# Smart Energy System para incrementar la participación de renovables en el sector de la desalación

**Autor: Pedro Jesús Cabrera Santana**

**Institución: Universidad de Las Palmas de Gran Canaria**

Evento Final E5DES | 28 noviembre 2023 | online

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# Componentes del Grupo de Investigación

grres ULPGC
group for the research on
renewable energy systems

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Cabrera Santana

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# Resumen de hitos del proyecto

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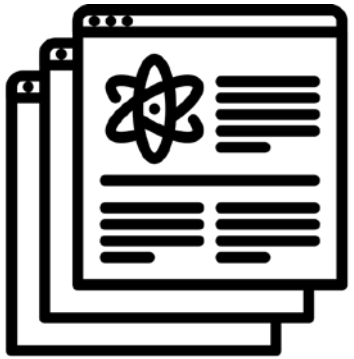
## ECOS 2023

36th INTERNATIONAL CONFERENCE ON EFFICIENCY, COST, OPTIMIZATION, SIMULATION AND ENVIRONMENTAL IMPACT OF ENERGY SYSTEMS

LAS PALMAS DE GRAN CANARIA

AUDITORIO ALFRESO KRAUS

25-30 de Junio 2023



+ 9 artículos científicos publicados en revistas

+ 6 congresos científicos

+ 2 estancias de investigación

+ 4 puestos de trabajo
(+ 3 mujeres)

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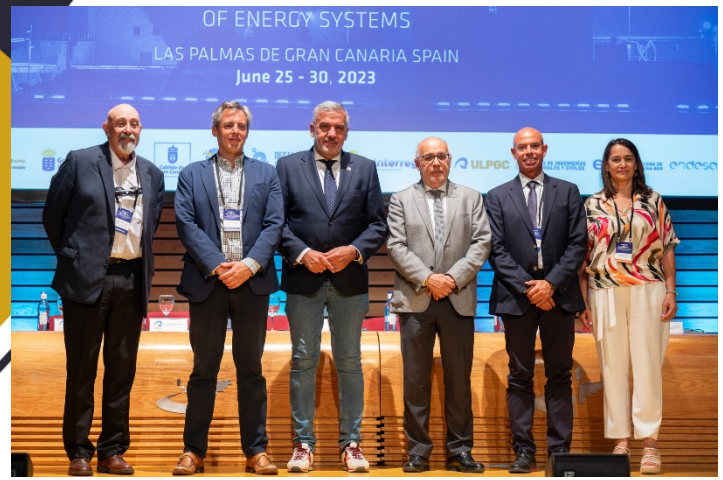
# Apertura del Congreso

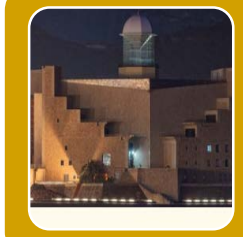


*Imagénes. Apertura del Congreso ECOS2023*

El acto de apertura tuvo un gran acogimiento por parte de los asistentes y diversos medios de comunicación (11 medios digitales, 2 medios de prensa y 6 medios de radio)

ECOS 2023

# Estadísticas



## Abstracts recibidos

- Total: 612
- Aceptados: 608
- Rechazados: 4

## Full papers recibidos

- Aceptados: 425
- Rechazados: 6

## Presentaciones

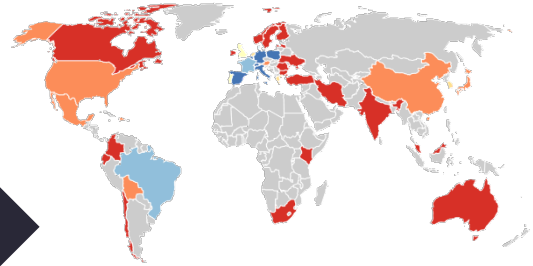
- Oral: 310
- Poster: 115

65 Sesiones Paralelas
2 Sesiones de Pósters

ECOS 2023

# Estadísticas

419 Participantes registrados



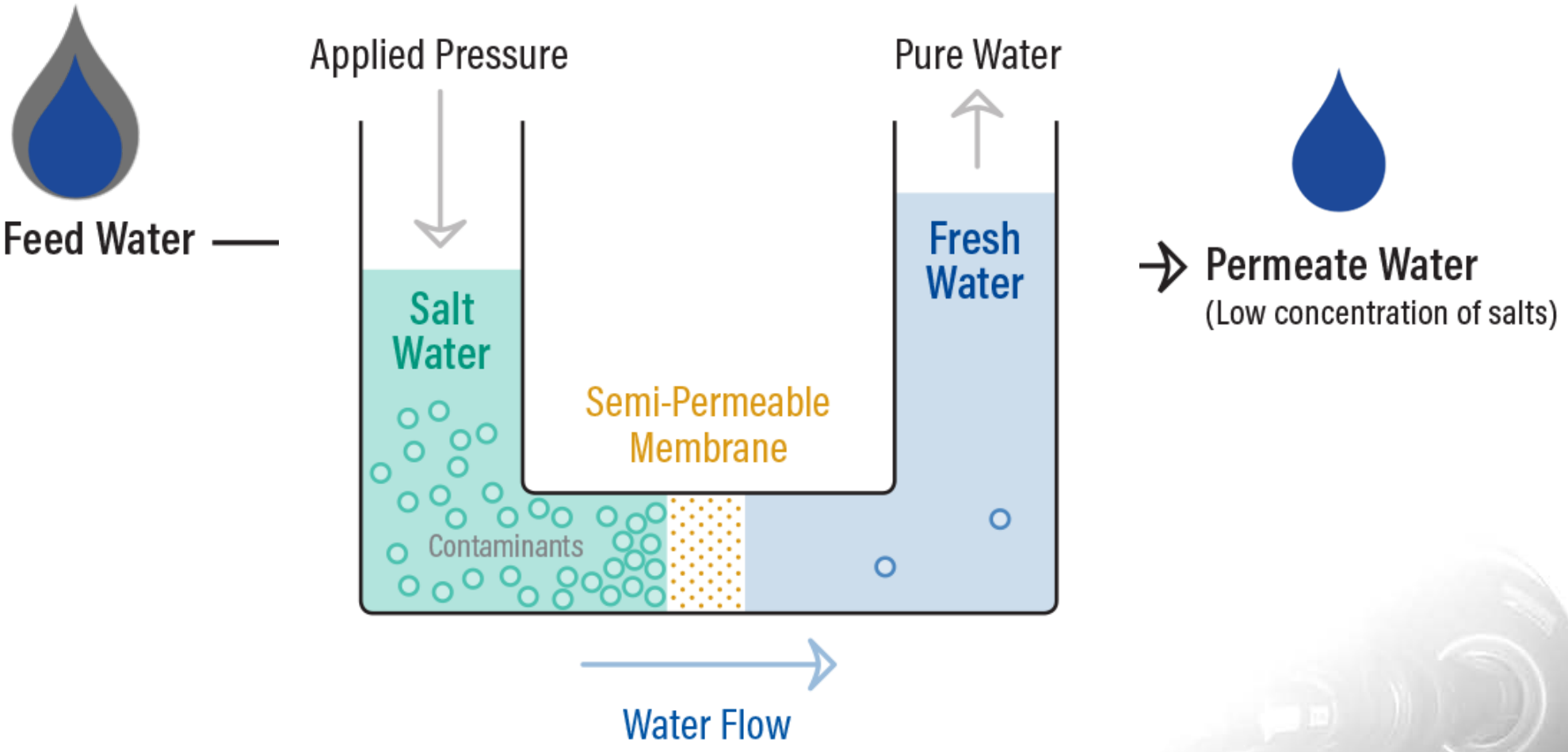
38 Nacionalidades

*Imagen. Asistentes de la trigésimo sexta edición del congreso ECOS*

# Smart Energy System para incrementar la participación de renovables en el sector de la desalación

Hipótesis de partida

# Reverse Osmosis

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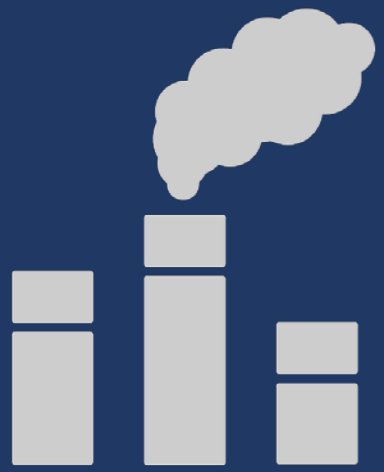
# Problema

Energía

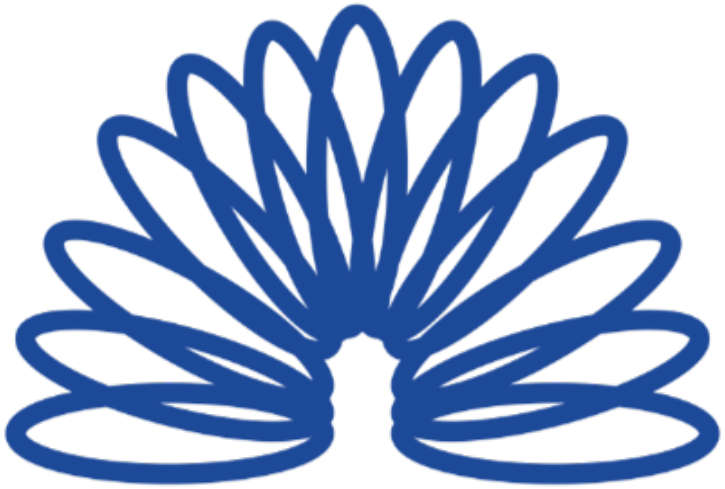
Coste



Contaminación

La desalación es un consumo constante e intensivo de Energía

# Hipótesis de partida

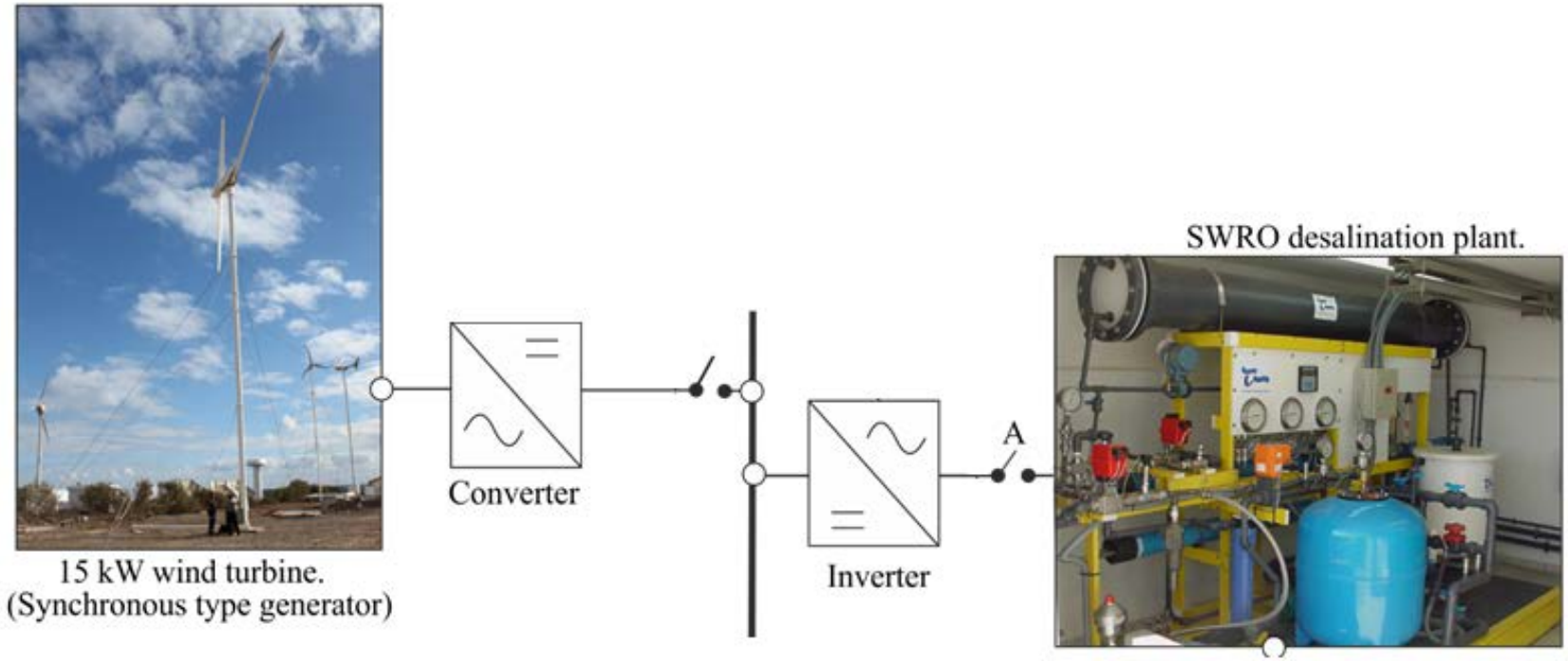


Se puede incrementar la flexibilidad de operación de una planta desalinizadora.

# Hipótesis validada con nueva idea de prototipo de planta basado en IA completamente flexible

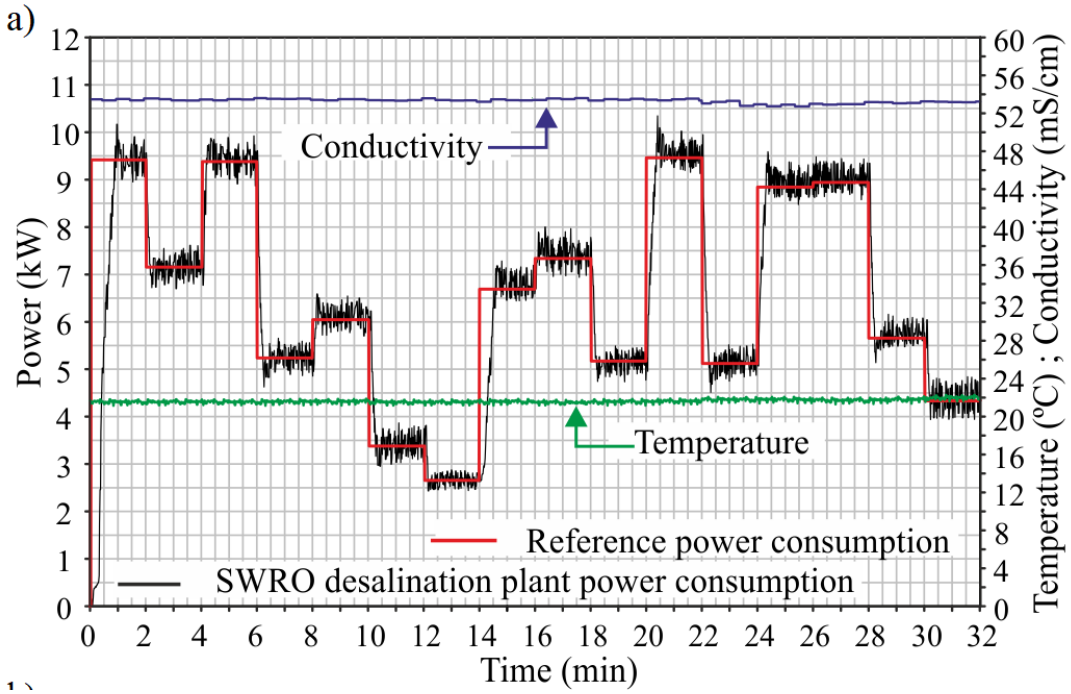
(1) Pumping center. (2) Product water reservoir. (3) Anemometer and wind vane. (4) Desalination plant house.

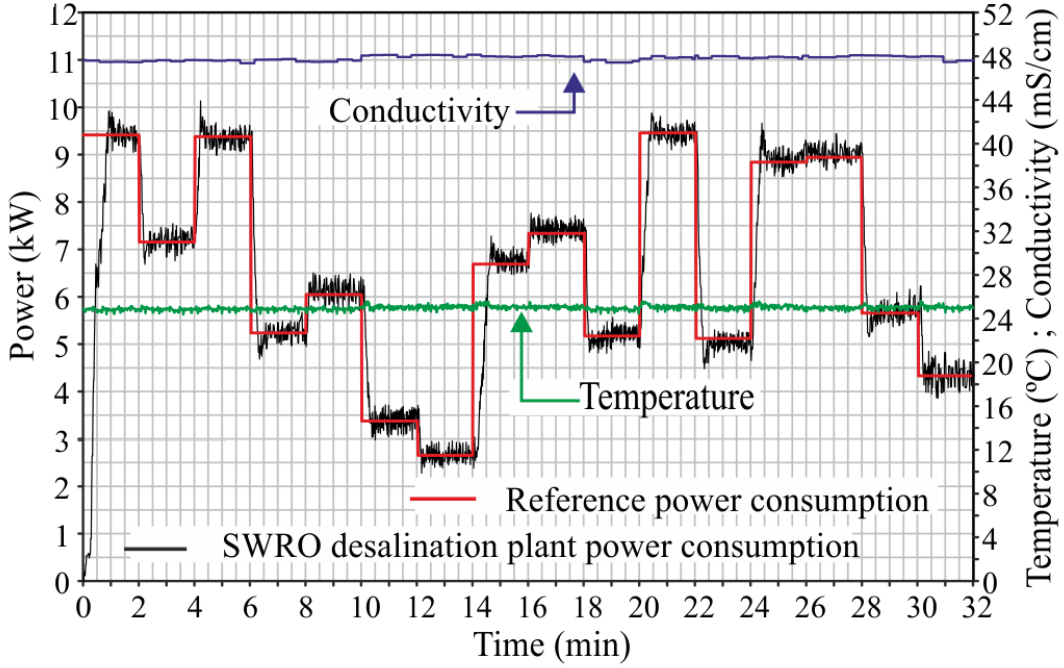
# Hipótesis validada con nueva idea de prototipo de planta basado en IA completamente flexible




IA

# Hipótesis validada con nueva idea de prototipo de planta basado en IA completamente flexible



*…the authors were able the combine the ANN and the engineering to a level that deserve publication as one of* ***the first steps towards optimal operation of membrane systems****. For this they deserve a real applause.*

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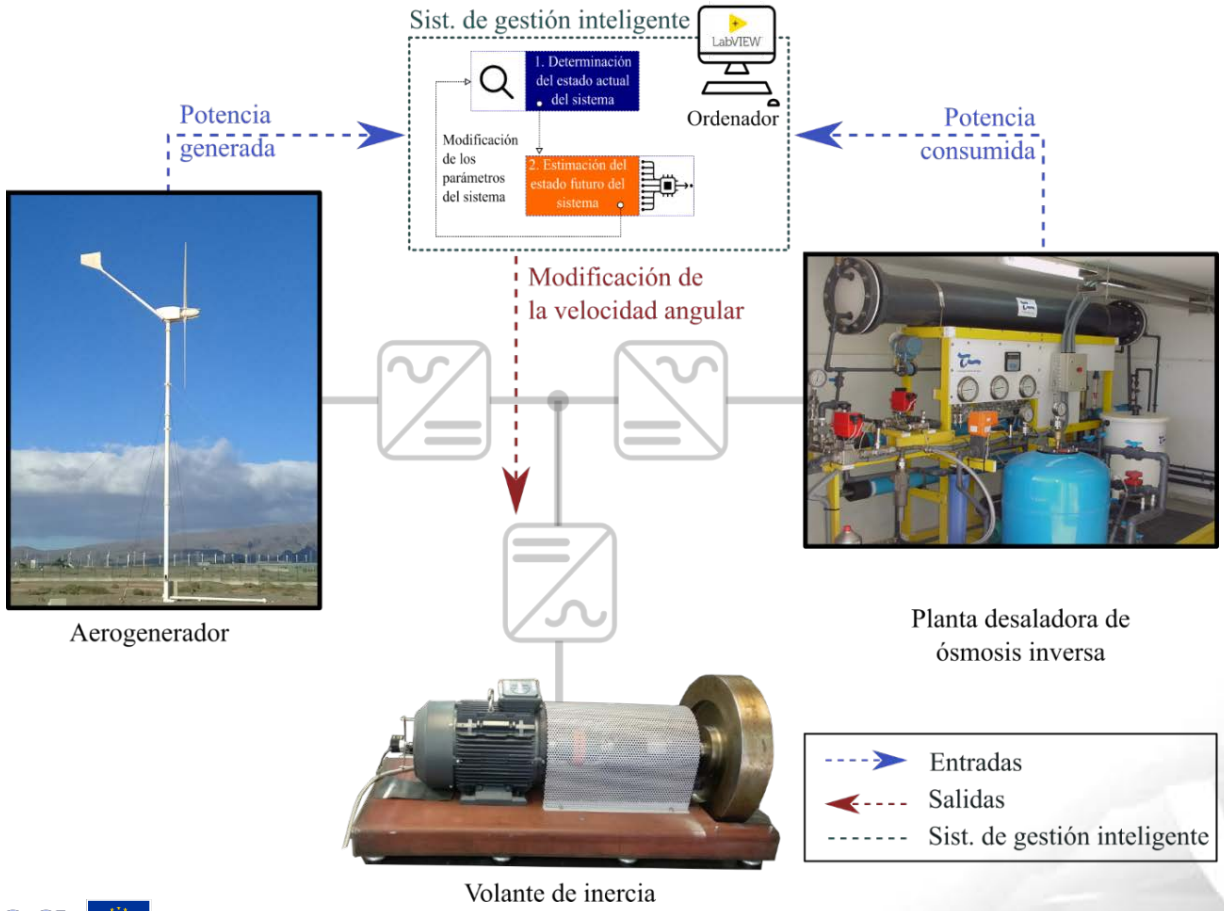
**Convocatoria 2022 - «Proyectos de Generación de Conocimiento»**
**Formato Memoria Científico-Técnica Proyectos Individuales**

**TÍTULO DEL PROYECTO (ACRÓNIMO):** Gestión inteligente de un volante de inercia para su integración en sistema aislado de desalación accionado con energía eólica (INERTIA).



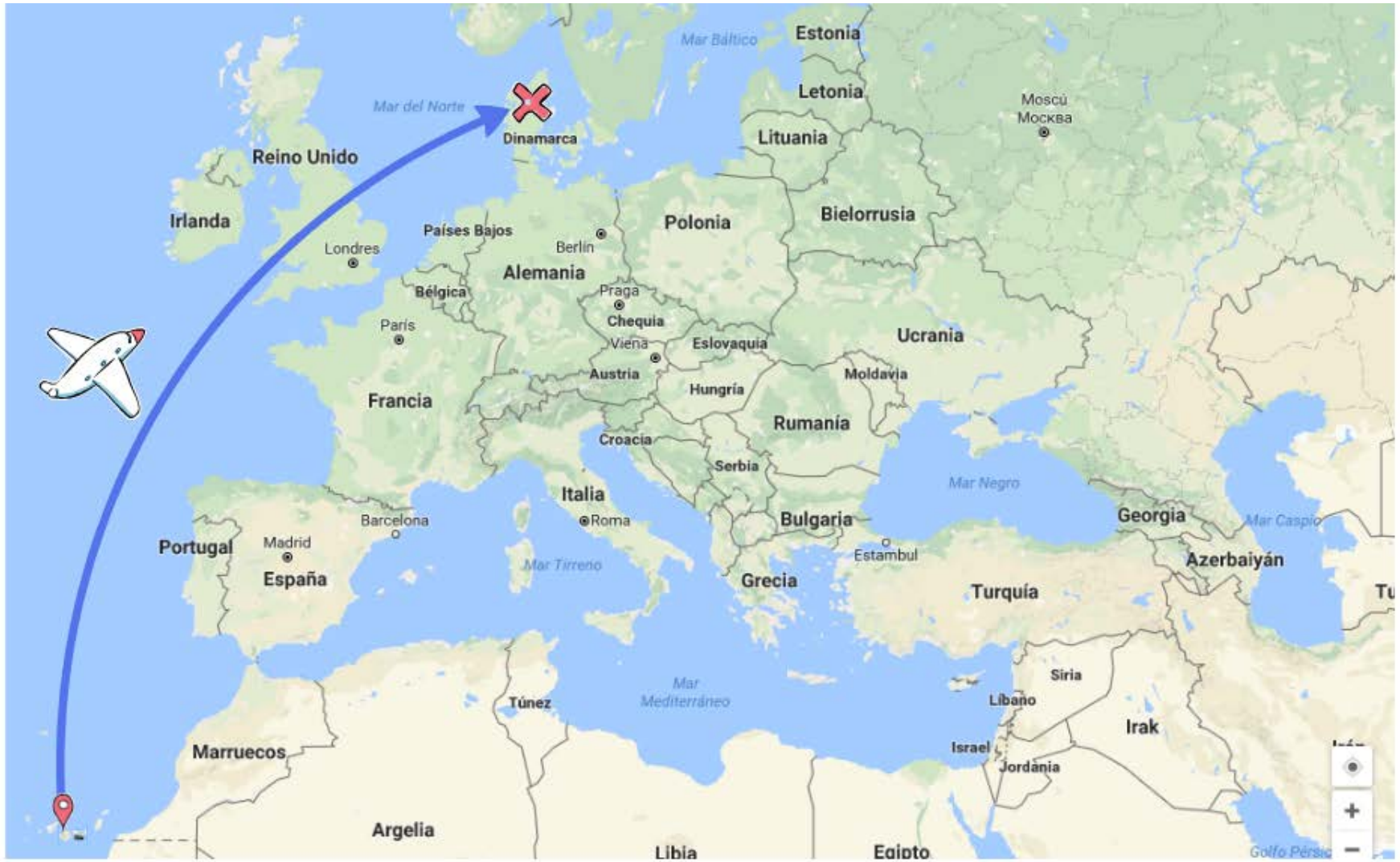
# Cuestión a resolver

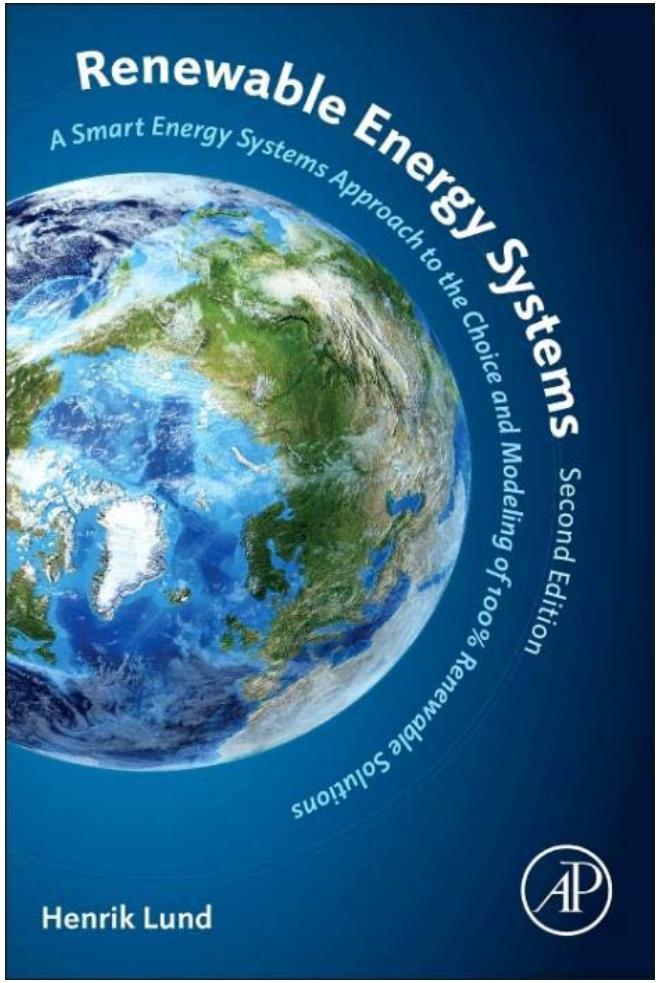


¿se puede incrementar el uso de Energías Renovables en todo un sistema energético al flexibilizar la desalación?

# *Smart Energy System* para incrementar la participación de renovables en el sector de la desalación

## Método


Mar Báltico
Estonia
Letonia
Lituania
Moscú
Москва
Mar del Norte
Dinamarca
Reino Unido
Irlanda
Londres
Países Bajos
Berlín
Polonia
Bielorrusia
Alemania
Bélgica
Praga
Chequia
París
Viena
Eslovaquia
Ucrania
Austria
Moldavia
Hungría
Francia
Rumanía
Croacia
Serbia
Mar Negro
Italia
Roma
Bulgaria
Georgia
Mar Caspio
Barcelona
Portugal
Madrid
España
Estambul
Azerbaiyán
Mar Tirreno
Grecia
Turquía
Siria
Mar Mediterráneo
Túnez
Líbano
Irak
Israel
Jordania
Marruecos
Argelia
Libia
Egipto
Golfo Pérsico



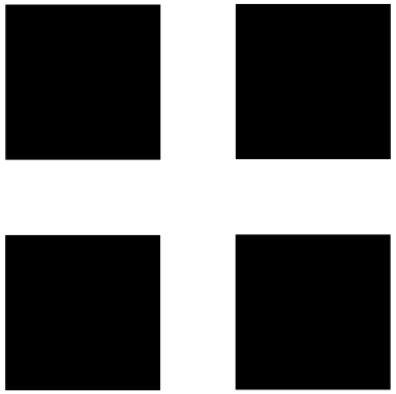

- Teoría de la elección consciente
- Smart Energy Systems

Henrik Lund

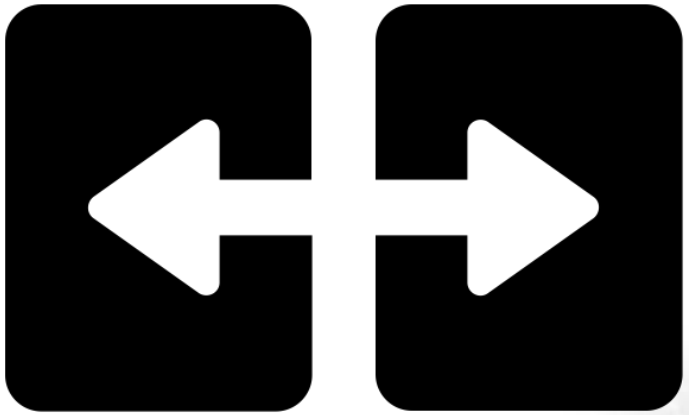
*Sustainable Energy Planning Research Group*
*Universidad de Aalborg (Dinamarca)*

# *¿Smart Energy System?*

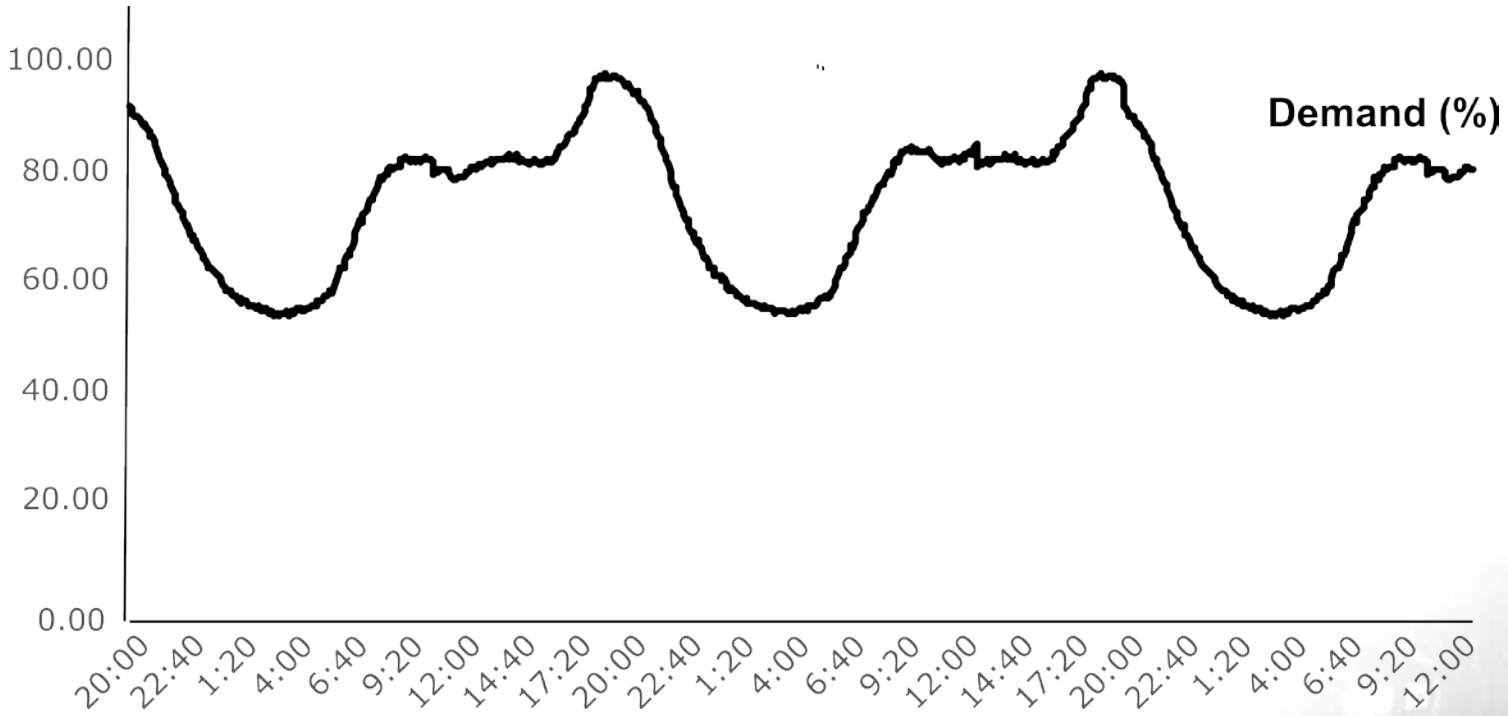
**Los sectores de un sistema energético se consideran independientemente**



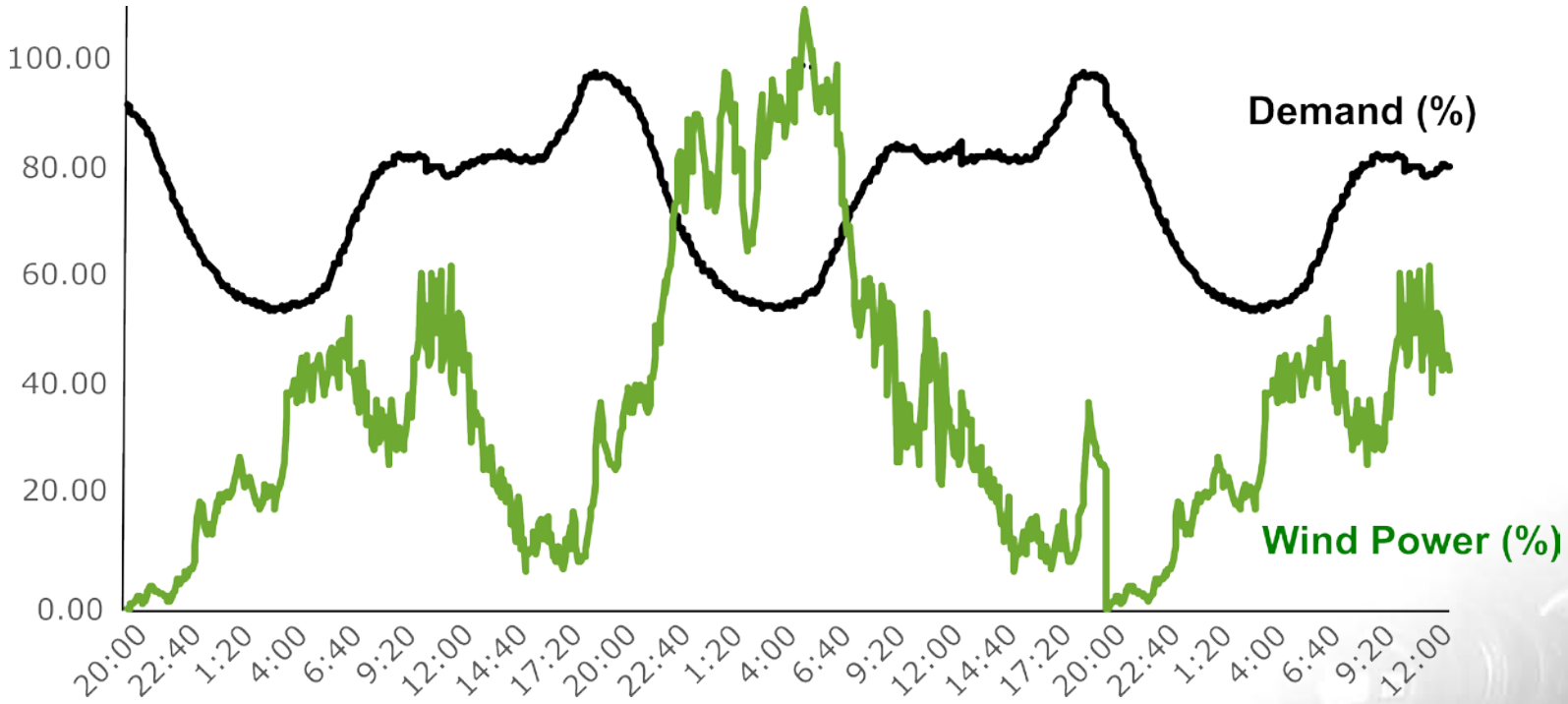
**Sin embargo si estos se integran y colaboran entre sí, se optienen mejores soluciones**



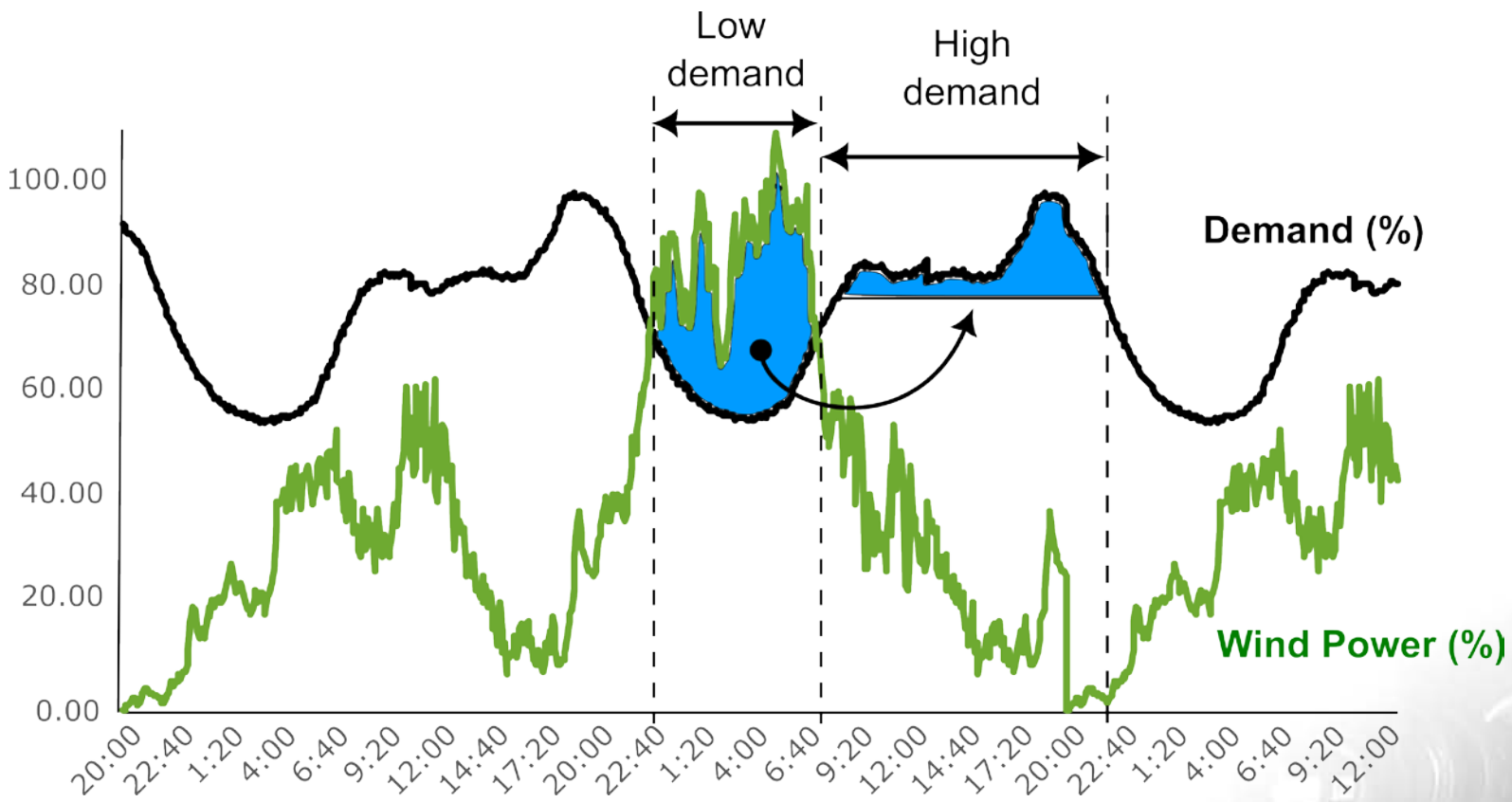
# ¿Smart Energy System?

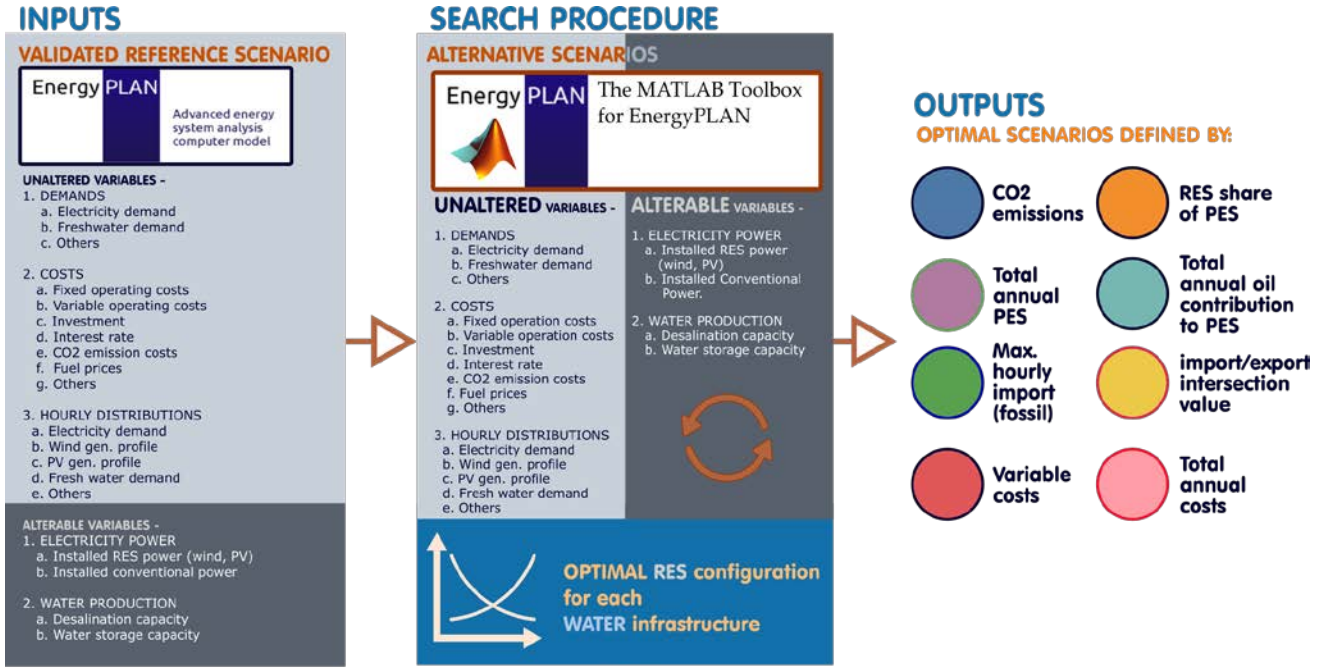


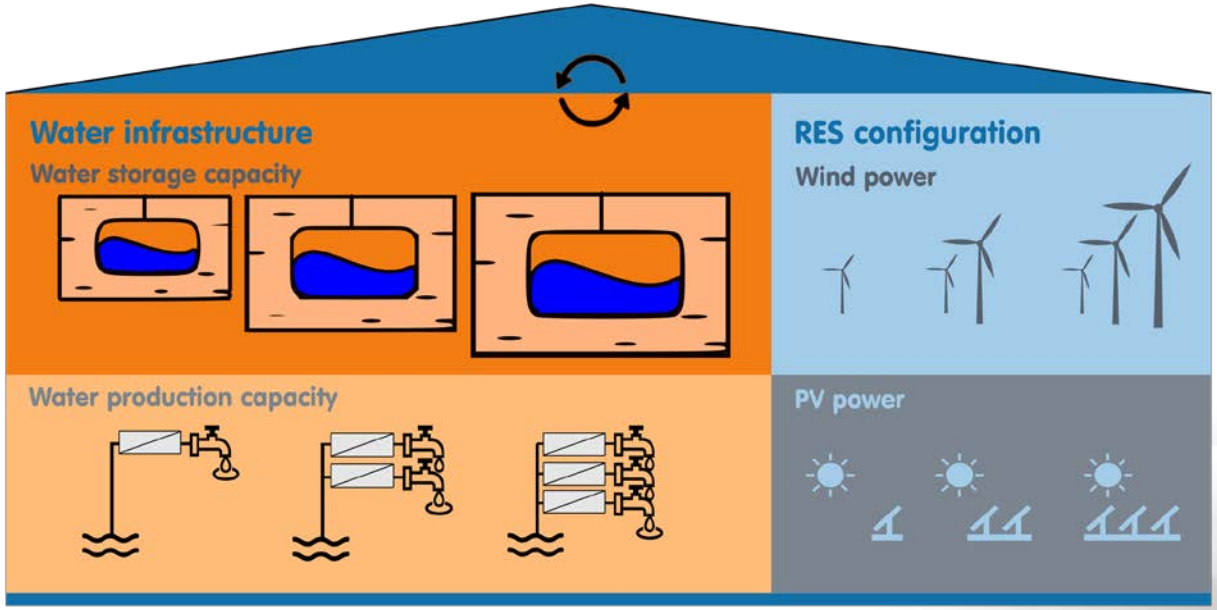
# *¿Smart Energy System?*



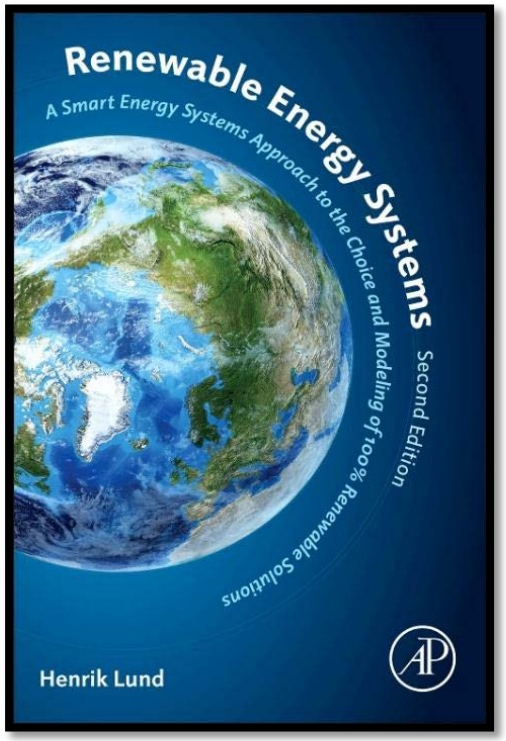
# *¿Smart Energy System?*

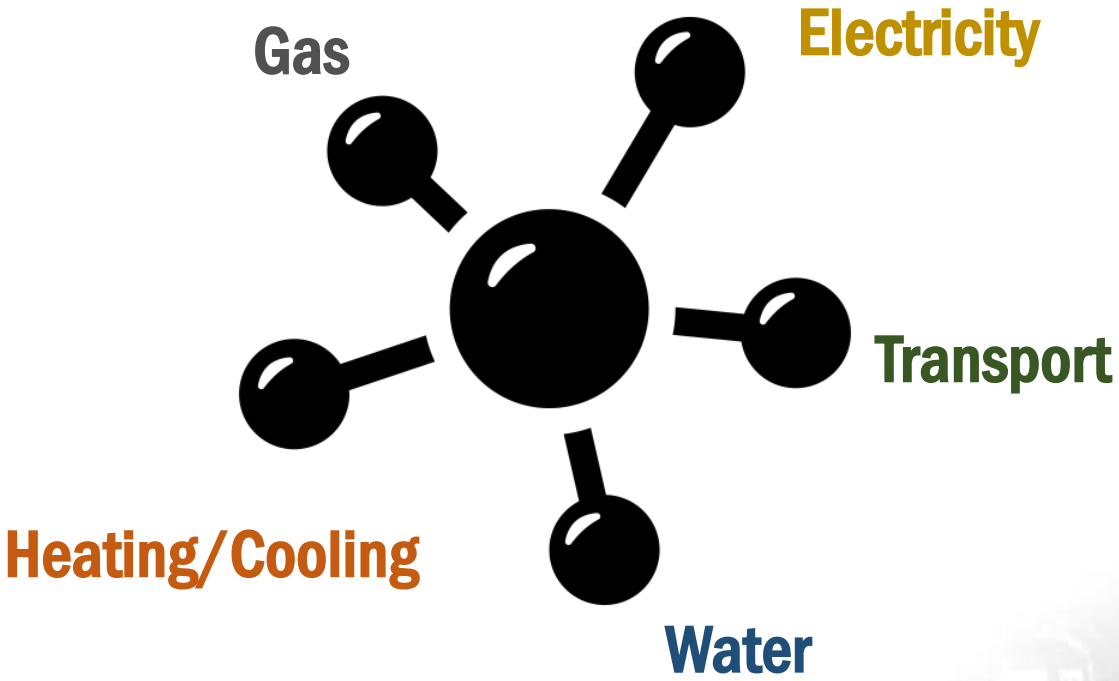



INPUTS
VALIDATED REFERENCE SCENARIO
Energy PLAN
Advanced energy system analysis computer model
UNALTERED VARIABLES -
1. DEMANDS
a. Electricity demand
b. Freshwater demand
c. Others
2. COSTS
a. Fixed operating costs
b. Variable operating costs
c. Investment
d. Interest rate
e. CO2 emission costs
f. Fuel prices
g. Others
3. HOURLY DISTRIBUTIONS
a. Electricity demand
b. Wind gen. profile
c. PV gen. profile
d. Fresh water demand
e. Others
ALTERABLE VARIABLES -
1. ELECTRICITY POWER
a. Installed RES power (wind, PV)
b. Installed conventional power
2. WATER PRODUCTION
a. Desalination capacity
b. Water storage capacity
SEARCH PROCEDURE
ALTERNATIVE SCENARIOS
Energy PLAN
The MATLAB Toolbox for EnergyPLAN
UNALTERED VARIABLES -
1. DEMANDS
a. Electricity demand
b. Freshwater demand
c. Others
2. COSTS
a. Fixed operation costs
b. Variable operation costs
c. Investment
d. Interest rate
e. CO2 emission costs
f. Fuel prices
g. Others
3. HOURLY DISTRIBUTIONS
a. Electricity demand
b. Wind gen. profile
c. PV gen. profile
d. Fresh water demand
e. Others
ALTERABLE VARIABLES -
1. ELECTRICITY POWER
a. Installed RES power (wind, PV)
b. Installed Conventional Power.
2. WATER PRODUCTION
a. Desalination capacity
b. Water storage capacity
OPTIMAL RES configuration for each WATER infrastructure
OUTPUTS
OPTIMAL SCENARIOS DEFINED BY:
CO2 emissions
RES share of PES
Total annual PES
Total annual oil contribution to PES
Max. hourly import (fossil)
import/export intersection value
Variable costs
Total annual costs

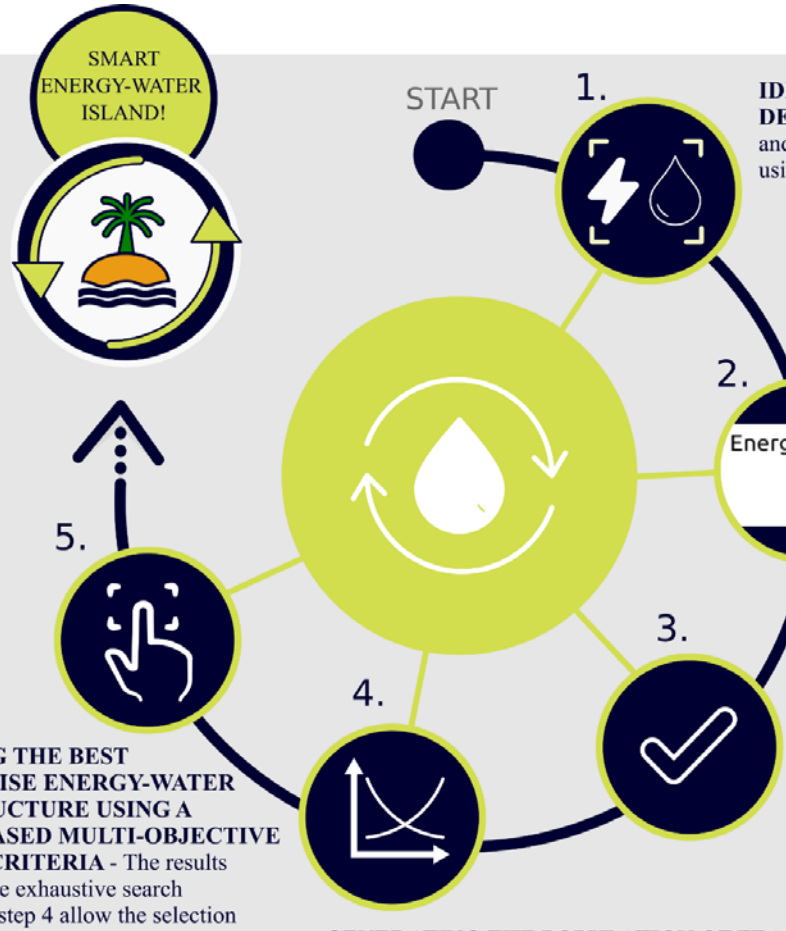

Water infrastructure
Water storage capacity
Water production capacity
RES configuration
Wind power
PV power

# *¿Smart Energy System?*



# GENERAL METHOD




**IDENTIFYING RESOURCES AND DEMANDS** - Energy-Water resources and demands are identified on the island using official records.

**MODELLING REFERENCE SCENARIO** - A known reference scenario is modelled using the EnergyPLAN tool.

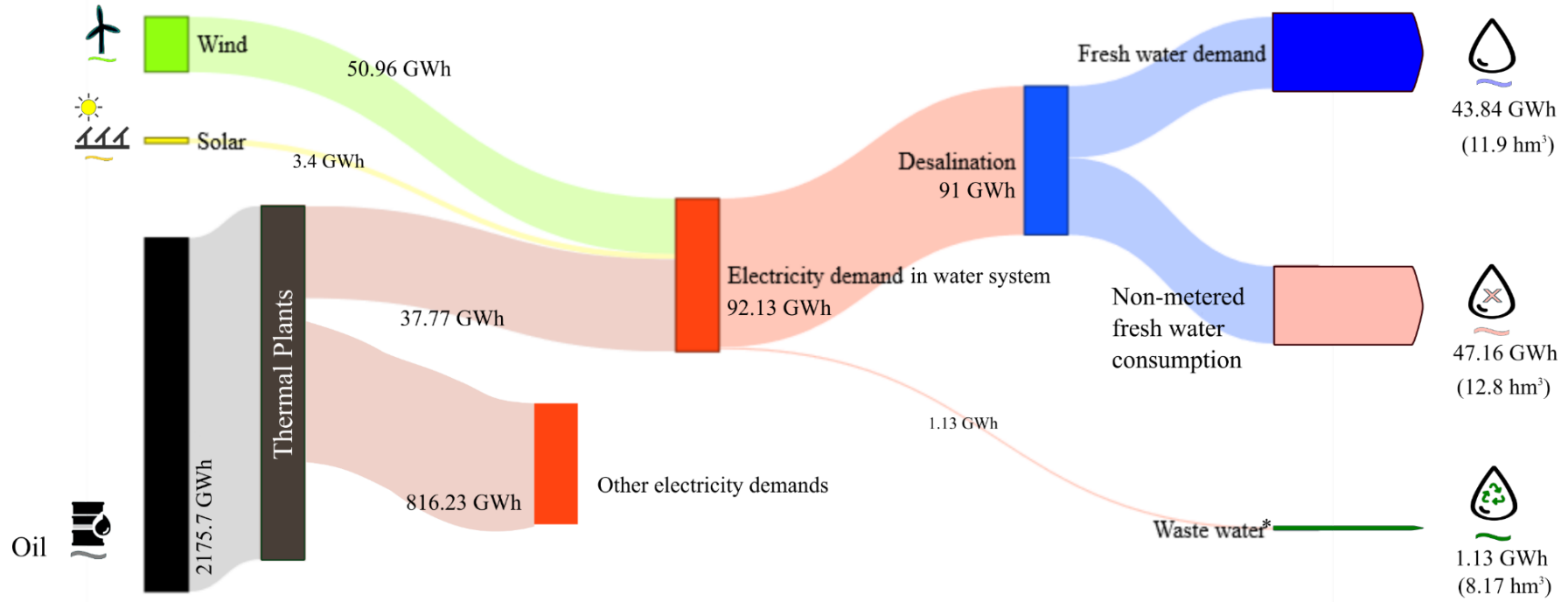
**VALIDATING REFERENCE SCENARIO** - Data obtained from EnergyPLAN and official real data are cross-crecked to validate the results obtained from the model.

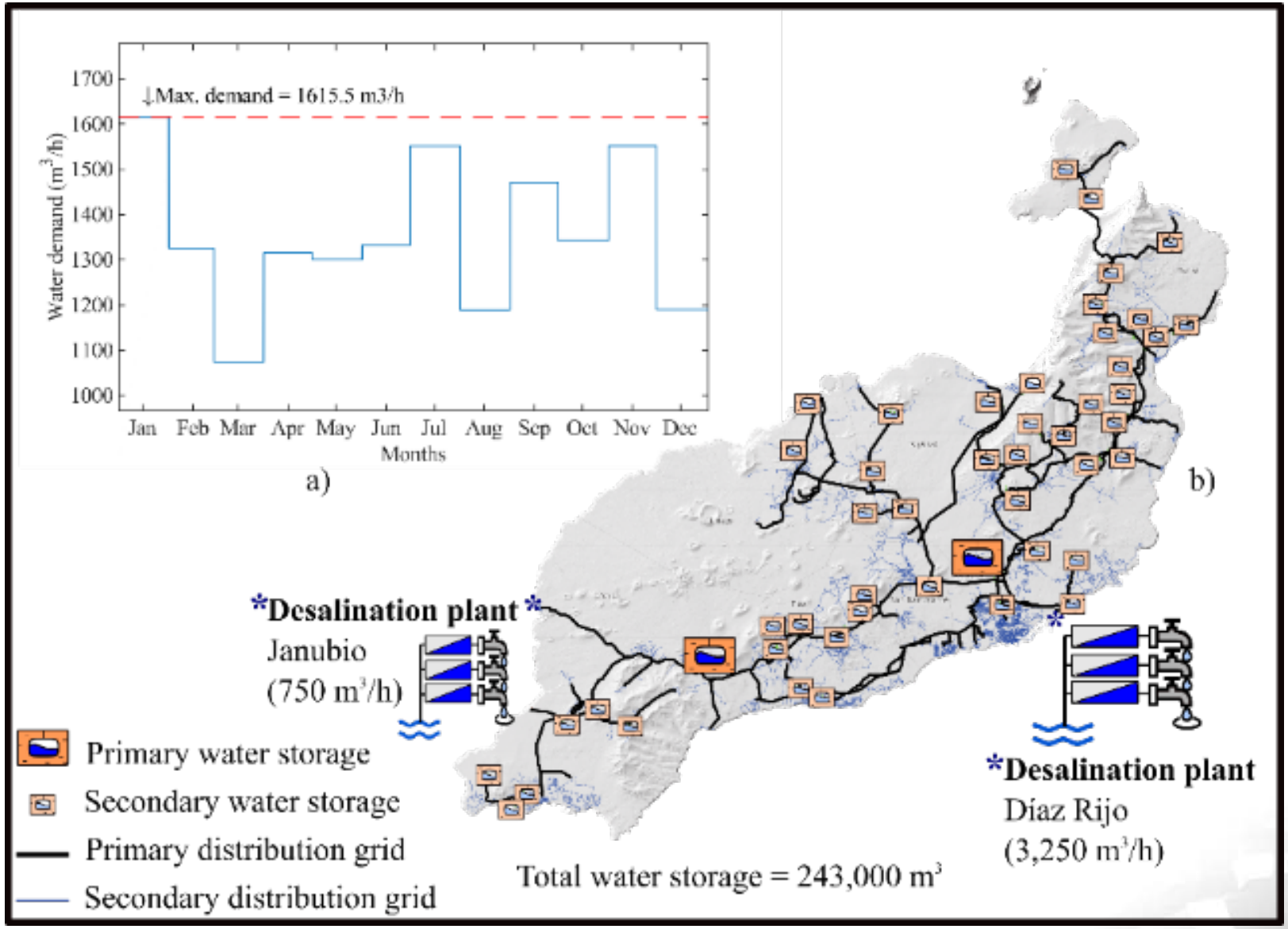
**GENERATING THE POPULATION OF FEASIBLE ENERGY-WATER SYSTEMS USING AN *EXHAUSTIVE SEARCH*** - An exhaustive search of water infrastructures and optimal renewable configurations is made to generate a set of optimal energy-water feasible solutions to be analysed in the following step..

**SELECTING THE BEST COMPROMISE ENERGY-WATER INFRASTRUCTURE USING A PARETO-BASED MULTI-OBJECTIVE OPTIMAL CRITERIA** - The results obtained in the exhaustive search performed in step 4 allow the selection of alternative infrastructures attending to different criteria (minimum CO2 emissions, minimum costs, maximum RES share of PES, etc.). A Pareto-based multi-objective optimal criteria is applied.

# *Smart Energy System* para incrementar la participación de renovables en el sector de la desalación

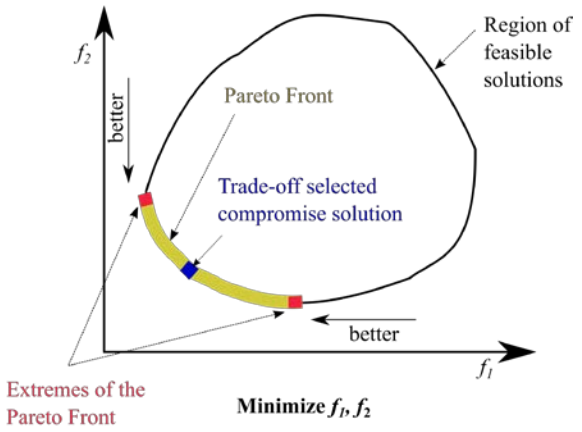
## Aplicación a la isla de Lanzarote

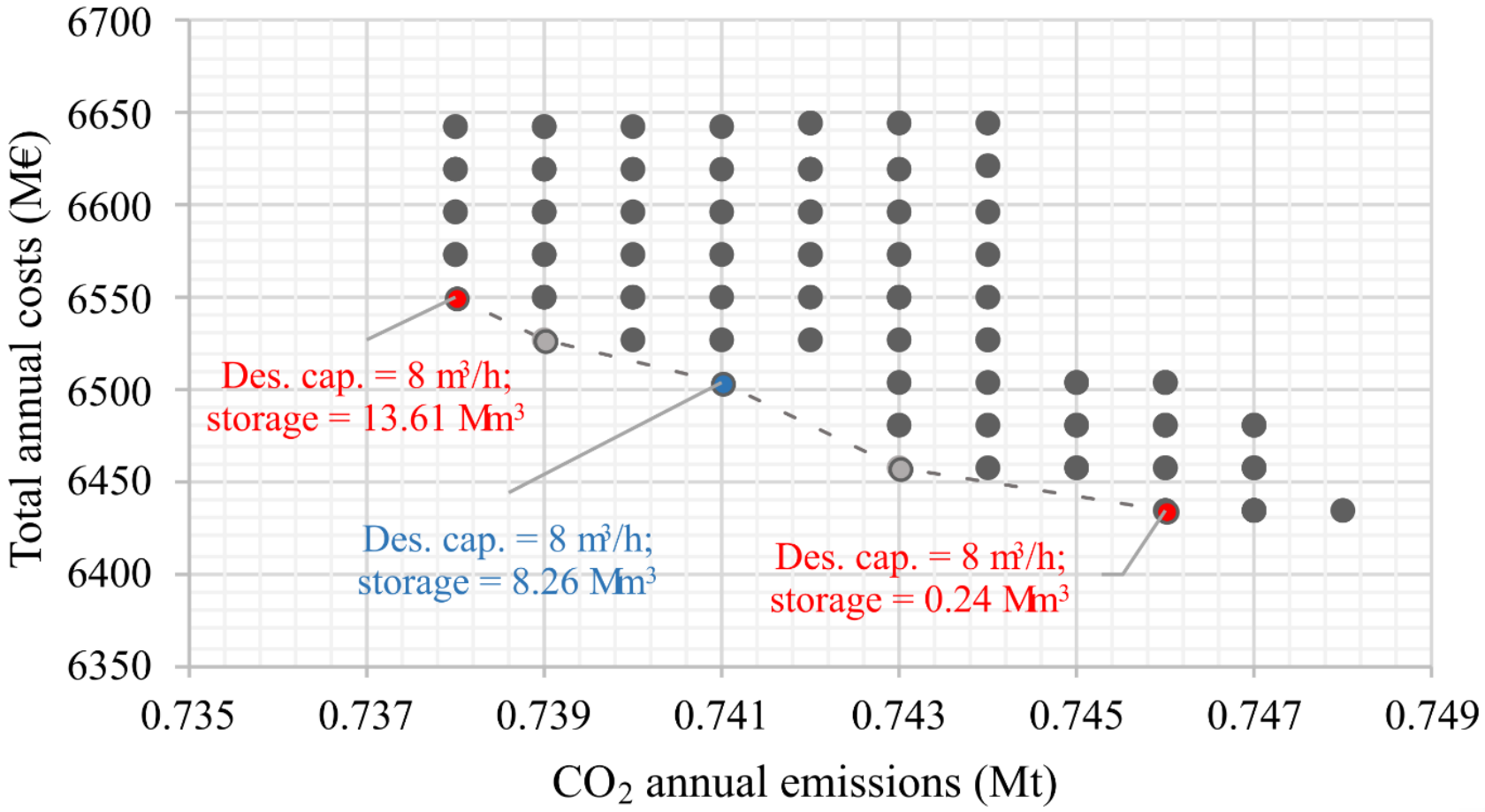

Wind
50.96 GWh
Solar
3.4 GWh
Oil
2175.7 GWh
Thermal Plants
37.77 GWh
816.23 GWh
Other electricity demands
Electricity demand in water system
92.13 GWh
Desalination
91 GWh
1.13 GWh
Fresh water demand
Non-metered
fresh water
consumption
Waste water*
43.84 GWh
(11.9 hm³)
47.16 GWh
(12.8 hm³)
1.13 GWh
(8.17 hm³)


Max. demand = 1615.5 m3/h
Water demand (m3/h)
1700
1600
1500
1400
1300
1200
1100
1000
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Months
a)
b)
*Desalination plant*
Janubio
(750 m3/h)
*Desalination plant
Díaz Rijo
(3,250 m3/h)
Primary water storage
Secondary water storage
Primary distribution grid
Secondary distribution grid
Total water storage = 243,000 m3

# *Smart Energy System* para incrementar la participación de renovables en el sector de la desalación

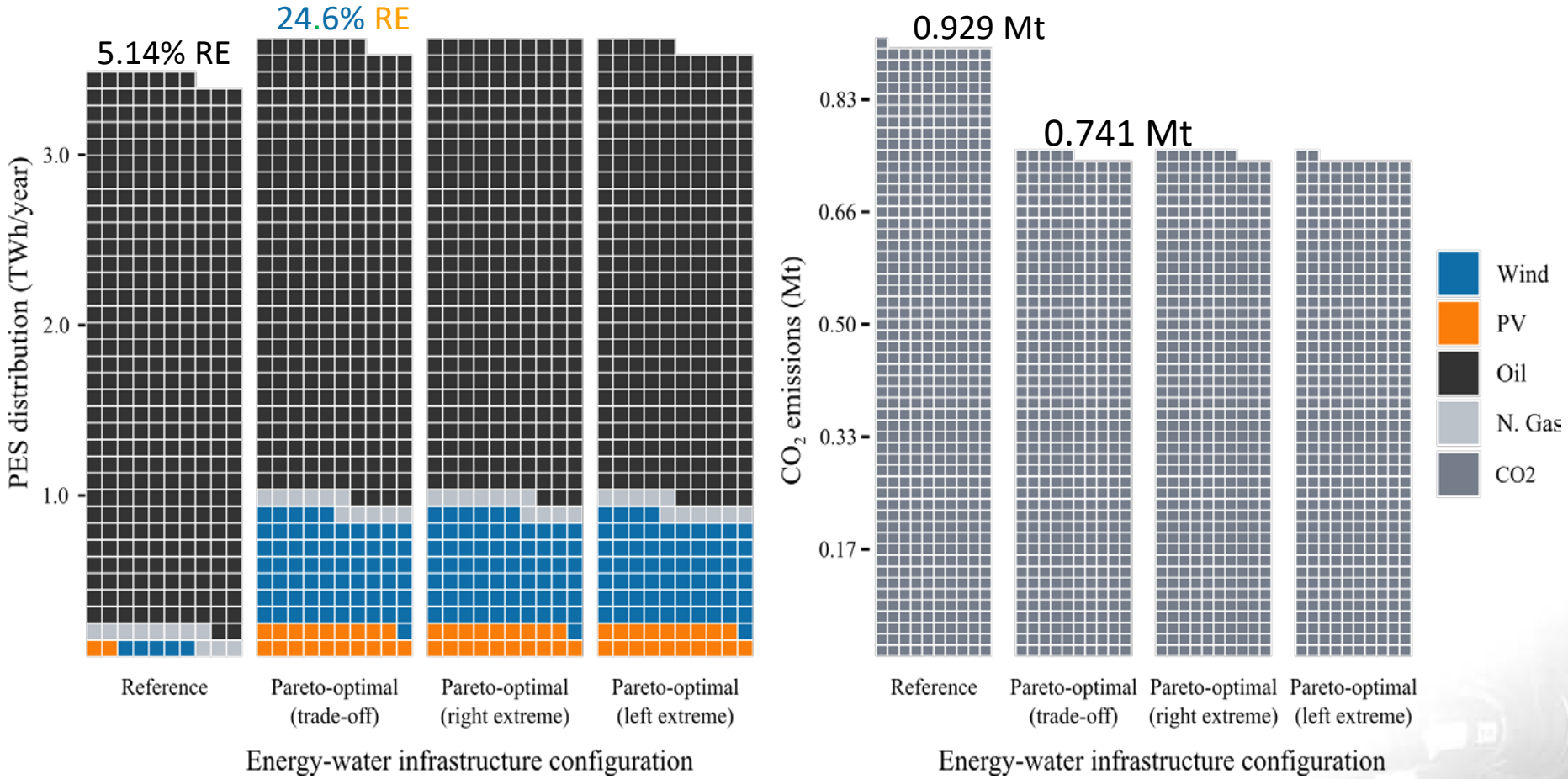
## Resultados


$f_2$
better
Region of feasible solutions
Pareto Front
Trade-off selected compromise solution
better
$f_1$
Extremes of the Pareto Front
Minimize $f_1, f_2$


6700
6650
6600
6550
6500
6450
6400
6350
Total annual costs (M€)
0.735
0.737
0.739
0.741
0.743
0.745
0.747
0.749
CO2 annual emissions (Mt)
Des. cap. = 8 m³/h;
storage = 13.61 Mm³
Des. cap. = 8 m³/h;
storage = 8.26 Mm³
Des. cap. = 8 m³/h;
storage = 0.24 Mm³

# PES distribution and $CO_2$ emissions

for the Pareto-optimal configurations and the reference scenario



# *Smart Energy System* para incrementar la participación de renovables en el sector de la desalación

## Conclusiones

# Conclusiones

El concepto *Smart Energy System* permite incrementar la participación de renovables en todo el sistema energético de una isla flexibilizando la desalación

La solución más apropiada –en términos de maximizar la contribución de renovables y reducir las emisiones de CO2, el uso de combustibles y los costes anuales– es un punto de equilibrio basado en el concepto de eficiencia de Pareto

El almacenamiento de agua como sistema de almacenamiento energético (cada $m^3$ de agua almacenado supone 3.5 kWh de energía) es esencial para este propósito

Energy Conversion and Management 235 (2021) 113982

Contents lists available at ScienceDirect

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journal homepage: www.elsevier.com/locate/enconman

# Large-scale optimal integration of wind and solar photovoltaic power in water-energy systems on islands

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ARTICLE INFO

*Keywords:*
Renewable energy integration on islands
Energy-water planning
Pareto multi-objective optimization
Energy-water synergies
Smart energy-water system approach

ABSTRACT

This paper presents a new method based on the Smart Energy System concept to link the water infrastructure and the energy system of an island. The principal aim of this study is to determine whether this new method can increase the contribution of renewables (wind power and photovoltaic) to the primary energy supply of the island. The method considers water production and treatment systems as flexible loads and explores a wide range of possible water supply infrastructures and PV/wind power combinations in the search for an optimal energy-water configuration. The final optimal solution is based on a balance between energy fuel needs and energy excesses, $CO_2$ emissions, oil consumption, minimization of total annual costs and maximization of the renewable contribution. The proposed method increased the contribution of renewables from 5.14% to 24.6%. This corresponds to, on average, over 35% of the hourly electricity demand throughout 2018 being covered by renewables, against the current 6.6%. The study reveals that wind technology integration is of fundamental importance for renewable exploitation in insular water-energy systems, with wind energy contributing more than 70% of the renewable participation in this case study.

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Gobierno de Canarias

ULPGC

Universidad de La Laguna

PLOCAN Plataforma Oceánica de Canarias

Gobierno de Canarias
Consejería de Economía, Industria, Comercio y Conocimiento
Agencia Canaria de Investigación, Innovación y Sociedad de la Información

aream

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