Canary Island Institute of Technology, S.A

Renewable Energies department

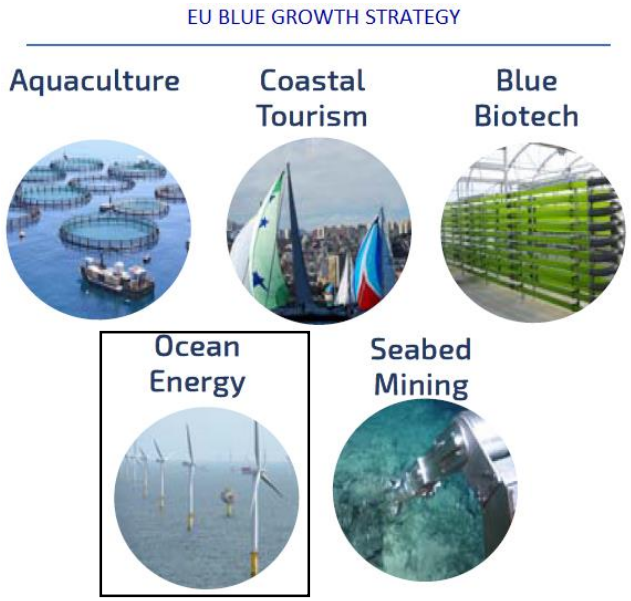
Climate Change and adaptation plans for African countries and insular electrical systems (SOCLIMPACT, ACLIEMAC & ENERMAC).

ECREEE
Towards Sustainable Energy

itc INSTITUTO TECNOLÓGICO DE CANARIAS

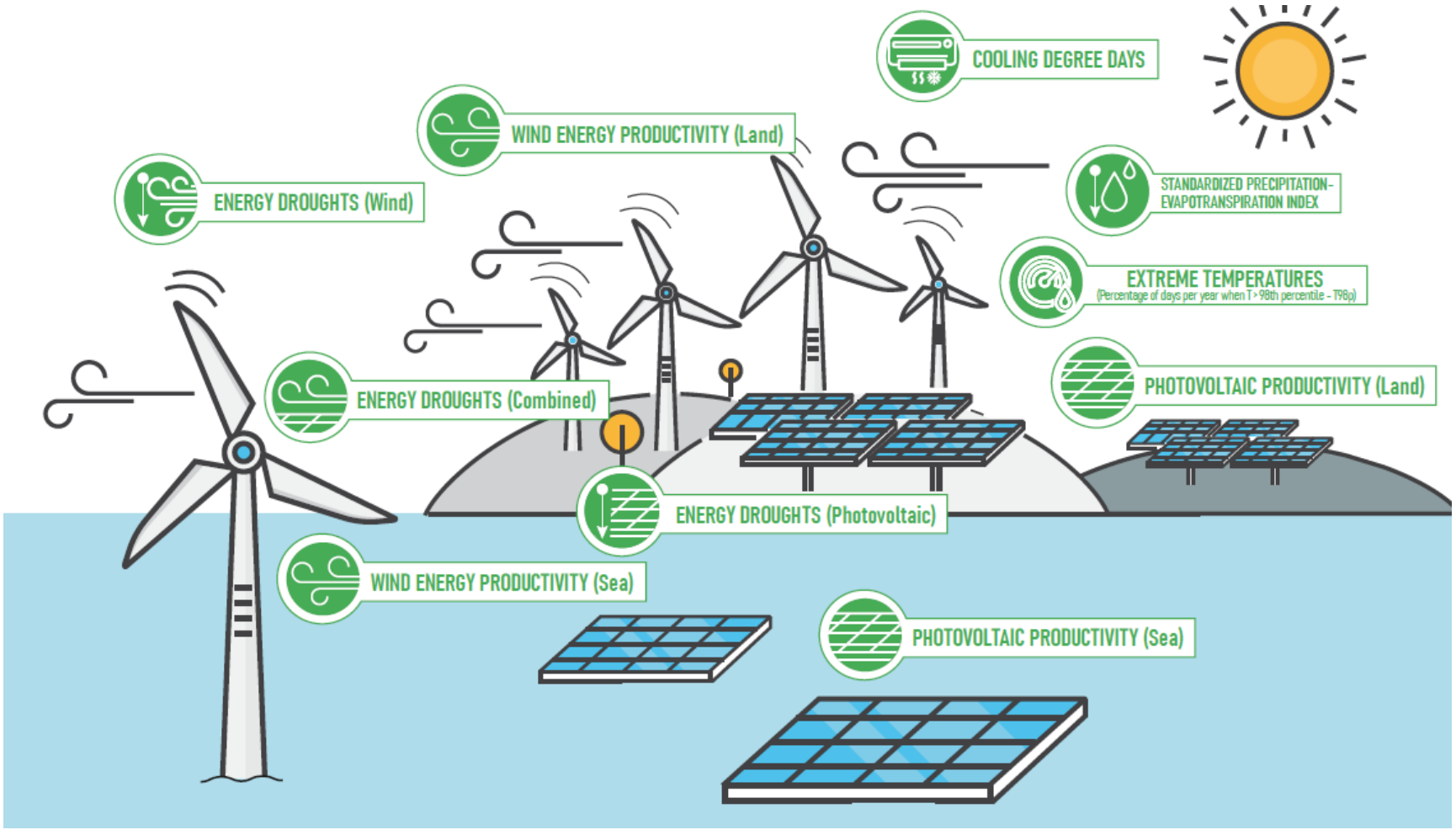
Gobierno de Canarias

SOCLIMPACT – H2020



Goals:

- Based on **Renewable Energies** and **Circular economy**.
- Provide **sustainable, social and economic development**.
- Protect and **maintain the diversity, productivity and resilience of marine ecosystems**.



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Climate Change Scenarios

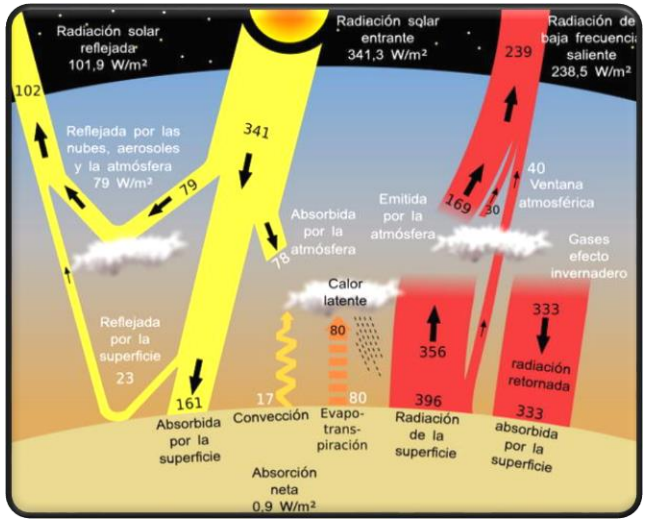
IPCC

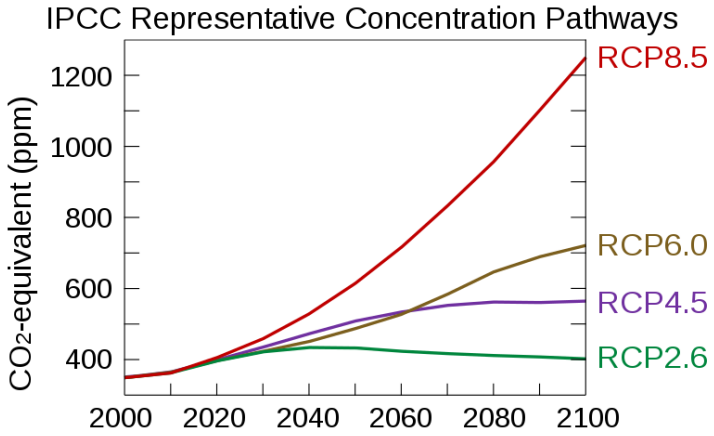
United Nations intergovernmental organization whose objective is to provide objective information on Climate Change and its consequences.

Fifth Evaluation Report IPCC (2014)

RCP

- They formulate **4 climate change scenarios.**
- These scenarios have a different level of concentration of **Greenhouse Emissions.**
- Labelled according to **degree of radioactive forcing (W/m2).**





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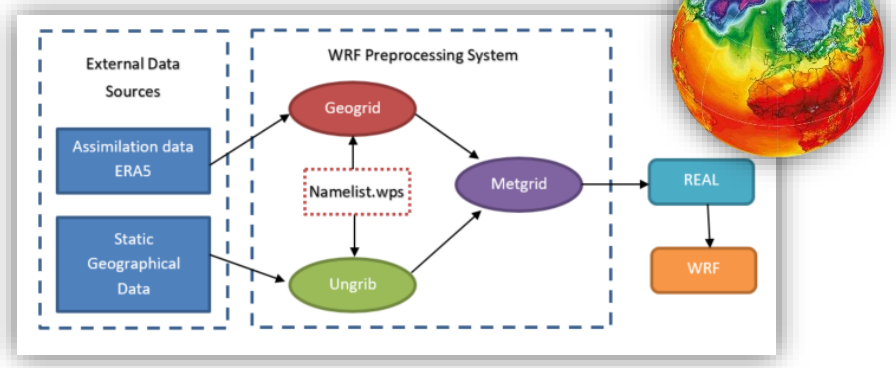
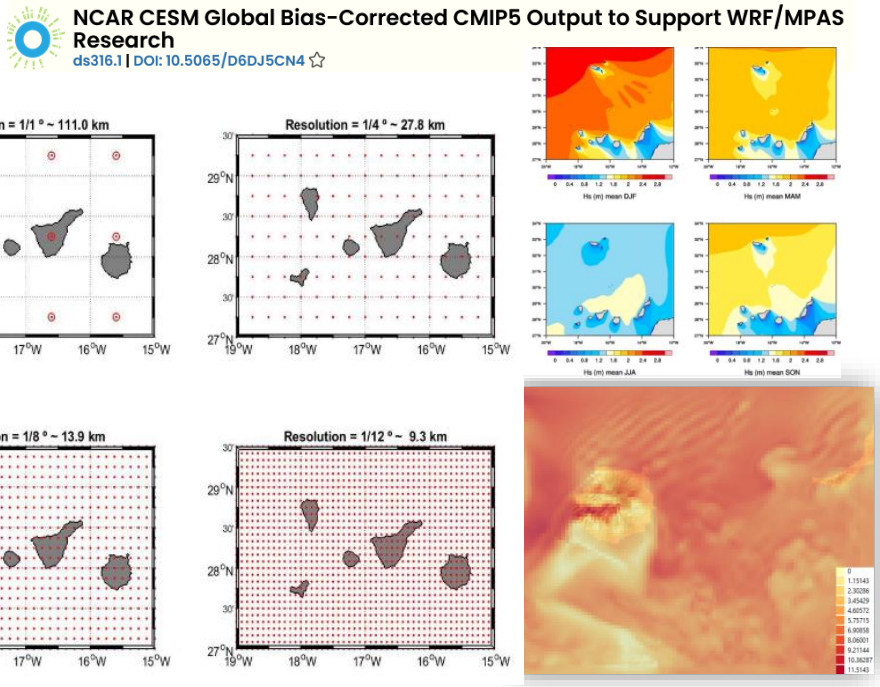
Climate Change Modelling

Modelo WRF+CESM6
(Community Earth System model)





Impact Chains

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CLIMATE VARIABLE

for Canary Islands

Temperature

OBSERVED

	SEA LEVEL	PICO DEL TEIDE
Annual average	20° - 21°	below 4°
Maximum	24°	below 10°
Minimum	18° *Slightly bellow in Fuerteventura and Lanzarote	below -2°

PROJECTED

	RCP 2.6 -4.5		RCP 6.0	RCP 8.5	
Annual average	2100 ↑ 1° - 1.44°		↑ 2°	↑ 2.68°	
Maximum	2045-2054 ↑1° to 1.8°	2090-2099 ↑2° to 2.5°		2045-2054 ↑1° to 1.8°	2090-2099 ↑3° to 4.5°
Minimum	2045-2054 ↑ 0.5° to 2°			2045-2054 ↑ 0.5° to 2°	

Increase in annual average **air temperature**

Increase in sea level

WILL RISE

FROM

- 15CM TO 30 CM by 2100 — under RCP 2.6
- 40CM TO 70 CM by 2100 — under RCP 8.5

Precipitation

ANNUAL AVERAGE

Specially in MOUNTAIN AREAS with larger annual rainfall

Winter precipitation is **more relevant** for total precipitation

Results are only statistically **significant for small areas** in the islands.

SEASONAL PRECIPITATION

	RCP 2.6	RCP 4.5-6.0	RCP 8.5
Annual average	↓ 10 ± 5%	↓ 19 ± 4% to 24 ± 5%	↓ 37 ± 5%

This reduction maybe related with a migration of the Azores high-pressure system in a warmer climate

Decrease in annual precipitation; decrease in winter precipitation

Formulation of impact chains in the field of energy

HAZARD

Climate variability and climate change

- Frequency & intensity of Extreme events
- Wind
- Waves
- Temperature
- Humidity
- Ocean temperature
- Solar radiation
- Drought
- Flood
- Dust

RISK

- Change in marine power generation
- Change in conventional power generation
- Damages to transmission lines
- Damages to distribution lines of sea cables
- Damages to substations
- Change in electricity consumption
- Increase in air conditioning and cooling
- Increase water demand and desalination

IMPACTS

Socio-economic & environmental

- Increase in investments
- Increased maintenance cost
- Risk of black out
- Loss in quality and guarantee of power supply
- Increased energy cost for all economic sectors

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Impact Chains

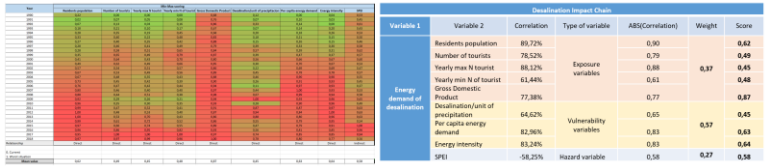
Impact Chain: Desalination

Weights:

- ✓ Ponderación por grupo de variables:
  - Hazard.
  - Exposure.
  - Vulnerability.
- Uso de correlaciones lineales como referencia en la estimación de pesos.

Scores:

- ✓ Un score por variable.
- ✓ **Min-Max scoring**:
  - Valor comprendido entre 0 - 1.
  - Z scores fue testeado. No válido (múltiples escalas).
  - Se testean nuevas alternativas.



Desalination Impact Chain

Variable 1	Variable 2	Correlation	Type of variable	ABS(Correlation)	Weight	Score
Energy demand of desalination	Residents population	89,72%	Exposure variables	0,90	0,37	0,62
	Number of tourists	78,52%		0,79		0,49
	Yearly max N tourist	88,12%		0,88		0,45
	Yearly min N of tourist	61,44%		0,61		0,48
	Gross Domestic Product	77,38%		0,77		0,87
	Desalination/unit of precipitation	64,62%	Vulnerability variables	0,65	0,57	0,45
	Per capita energy demand	82,96%		0,83		0,63
	Energy intensity	83,24%		0,83		0,64
	SPEI	-58,25%	Hazard variable	0,58	0,27	0,58

HAZARD

Standardised precipitation-evaporation index (SPEI)

EXPOSURE

- Residents population
- Number of tourists
- Tourism seasonality (yearly max. and min.)
- Percentage of desalinated water with respect to total water

RISK

Increased energy demand due to increased desalination/pumping needs

VULNERABILITY

- Per capita energy demand
- Energy intensity
- Purchasing power for increased consumption (per capita GDP)
- Demand side management

Factors of sensitivity

Factors of adaptive capacity

Impact Chain: Cooling

HAZARD

Cooling degree days (CDD)

EXPOSURE

- Residents population
- Number of tourists
- Tourism seasonality (yearly max. and min.)
- Cooling penetration rate

RISK

Increased energy demand due to increased cooling demand

VULNERABILITY

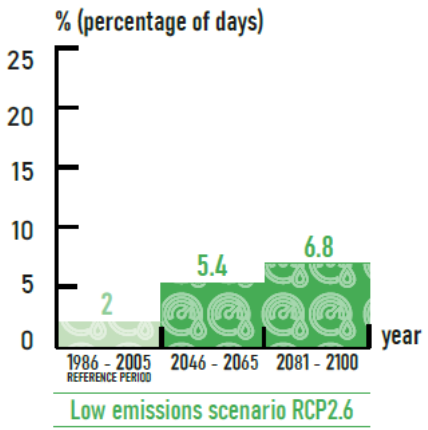
- Per capita energy demand
- Energy intensity
- Purchasing power for increased consumption (per capita GDP)
- Demand side management
- Availability of energy strategy for temperature increases

Factors of sensitivity

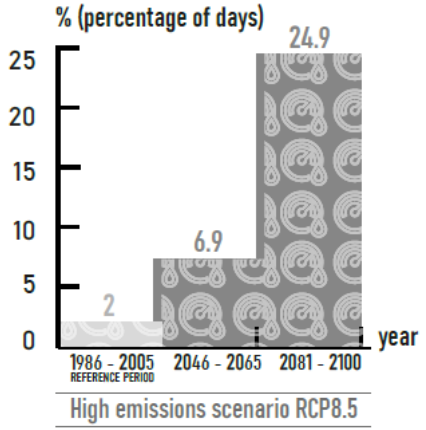
Factors of adaptive capacity

Consequences of the current model

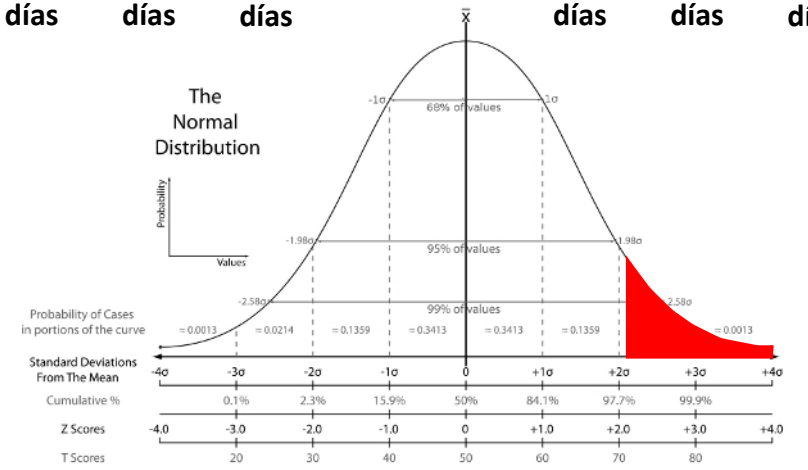
EXTREME TEMPERATURES
(Percentage of days per year when T > 98th percentile - T98p)



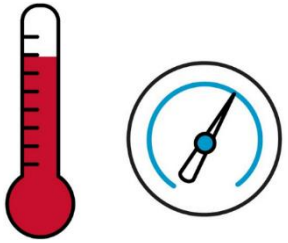
7 días | 20 días | 25 días



7 días | 25 días | 90 días



Increase in annual average of air temperatures



Low emissions scenario RCP2.6

Ref (1986-2005)	*(2046-2065)*	*(2081-2100)*
94.42 CDD	143.14 CDD	170.05 CDD
195.99 GWh/year	309.01 GWh/year	315.84 GWh/year
		61%

High emissions scenario RCP8.5

Ref (1986-2005)	*(2046-2065)*	*(2081-2100)*
186.72 CDD	395.66 CDD	665.24 CDD
504.06 GWh/year	1178.40 GWh/year	1839.99 GWh/year
		265%

	(2046-2065)	*(2081-2100)*
Low emissions scenario RCP2.6	SPEI -1.4 1749.38 GWh/year	SPEI -1.5 1794.24 GWh/year 60%
High emissions scenario RCP8.5	SPEI -2.1 2063.38 GWh/year	SPEI -2.4 3428.79 GWh/year 206%

Present time: SPEI 0 1121.40 GWh/year

Legend SPEI : Normal (-1 to 1) | Medium Dry (-1 to -1.5) | Very Dry (-1.5 to – 2) | Extremely Dry (<=-2)

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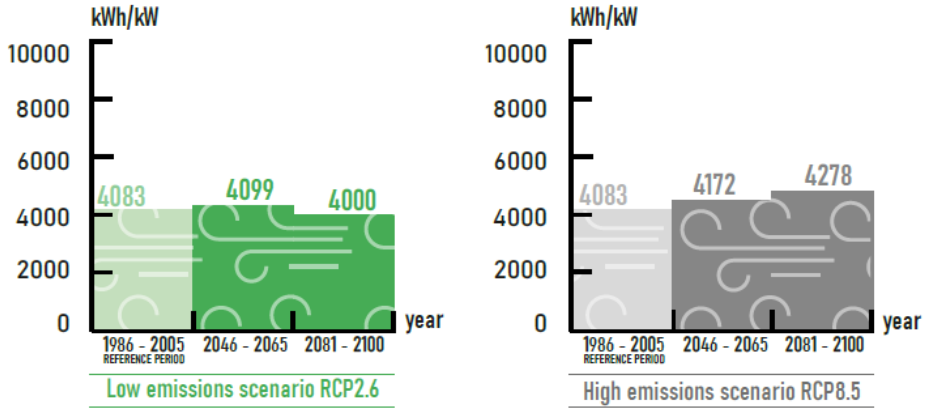
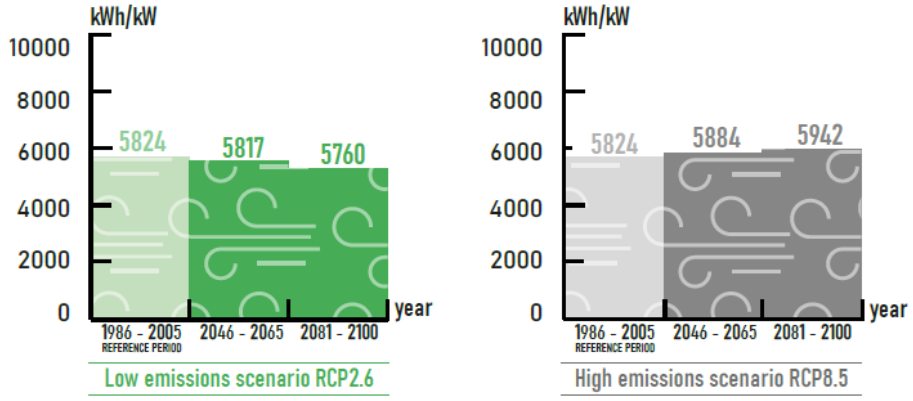
Consequences of the current model

WIND ENERGY PRODUCTIVITY (LAND)



WIND ENERGY PRODUCTIVITY (SEA)

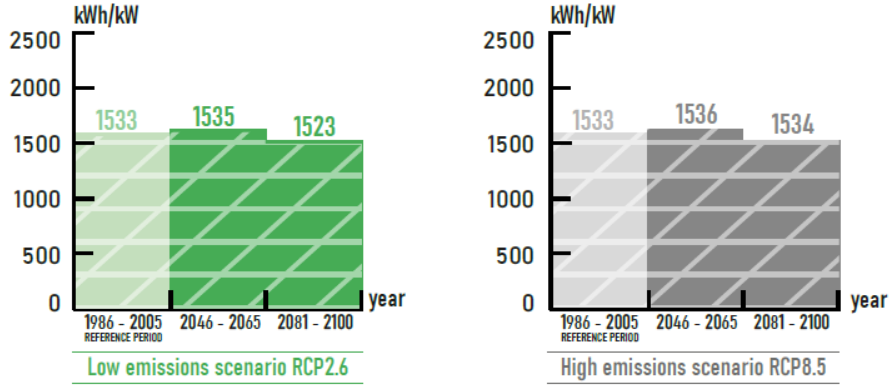


Wind farms

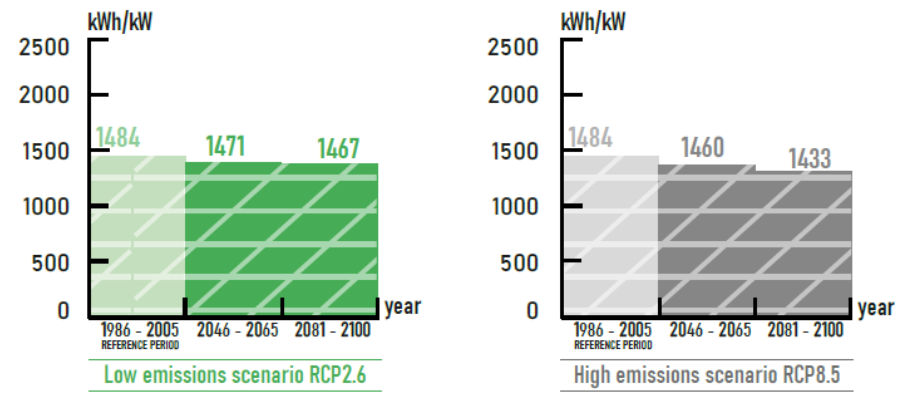
RCP2.6 → Reduction:
- **Onshore: 2,0%**
- **Offshore: 1,2%**

RCP8.5 → Increase:
- **Onshore: 4,8%**
- **Offshore: 2,1%**

PHOTOVOLTAIC PRODUCTIVITY (LAND)



PHOTOVOLTAIC PRODUCTIVITY (SEA)



Photovoltaic plants

RCP2.6 → Reduction:
- **Onshore: 0,7%**
- **Offshore: 1,1%**

RCP8.5 → Reduction:
- **Onshore: 1,1%**
- **Offshore: 3,4%**

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RES as a main mitigation plans

From the technical point of view different alternatives are currently available.

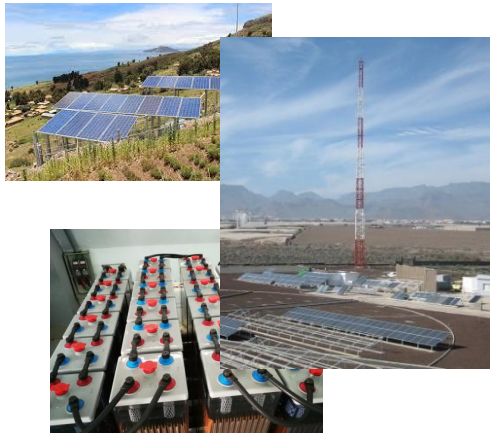
Electric System | **Land Planning** | **Economic-Administrative issues**

Strategy for maximizing RES penetration

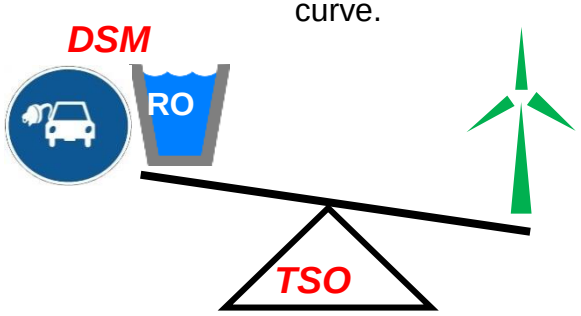
- **Grid stability analysis**
- **Forecasting wind and solar**
- **Demand Management**
- **Energy storage**
- **Distributed generation**

Security and reliability | Market - Risk analysis | Planning | Scheduling

Development of **integration scenarios of distributed generation and energy storage associated** with the energy demand of rural and urban areas as well as industrial and service areas.



Through DSM and Demand Response (DR) the Transmission System Operator (TSO) adjust load power consumption to variable RES power generation, and dispatchable non-critical loads are put to full operation capacity at valley hours of the electric demand curve.



Energy storage capacity is essential to maximize RES penetration in small and weak electrical grids.

- Solutions to store surplus RES in peak hours to feed into the grid in peak demand.
- Energy carriers for the use of RES in transport.

Main Characteristics of ACLIEMAC

- Project approved 2nd Interreg MAC 2014-2020 call.
- Code: MAC2/3.5b/380.
- LINE 3: Promote adaptation to climate change and risk prevention and management.
- Investment Priority 5b : Promotion of investment to address specific risks, guarantee of resilience to disasters and development of catastrophe management systems.
- Action regions: Madeira, Azores, Senegal, Mauritania, Cape Verde and Canary Islands.
- Duration: 36 months (3 years).

PARTICIPATING ENTITIES	
ITC - Instituto Tecnológico de Canarias, S.A. (Beneficiario prinicipal)	Canarias
ULPGC - Universidad de Las Palmas de Gran Canaria	Canarias
AREAM - Agência Regional da Energia e Ambiente da Região Autónoma da Madeira	Madeira
ULL - Universidad de La Laguna	Canarias
CIVISA - Centro de Informaçao e Vigilância Sismovulcânica dos Açores	Azores
CEICC - Consejería de Transición ecológica y lucha contra el cambio climático (GobCan)	Canarias
COIICO - Colegio Oficial de Ingenieros Industriales de Canarias Oriental	Canarias
Federación BEN MAGEC - ECOLOGISTAS EN ACCIÓN	Canarias
FECAM - Federación Canaria de Municipios	Canarias
CIEGC – Consejo Insular de la Energía de Gran Canaria	Canarias
UNICV - Universidade de Cabo Verde	Cape Verde
UNA - Universidad de Nouakchott Al Aasriya	Mauritania
AEME - Agence pour l'Economie et la Maitrise de l'Energie	Senegal

Main goal and activities

The main objective of the project is to **increase the autonomy and energy independence of the participating regions**, so that if there were **extreme phenomena caused by climate change**, they have sufficient response capacity to guarantee the energy supply to their inhabitants.

Activity 1- Preparation

Activity 2- Execution

- **Specific objective 2.1 - Climate change adaptation of energy infrastructure**
  - Activity 2.1.1 Diagnosis of the current energy model. Risk study and prevention of energy infrastructure.
  - Activity 2.1.2 Distributed generation, self-consumption and energy storage systems.
  - Activity 2.1.3 Adaptation of electrical infrastructure to climate change.
- **Specific objective 2.2 - Adaptation to climate change in energy production and supply through the exploitation of new economies**
  - Activity 2.2.1 Circular Economy Energy recovery of the organic fraction of waste and others.
  - Activity 2.2.2 Blue economy. Marine Renewable Energy Development.
  - Activity 2.2.3 Low carbon economy Empowerment of renewable energies and energy efficiency.
- **Specific objective 2.3 - Environmental awareness to achieve greater adaptation of energy consumption to climate change**
  - Activity 2.3.1 Climate change adaptation of large consumers.
  - Activity 2.3.2 Climate change adaptation of buildings.
  - Activity 2.3.3 Adaptation to climate change at the local level.

Activity 3- Coordination

Activity 4- Communication

Mitigation plans

- **Climatic scenarios. Mesoscale model execution**. Projection of different climatic scenarios on the 2030, 2050 and 2100 time horizons.
- **Risk and vulnerability analysis of the current energy model**, and how it can affect the effects of climate change in response to the scenarios analysed for 2030.
- Adaptation plan of the **electrical infrastructure** against the effects of climate change.
- Economic valuation of the effects caused and the measures to be implemented on the electrical infrastructure to adapt them to the possible effects caused by climate change.
- Development of **integration scenarios of distributed generation and energy storage associated** with the energy demand of rural and urban areas as well as industrial and service areas.
- Study of **risks and vulnerabilities of waste** management and treatment.
- Analysis of the contribution to the **energy self-supply of Syngas and methanol** obtained from the initial gasification of waste.
- Analysis of the contribution to energy **self-supply of biogas**, bio-DME and methanol obtained from organic waste subjected to anaerobic digestion.

Mitigation plans

- **Technical-economic feasibility study of the installation** of an existing prototype of a wave energy converter to evaluate its integration into the energy mix of the Canary Islands.
- Climate change adaptation plan in the **transport sector** through diversification and commitment to alternative fuels.
- **Expansion of the biomethane pilot plant in Gran Canaria, biogas plant in Senegal.**
- **Development of a solar thermal kit for teaching purposes.**
- **Preliminary draft of a cogeneration system in a rice husking plant in Senegal.**
- **Initial study of an air conditioning system with photovoltaic energy in a school in Senegal to increase its resilience.**
- **Integration study of linear focus solar technology in reference industries in the Canary Islands and Cape Verde as a measure of adaptation to climate change.**
- **Training seminars** for Senegal, Mauritania and Cape Verde technicians in face-to-face and on-line energy efficiency.

Main Characteristics of ENERMAC

The project aims to develop actions that contribute to ...

MAXIMIZE the use of renewable and indigenous energy sources, in order to reduce the energy dependence and promote the sustainable development of Macaronesia Islands and West Africa.

CREATE a network of excellence where the knowledge generated among the participating regions is shared, fostering the training and exchange of research personnel, in order to multiply the impact of the know-how acquired on renewable energies.

Specific Objective 2.1 – Energy Planning

- **Activity 2.1.1** Marine and terrestrial EERR infrastructures
- **Activity 2.1.2** Low carbon mobility
- **Activity 2.1.3** Modelling for the optimization of energy planning

Specific Objective 2.2 - Rational Use of Energy

- **Activity 2.2.1** Integration of solar heat in industrial processes
- **Activity 2.2.2** Biomass: waste energy recovery
- **Activity 2.2.3** Energy Efficiency

Specific Objective 2.3 - Analysis of Electrical Networks and Microgrids

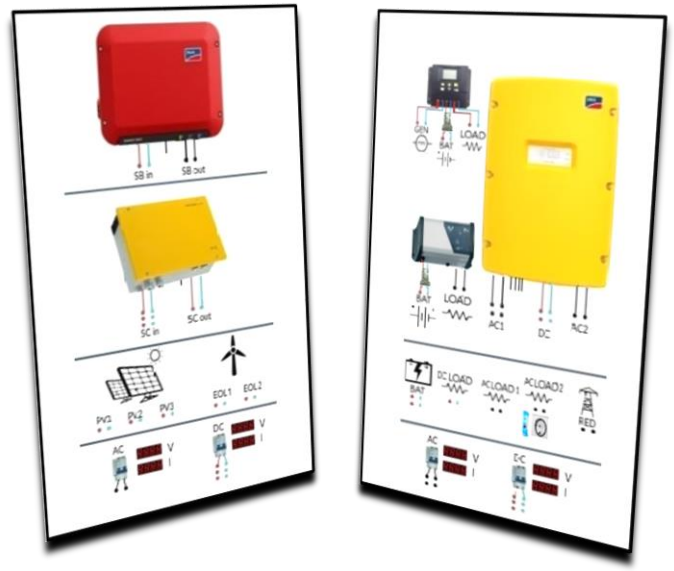
- **Activity 2.3.1** Grid studies of electrical systems
- **Activity 2.3.2** Optimization of the penetration of renewable energy networks
- **Activity 2.3.3** Design, implementation and operation of microgrids

Beneficiary participating entities of the FEDER	
ITC - Instituto Tecnológico de Canarias, S.A. (Jefe de Fila)	Canary Islands
AREAM - Agência Regional da Energia e Ambiente da Região Autónoma da Madeira	Madeira
ULPGC - Universidad de Las Palmas de Gran Canaria	Canary Islands
ULL - Universidad de La Laguna	Canary Islands
MITI - Madeira Interactive Technologies Institute-Associação	Madeira
COAGC - Colegio Oficial de Arquitectos de Gran Canaria	Canary Islands
Consejería de Economía, Industria, Comercio y Conocimiento del Gobierno de Canarias	Canary Islands
DRET - Direção Regional da Economia e Transportes	Madeira
FECAM - Federación Canaria de Municipios	Canary Islands
Cabildo Insular de El Hierro	Canary Islands
Cabildo Insular de Lanzarote	Canary Islands
UNICV - Universidade de Cabo Verde	Cape Verde
UNA - Universidad de Nouakchott Al Aasriya	Mauritania
DGECV - Direção Geral da Energia	Cape Verde

Main goals and activities of ENERMAC

Design and installation of a RES Laboratory for UNICV

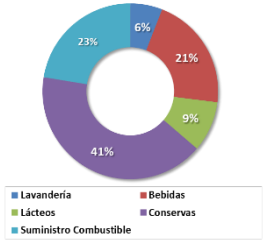
The **main objective** of this Task is to design a **Renewable Energy Laboratory**, which enables to implement the most common topologies of Micro-Grids.



The Renewable Energy Laboratory will be made up of:

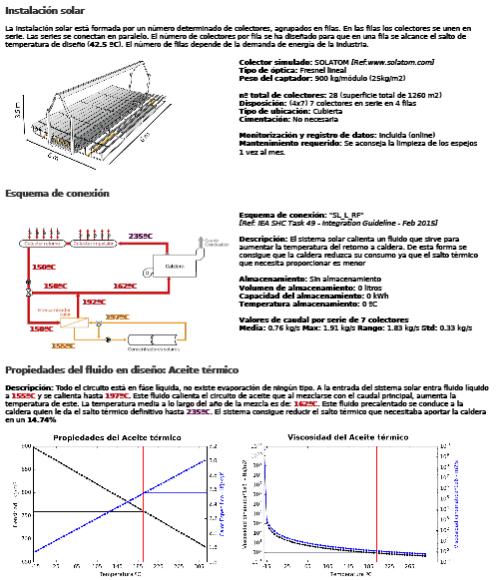
- PV power plant
- 2 small wind turbines
- Lead Acid batteries
- Solar inverter
- Battery Charger
- Battery Inverter
- Charge regulator
- Bidirectional Charger/Inverter
- AC and DC loads

Solar heat integration in industrial processes of Cape Verde



The thermal energy demand of the Cape Verde industries is **72%** of the total heat demand.

Industria	Tipo de combustible	Consumo (MWh)
1. Lavado de ropa	Fuel 180	1.630
2. Fabricación de bebidas	Fuel 180	5.824
3. Fabricación de conservas 1	Gasóleo	396
4. Fabricación de conservas 2	Fuel 180	10.996
5. Fabricación de productos lácteos	Gasóleo	1.394
6. Fabricación de bebidas y lácteos	Gasóleo	1.176
7. Fabricación de jabones	Fuel 180	443
8. Suministro de combustibles 1	Fuel 380	3.364
9. Suministro de combustibles 2	Fuel 380	2.826
TOTAL		28.050

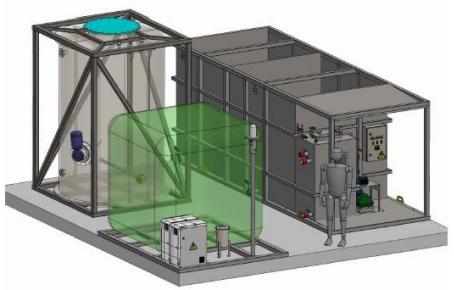


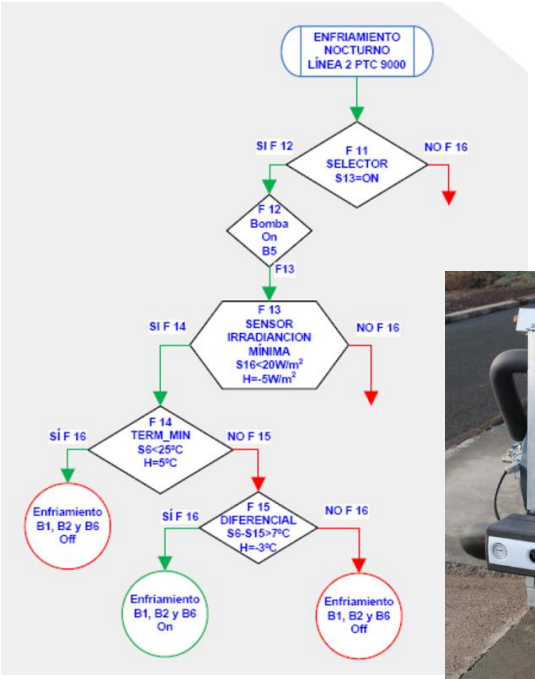
Results of ENERMAC

Installation of a biogas plant in Mauritania

Design, manufacturing and commissioning of a biogas plant for the Faculté des Sciences et Techniques (FST) de l'Université de Nuakchot Al Aasriya (UNA).

The system has been already designed and manufactured.





Custom built solar thermal system for training activities

Design, manufacturing and delivering of a custom built solar thermal system with the capacity to register data on solar radiation, temperature and flow and to reproduce conditions and possible operational failures of the equipment under real conditions. It has been sent to University of Cape Verde in December 2018.

Canary Island Institute of Technology, S.A

Renewable Energies department

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SOCLIMPACT

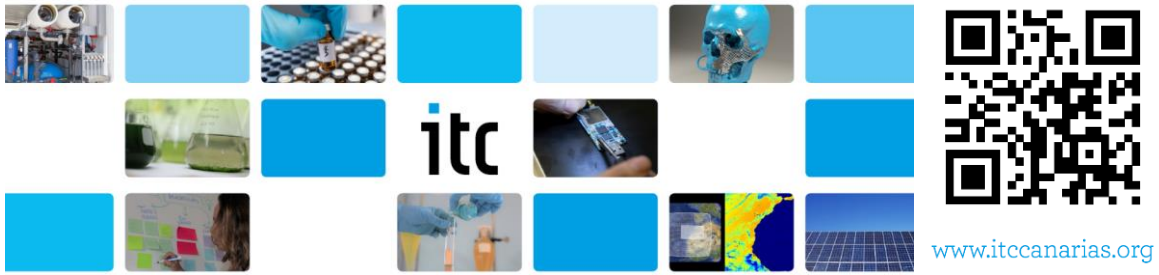
ACLIEMAC
Adaptación al Cambio Climático de los Sistemas Energéticos de la Macaronesia

ENERMAC

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No776661

MAC 2014-2020 Cooperación Territorial

Interreg



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