee water security through a viable model. The Algarve Region was chosen as a case study because it is particularly water stressed and subject to highly varying demographics depending on the season. Two strategies are considered: either one large plant supplies the whole region (centralised) or two smaller ones supply their respective sub-regions (decentralised). Taking the region's freshwater demand, hourly RES production and electricity consumption profiles, a cost analysis is performed in order to obtain an estimation for the produced levelised cost of water (LCOW). Two models were developed to estimate the LCOW: a spreadsheet model and a subsequent optimisation model, minimising electricity costs. The resulting 0.7266 €/m^3 of desalinated water, obtained for the decentralised solution, fits within the industry standard rate although being 61.3% higher than the estimated conventional water supply production cost. Finding external financing through European or national funding could further lower CAPEX and get desalination on par with the current market price of water.

KEYWORDS

Seawater desalination, Renewable energy sources, Water-energy nexus.

INTRODUCTION

Listed by the World Economic Forum as the biggest threat to the world's economies, environment and people, water scarcity sets an unprecedented challenge to water management and energy policy makers. Despite water availability above the European average, mainland Portugal is characterized by a severe seasonal concentration of precipitation, unevenly distributed water resources and frequent droughts and floods. The water supply in Portugal is under stress, and the problem is expected to increase with climate change. Water desalination technologies, namely seawater reverse osmosis (SWRO), have matured in the last decade from being a last resort solution to becoming strong candidates in water resource diversification. This shift was made possible by bringing down desalination's energy consumption, its main drawback, towards the thermodynamic limit and plateauing at around 3 kWh/m^3 (Semiat, 2008; Zarzo and Prats, 2018).

The main recent developments have been in pairing SWRO desalination plants with renewable energy sources (RES) and in dealing with the challenges that intermittent power sources entail. It has been shown (Abdelkareem et al., 2018; Caldera et al., 2018) that solar photovoltaic (PV) and wind turbines are two of the strongest candidates to power low carbon-emission desalination.

Case studies in pairing reverse osmosis (RO) plants with RES have been dedicated to locations of varying scales: islands (Mentis et al., 2016), edge-of-grid rural communities (Fornarelli et al., 2018) and large coastal cities (Vakilifard et al., 2017). Mentis et al. considered the arid islands in the Aegean Sea. Comparing desalination technologies and local RES potential, the authors opt for a RO plant powered by wind turbines and PV panels. This system was dimensioned in order to supply 100% of local water demand within the Greek RES legislation framework. The resulting production cost of water and suggested selling price indicate that RES powered desalination is a suitable alternative to the expensive and polluting solution of water transportation from the mainland. Fornarelli et al. compared seven energy configurations (consisting of centralised or decentralised PV panels, wind turbines and a connection to the grid) to determine the most cost-effective solution to power a brine water RO desalination plant, dimensioned to supply a rural community in the coastal town of Denmark, Australia. RES intermittency was accounted for by allowing the plant feed flow rate and operating pressure to vary within admissible limits. Vakilifard et al. developed a linear programming model for optimal operation of the water-supply system in Perth, Australia while considering hourly electricity tariffs. The daily surplus output from residential PV panels was used as the priority power source, complemented by the power grid.

This study aims to assess if SWRO powered by a hybrid of RES and grid power is a viable solution to guarantee water security in mainland Portugal, namely through a novel cost structure. The Algarve region is chosen as a case study because it is particularly water stressed and subject to highly varying demographics depending on the season. Three scenarios are considered:

- Baseline, where one desalination plant supplies the whole Algarve, powered exclusively by the grid;
- Centralised scenario, where one desalination plant supplies the whole Algarve, powered by three different power sources (excess RES, own production RES and grid power as backup);
- Decentralised scenario, where two plants supply their respective sub-regions of Algarve, powered by three different power sources (excess RES, own production RES and grid power as backup).

The viability of such solutions is assessed by estimating the levelised cost of water (LCOW) and comparing it to the estimated production cost of the conventional water supply. To estimate the LCOW, two models are developed: a spreadsheet model with a constant hourly output and a subsequent optimisation model to find the operational strategy that minimises electricity costs. Once the resulting LCOWs are obtained, a comparative analysis of the various scenarios is made in order to conclude on the project's viability and to advise on which setup to choose.

Contribution

1. The main contributions of this work are as follows:
2. Introducing a novel cost structure, using excess RES, that allows for both a reduction of LCOW and an increase in RES exploitation;
3. Establishing three scenarios of desalination integration into the existing water supply network of Algarve.

We first describe the methods used in estimating the LCOW, followed by a brief characterisation of the case study. We then present and discuss the results obtained for each one of the three scenarios previously described and for a sensitivity analysis on key input variables. Finally, we summarise the main findings of this work and conclude on the project’s feasibility.

METHODS

General assumptions

In order to determine the necessary capacity of the desalination plant, the average daily water demand is computed for each of the four seasons of the year. Taking the highest consumption of the four, and dividing by a plant factor of 0.85 to account for maintenance downtime, the nominal plant capacity is chosen so that the real capacity could cover 100% of the demand.

The desalination plant must be connected to both the water supply network and the power grid. It is assumed that both these networks have the capacity to absorb/supply the flows generated/needed by the plant.

A pipeline and a pumping station are dimensioned to inject the desalinated water into the water distribution network. The capacity of the pipeline (namely its diameter) must be sufficient to drain out the daily water volume needed for peak demand, assuming a flow velocity of 1.5 m/s (i.e. the recommended upper limit, Sousa E., 2011). The pumping station is dimensioned accordingly, considering the pumping head needed between the plant and the closest connection to the water supply network and assuming a pumping efficiency of 90%.

The power used to desalinate and pump water comes from three different sources: first priority is given to the region’s RES excess output, followed by the plant’s own power production (through a private wind and/or PV solar installation) and lastly the national power grid. This solution aims to ensure that the share of RES used for powering the plant is maximised and that the high electricity cost of the grid is avoided as much as possible.

To accurately grasp the availability and subsequent costs of each power source, it is determined that the analysis is hourly based, with one representative day (comprised of 24-hour blocks) for each one of the four seasons of the year.

The region’s RES production is estimated considering the existing wind farms and PV solar installed capacities as of 2018, to which the PV solar capacities of the plants whose construction is in progress and due until 2021 are added.

PV solar output is computed as the seasonal average of the estimated hourly output of each location. Wind power being particularly unpredictable, its’ output is computed as the seasonal average over three years of the estimated hourly output of each location. The same methodology is used to estimate the production

profile of the desalination plant's own power production. A PV installation of 1.3MW covering the rooftops of the plant is considered, to which two capacities (1.3MW, 5MW) of both PV solar and wind turbines can be added. The installation capacity chosen is the one that results in the lowest LCOW.
Assuming that the penetration of RES will increase significantly in the next decade, we consider that, on average, RES will supply 80% of the total power demand. If there is a surplus of RES power after the deduction of this power demand, the surplus is either exported (if there is instantaneous demand) or not used. We consider that ensuring a power demand for desalination, whatever time of the day, represents an added guarantee to RES producers. This guarantee is assumed to ensure a price discount of 25% on the RES surplus, relative to the instantaneous Iberian electricity market (MIBEL) price.
To define this available RES surplus, we must quantify the power demand of the region. Taking one representative day in 2018 for each season, we first obtain an hourly power consumption profile for the whole country. Using the latest census on population, we compute a per capita profile. Having no precise data on the number of temporary residents resulting from tourism inflow in summertime, we take the increase in water consumption throughout the year as an indication of population variation and use it to estimate the power consumption profile of the region.

Model specific assumptions

As previously mentioned, two different models are developed to estimate the LCOW of the Centralised and the Decentralised scenarios: a spreadsheet model and an optimisation model. The spreadsheet model takes a simpler approach, considering the production and pumping a constant output of desalinated water for every hour of the day (no water storage is considered). In turn, the optimisation model determines the operational schedule of the desalination plant that minimises the total electricity costs. The SWRO plants are modelled with a pressure centre design, which evenly splits the total output capacity into four modules. This gives the desalination plant the ability to mirror demand fluctuations without incurring in fouling problems, while also staying in optimal pumping regime.
The optimisation variables in this model are:

- The power consumption from each one of the three sources, for desalination purposes (3 variables);
- The power consumption from each one of the three sources, for pumping purposes (3 variables);
- Which plant modules are in use (4 variables).

The dimension of the vector space is 10 × 24: from 0h to 23h, for the 10 optimisation variables.
The optimisation model also considers the usage of a storage tank for added operational flexibility, although its level is forced to be at 0 at the start and at the end of each day.

Sensitivity analysis

Using the optimisation model applied to the Centralised scenario, a sensitivity analysis is carried out on three key input variables in order to understand how much of an impact they might have on the obtained LCOW. The chosen variables are:

1. $FactorRES_{penetr.}$, the share of electricity demand to be supplied by regional RES production, varying -30/+20 percentage points;
2. PriceFactor, the price discount awarded to SWRO plants for buying electricity in bulk, varying -20/+10 percentage points;
3. $StorageTank_{capacity}$, the volume available for water storage, for capacities from 0 to 15 000 m^3.

Costs structure

The LCOW of the desalination plant is calculated according to Eq. 1.

$$LCOW = (CAPEX \cdot CRF + OPEX + EC)/TWP) \qquad (1)$$

Where CAPEX is the total capital expenditure, CRF is the capital recovery factor, OPEX is the total annual operational expenditure, EC is the annual electricity cost and TWP is the total annual desalinated water produced.
The electricity cost of the RES surplus is calculated based on the hourly average cost of kWh of the MIBEL over a decade, for each season of the year. The costs of power from own production are included in the CAPEX and OPEX. The cost of electricity from the grid is based on the power supplier's tariffs.
Table 1 summarises the CAPEX relative to the capacity installed, and the OPEX relative to the produced volume for a large SWRO plant (>100,000 m^3/day).

Table 1 – CAPEX and OPEX of a SWRO desalination plant (Caldera et al., 2016; Gao et al., 2017)

CAPEX		OPEX	
Desalination plant	2.23 €/(m^3/a)	Labour	0.092 €/m^3
PV panels	550 €/kWp	Maintenance	2% of desalination plant CAPEX
Wind turbines	1000 €/kW	Chemical	0.065 €/m^3
Lifetime	30 years	Membrane Exchange	0.028 €/m^3
Weighted Average Cost of Capital	7%	OPEX PV panels	1.5% of PV power CAPEX
		OPEX Wind turbines	2% of wind power CAPEX

Carbon footprint of power consumption

Powering desalination with RES helps decrease the total carbon footprint of water desalination. The carbon footprint of the Baseline scenario is estimated by taking the total grid power consumed in a year and converting it using the grid supplier's average emission of 256 ton of CO_2 per GWh consumed (DGEG, 2017). The same method is then used to estimate the CO_2 emissions of both the Centralised and Decentralised scenarios, and the emission savings are computed referring to the Baseline scenario's emissions.

CASE STUDY

Algarve, the southernmost region of continental Portugal, has a challenging water supply. It is one of the most water stressed regions of Portugal (Water Exploitation Index of 27% vs. a 14% national average (APA, 2016)). Superficial water sources, although being fairly abundant, are subject to precipitation fluctuations. The main subterranean source and water supply backup of the region, the Campina de Faro, has systematically been in the lower 20th percentile of its capacity in 2017/2018 (SNIRH, 2018). Adding the severe seasonal fluctuation in water consumption caused by the touristic inflow in the summer, the effects of climate change on aquifer recharge rate, precipitation variability and the impending desertification of the region, Algarve could use the added robustness in water sources provided by water desalination.

Table 2 shows the estimated daily average drinking water demand for each season. Peak daily demand (nearly 280,000 m^3/day) is observed in the summer and sets the total desalination capacity needed.

Table 2 – Daily average water demand (Águas do Algarve, 2017).

Season	Daily average water demand (m^3/day)		
	Windward	Leeward	Algarve total
Winter	66,926	59,363	126,289
Spring	89,348	79,251	168,599
Summer	148,200	131,454	**279,654**
Autumn	106,305	94,293	200,598

Figure 1 shows the current electricity tariff of the Portuguese grid supplier (EDP) and the average tariff over the last decade on the MIBEL (Merino et al., 2018), for a day in summer.

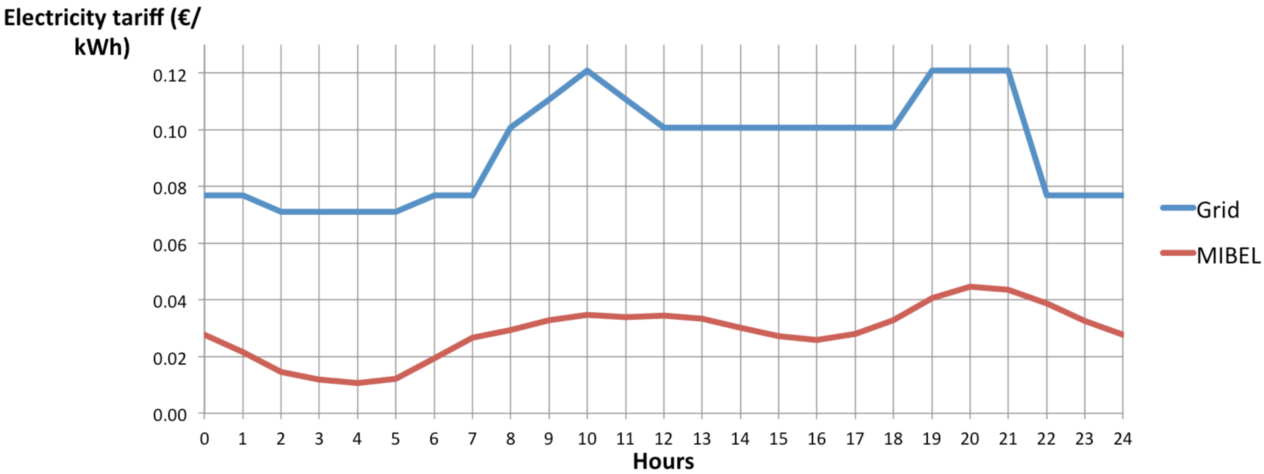

Figure 1 – Grid and MIBEL tariffs for a day in summer.

The wind power installed in Algarve is about 225 MW. The current PV power installed in this region is 45 MW, and 472 MW are expected to be installed until 2021.
Figure 2 shows the map of the Algarve Region with the two potential locations for the desalination plants. The main selection criteria were the proximity to the ocean, to the water distribution network and to the power grid while avoiding national park areas and main recreational beaches.

Figure 2 – Potential locations for the desalination plants. Top: at regional scale, Bottom left: Windward site (Portimão), Bottom right: Leeward site (Monte Gordo).

RESULTS

Baseline scenario

The Baseline scenario was analysed using the spreadsheet model and serves as reference for the production cost that a conventionally powered desalination plant would obtain. The resulting annual costs are of 64.1 M€ and the LCOW obtained is of 0.9055 €/m^3, within the range of 0.59 - 2.81 €/m^3 mentioned in the literature (Caldera et al. 2016). The relative cost contributions are shown in Figure 3: electricity costs represent the largest contribution to the LCOW at 43.7%, which is consistent with the literature.

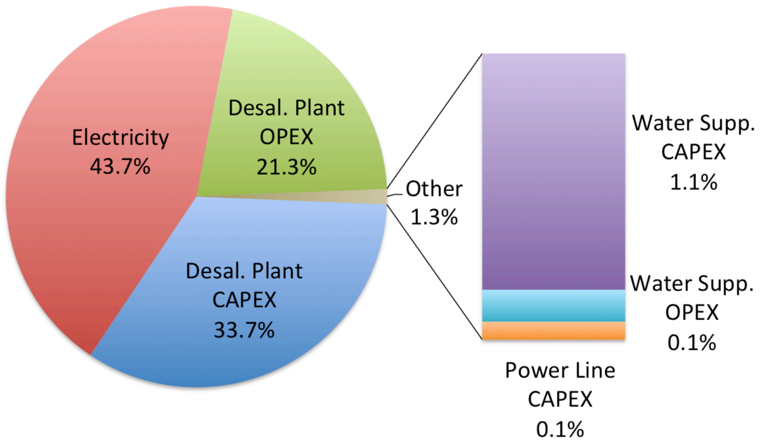

Figure 3 – Cost contributions to the LCOW of the Baseline scenario

Centralised scenario

Spreadsheet model

The spreadsheet model applied to the Centralised scenario yields a LCOW of 0.8409 €/m^3, a 7.1% reduction when compared to the Baseline scenario. This cost difference is a result of a much lower (-19.3%) electricity expenditure for the solution using RES power even though it adds RES CAPEX and OPEX to the total cost. The reason behind the electricity cost difference is that the tariff of grid power is systematically higher than the MIBEL market price used in the computation of surplus RES power, as illustrated by Figure 1.

Optimisation model

Table 3 summarises the main characteristics of the solution that minimises the electricity costs for a centralised desalination plant and its resulting LCOW. The installed capacity of RES is the maximum allowed: the savings in electricity costs it represents (by avoiding buying from the grid) compensate for the added annualised CAPEX and OPEX of the PV and wind power installation. The LCOW of this scenario after optimisation is 0.7420 €/m^3, 18.1% lower than the Baseline scenario and an 11.8% improvement over the non-optimised centralised solution. The obtained LCOW is however, 64.7% higher than the estimated production cost of 0.4504 €/m^3 of the regular water supplier (Águas do Algarve, 2017).

Table 3 - Main characteristics of the optimised Centralised solution

	Algarve (Monte Gordo)
Nominal desalination plant capacity	330,000 m^3/day
Own PV power installed	6.3 MW
Own wind power installed	5 MW
Storage tank capacity	10,000 m^3
Annual cost	52.3 M€
LCOW	0.7420 €/m^3

Figure 4 illustrates the cost contributions to the resulting LCOW. The annualised CAPEX of the desalination plant is the largest contribution closely followed by the electricity costs, whose share dropped 4.3% when compared to the share of LCOW of the Baseline scenario shown in Figure 3.

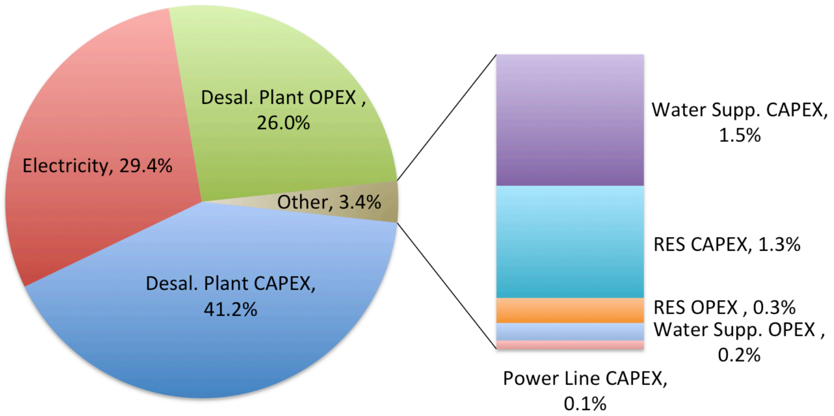

Figure 4 - Total cost contribution to LCOW in the centralised solution

The further reduction in electricity costs of the optimised solution (when compared to the spreadsheet solution) is possible due to the operational flexibility. Since the desalination plant is oversized for the seasons where water demand is smaller than peak demand, the plant can work at an hourly output below or above the hourly average output of the season. The main consequence is that the hours with the largest desalination output (and therefore power consumption) coincide with the hours with lower tariffs, as seen by comparing Figures 1 and 5.

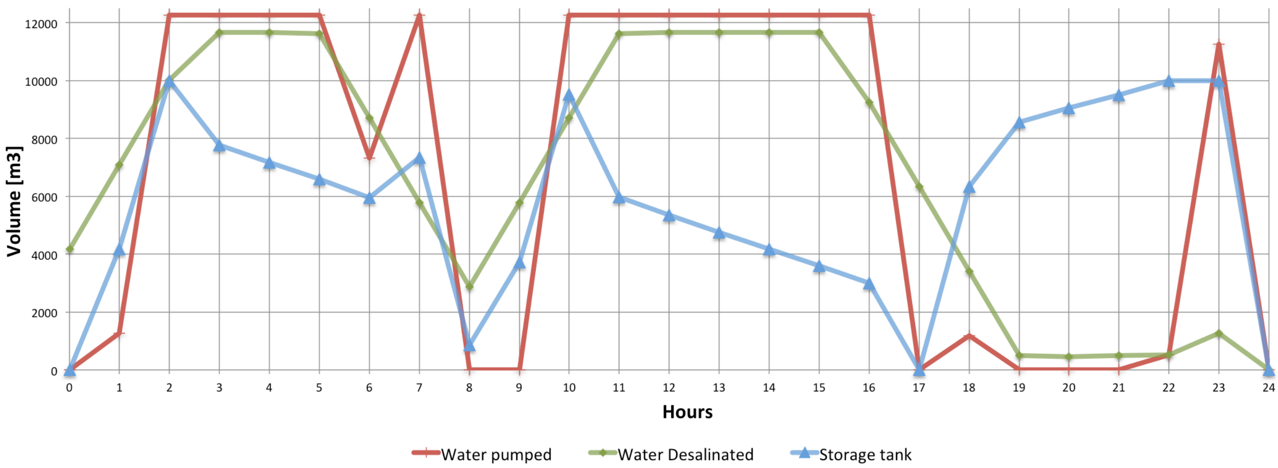

Figure 5 – Hourly operation of the optimised Centralised scenario, for a storage tank capacity of 10,000 m^3

Figure 5 also shows that the storage tank acts as a buffer, allowing for a looser management of water pumping and, consequently, a smaller expense in pumping power costs. The optimisation model makes it so that the storage tank reaches its maximum capacity around the time where it is less expensive to pump the desalinated water to the water supply network, while ensuring that the storage tank is empty at the start of each new day, as per the model assumptions.

Sensitivity analysis

Taking values of RES penetration from 50% to 100%, the resulting LCOWs for the Centralised scenario are given in Table 4. The large decrease in LCOW that results from lowering $FactorRES_{penetr}$ to 50% is the result of two factors. The first is straightforward: for the hour blocks where Surplus RES was being consumed, a larger portion of this less expensive alternative to grid power is now available. The second is a consequence of the Gaussian shape of the profile of RES production: for high values of $FactorRES_{penetr}$, the only moment when Surplus RES is available is around the peak of production of PV panels at 13h/14h, limiting the possibilities of optimisation (explained by the fact that the installed capacity of PV panels is much larger than that of wind turbines). As the factor is brought down, the number of hour blocks where Surplus RES is available rises, leading to not only more Surplus RES power available but also more flexibility regarding when to use it.

Table 4 - RES penetration sensitivity analysis for the Centralised scenario

$FactorRES_{penetr}$	LCOW (€/m^3)	Diff. to $FactorRES_{penetr}$= 80%
50%	0.6859	-7.55%
60%	0.6984	-5.88%
70%	0.7286	-1.80%
80%	0.7420	-
90%	0.7528	+1.46%
100%	0.7596	+2.37%

Regarding PriceFactor variations, the LCOW is not particularly sensitive, yielding small differences when compared to the assumed 75% value. The most important factor in determining the LCOW is Surplus RES availability: the price difference between the MIBEL and the grid tariff shown in Figure 1 is significant and has therefore a bigger impact than the discount negotiated.

Finally, regarding storage tank capacities, adding a storage tank slightly loosens the constraints on the pumping operation and allows for a different optimum resulting in lower electricity costs. The sensitivity analysis shows, however, that the added annualised storage tank CAPEX and OPEX outbalance the savings in electricity costs for every capacity chosen. The relatively small impact on electricity costs of having a storage tank can be explained in part by it only influencing the pumping operation, while the desalination operation (which has a specific energy consumption two orders of magnitude larger) remains unchanged. The lowest LCOW possible is therefore for a solution where there is no storage tank installed, at 0.7404 €/m^3. Although the lowest LCOW is obtained without a storage tank, the recommended solution is one where a storage tank with a capacity of 10,000 m^3 is considered (for the Centralised scenario). The sensitivity analysis showed that capacities larger than 10,000 m^3 do not help further reduce electricity costs. At around 3% of the nominal plant capacity, this volume represents a safety measure for when maintenance work must be done and for when unexpected occurrences might temporarily disturb the plant's capacity to supply demand.

Decentralised scenario

Spreadsheet model

The spreadsheet model applied to the Decentralised scenario yields a LCOW of 0.8182 €/m^3, which is 81.7% higher than the estimated conventional water supply production cost, but 9.6% lower than the Baseline scenario's LCOW and 2.8% lower than the Centralised solution LCOW (with annual savings of 1.4 M€).

Optimisation model

Table 5 summarises the main characteristics of the solution that minimises the electricity costs for the decentralised scenario and its resulting LCOW. The LCOW of this scenario after optimisation is 0.7266 €/m^3, 19.7% lower than the Baseline scenario and 2.1% lower than the optimised Centralised solution. By yielding the lowest electricity expenditures of all the strategies studied, this scenario yields the lowest LCOW and represents the optimal solution for the case of Algarve. It is, however, 61.3% higher than the estimated production cost of the regular water supplier.

Table 5 - Main characteristics of the optimised Decentralised solution

	Windward (Portimão)	Leeward (Monte Gordo)	Total
Nominal desalination plant capacity	175,000 m^3/day	155,000 m^3/day	330,000 m^3/day
Own PV power installed	6.3 MW	6.3 MW	12.6 MW
Own wind power installed	5 MW	5 MW	10 MW
Storage tank capacity	5000 m^3	5000 m^3	10,000 m^3
Annual cost	27.3 M€	24.2 M€	51.5 M€
LCOW	0.7505 €/m^3	0.6996 €/m^3	0.7266 €/m^3

Figure 6 illustrates the cost contributions to the resulting optimised Decentralised LCOW. We notice an increase in the water supply and RES installation annualised CAPEX, 16.3% and 100.0% respectively when compared to the Centralised solution whereas electricity costs decrease 13.6%. The higher aggregate RES capacity, although more expensive (+0.853 M€ in CAPEX and +0.175 M€ in OPEX), allows for a significantly lower electricity expenditure (-2.11 M€ per year).

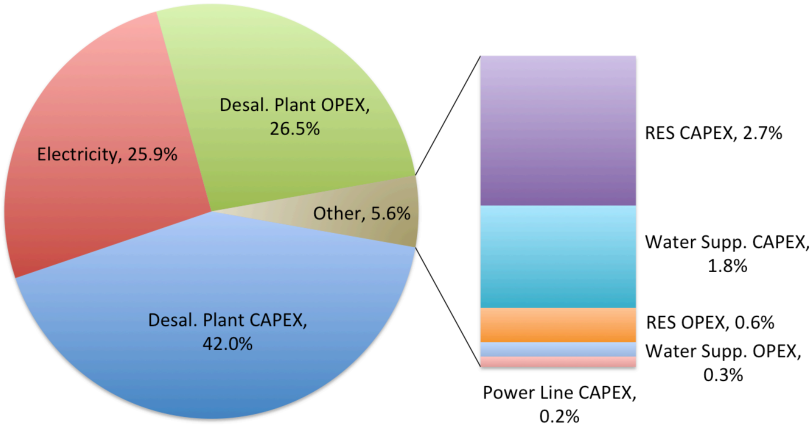

Figure 6 – Total cost contribution to LCOW in the decentralised solution

Centralised vs Decentralised scenario

An analysis of the absolute values of power consumption (shown in Table 6) helps us understand the difference in electricity costs between the two strategies and the main reason why the optimised Decentralised scenario yields the optimal LCOW: although the optimised Decentralised scenario leads to a slightly larger total power consumption (+0.5%, explained by the higher pumping head needed for the Windward plant), grid power consumption (the most expensive of power sources) is 9.2% lower than for the optimised Centralised scenario, which also adds a 24.6% improvement in CO_2 emission savings.

Table 6 - Yearly power consumption and resulting CO_2 emissions savings of each strategy

Power Consumption	Centralised scenario	Decentralised scenario
Grid (MWh)	1717	1559
Surplus RES (MWh)	426	324
Own Prod. RES (MWh)	217	489
Total (MWh)	2360	2372
CO_2 emissions savings (tCO_2)	164.6	205.1

CONCLUSIONS AND FURTHER RESEARCH

The main purpose of this work is to understand how RES powered desalination could become a viable solution for water stressed regions such as Algarve, and to determine whether a centralised or a decentralised strategy yields the lowest LCOW.

Of the two scenarios considered, the Decentralised scenario turned out being the solution with the lowest resulting LCOW at 0.7266 €/m^3, 2.1% lower than the Centralised scenario's LCOW and 19.7% lower than the Baseline scenario's LCOW. This result shows that, under the assumptions set for this project, having two smaller desalination plants comes at a slightly lower cost than having one large one. Although the Centralised scenario benefits from economies of scale, with yearly savings of 853,000 € in total CAPEX (-3.5%), the increased installed capacity in RES for own consumption of the Decentralised scenario leads to 2,11 M€ savings in electricity costs (-13.6%) every year. It must be noted, however, that if we relax the constraint on total RES capacity installed for the Centralised scenario and set it equal to the total capacity installed for the Decentralised scenario, the LCOW obtained for one large plant drops to 0.7204 €/m^3.

Sensitivity analysis is carried out on three variables: PriceFactor, $StorageTank_{capacity}$ and $FactorRES_{penetr}$. PriceFactor variations were found to have little impact on the obtained LCOW. $StorageTank_{capacity}$ variations show that, first, the lowest LCOW obtained is for a setup with no storage tank and secondly, increasing storage tank capacity has diminishing returns regarding electricity cost savings (which are exclusively related to water pumping). The retained solution settles for a total storage tank capacity of 10,000 m^3, a compromise between added expenses and the need for an operational security margin. Lastly, a variation in $FactorRES_{penetr}$ is shown to have a significant impact on the LCOW (-7.5% for a RES penetration of 50%). RES surplus availability strongly influences the total electricity costs, which makes RES penetration a very important aspect of the feasibility study. Under the conditions set for this project, the recommended solution considers a nominal plant capacity of 175,000 m^3/day at the Windward location (Portimão) and a 155,000 m^3/day plant at the Leeward location (Monte Gordo). Each of them is equipped with 5000 m^3 of storage tank capacity (for a total of 10,000 m^3), with 1.3 MW of rooftop solar PV, 5 MW of fixed tilt solar PV panels and a 5

MW wind turbines (for a total installed capacity of 12.6 MW of solar PV and 10 MW of wind turbines). The obtained LCOW of 0.7266 €/m^3 ranks among the lowest production costs mentioned by Gao et al., at around 0.8 USD/m^3, but is still 61.3% higher than the reference cost of the conventional water supplier. This means that from a purely economic point of view, and under the conditions set in this project, water desalination cannot compete with conventional water suppliers. However, the cost structure analysis carried out in this work show that with the right operational strategy we can minimise electricity costs (33.8% reduction when compared to the spreadsheet model), but further cost reductions are hampered by the total CAPEX (298 M€). To make this project economically viable, it is recommended to follow the example of Barcelona's LLobregat desalination plant project: built in 2008 with a capacity similar to the ones considered in this work (200,000 m^3/day) and a total investment of 230 M€, it financed its CAPEX thanks to contributions from the European Union's Cohesion Fund (150 M€) and from Spain's Ministry of Environment (52 M€). The company operating the water supply concession defrayed 28 M€, 12.2% of the total investment (Water Technology).
The solution presented can supply 100% of Algarve's freshwater demand, making desalinated water a suitable alternative to water sourced from ground and surface resources. This would greatly reduce the stress on local aquifers, allowing them to slowly replenish themselves and avoid the risk of contamination. It would make Algarve's fresh water supply drought-proof, and it would free surface resources, which are subject to precipitation and to the effects of advancing desertification, for agricultural use. Regarding CO_2 emissions, the Decentralised scenario has an advantage over the Centralised scenario by consuming less grid power, resulting in a 24.6% increase in CO_2 emission savings compared to the Centralised solution (and a 51.4% increased savings compared to the Baseline scenario.

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