

## Instituto Tecnológico de Canarias (ITC)

Gonzalo Piernavieja R&D&I Director



Erasmus+ Programme

REGIONAL ONLINE TEACHING &TRAINING ON RENEWABLE ENERGY TECHNOLOGIES FOR PROFESSIONNALS, PRACTICIONNERS AND UNIVERSITIES IN ECOWAS MEMBER STATES

UniPiaget

13-16 OCTOBER 2020

The Canary Islands as platform for the development of green energy technologies and transfer to the African continent



ANDE DESCRIPTION



Canary Islands Institute of Technology Technology and Innovation for a Sustainable Development

### The Canary Islands Institute of Technology (ITC)

- Renewable Energies and Energy Efficiency
- Sustainable Water Technologies
- Algae Biotechnology
- Enviromental Analysis (pollution prevention)
- Computing & ICTs
- Biomedical Engineering (customized implants)







- International Cooperation (above sectors; focus: West Africa)
- Innovation & Entrepreneurship

### www.itccanarias.org







RENEWABLE ENERGIES Department



## Canary Islands Institute of Technology (ITC)

Technology and Innovation for a Sustainable Development





### **Background:** Energy Singularities of the **Canary Islands**

- 2.2 mill. inhabitants; approx. 15 mill. tourists/year
- Isolated (insular) electrical systems
- Lack of water resources
- Significant weight of the transport sector
- Importance of the water-energy nexus (desalination)
- Insular dimension: strategic need to
  - reduce (the still high) external dependence on fossil fuels and diversify the energy mix
  - maximise the use of endogenous renewable energy resources

### **RENEWABLE ENERGIES** Department







# Goal: To maximize Renewable Energy penetration in insular and isolated regions

- Overcoming technical (and administrative) barriers
- Positioning the Canary Islands as a reference experimental platform of renewable Energies and
- Making use of the vision "Canary Islands = Natural (living) Lab for sustainable energy technologies"
- Transferring technology to less developed regions

#### **ITC Renewable Energies**

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+ **30 highly qualified engineers and scientists** specialized in several energy related areas



Technological activity in current trends of the renewable energy sector; Outstanding technological facilities

# **RENEWABLE ENERGIES Department**

Participation in more than 300 initiatives

(R&D& projects + technological and

consultancy services)

+ 25 years experience developing know-how and technology in renewable energies

**Participation in many transnational/international cooperation activities** (West Africa, Europe, RoW (focus: islands and remote/rural areas of less developed regions))





- > Assessment of renewable energy resources
- > Design and development of energy generation systems
- > Design and implementation of energy storage systems
- Analysis of energy transmission and distribution networks (vs. integration of variable renewables)
- > Energy efficiency and saving, demand management
- Energy Planning, techno-economical feasibility studies of energy projects
- > Development and testing of renewable energy systems components and complementary technologies

**ITC Renewable Energies** 

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#### **Assessment of Renewable Energy Resources**

Mapping of renewable energy resources (wind, solar, biomass, ocean energies) using numerical techniques and GIS

**Development of forecasting tools** of meteorological parameters, renewable power, electrical demand and other variables which affect electrical system operation, for different horizons and time resolutions

Geolocalization of heating and cooling demand in urban areas and development of energy demand density maps

### Design and Development of Energy Generation Systems

**Design and development of renewable energy generation systems** (on- and off-shore wind, solar termal and PV, ocean Energies, biomass, ...)

**Optimization of existing renewable energy generation systems** (monitoring, repowering, certification, re-conditioning)

**Design and development of distributed generation systems** (micro- and mini-grids, hybrid systems (incl. energy storage))







#### Design and Development of Energy Storage Systems

**Design and development of electrochemical, thermal and pumped storage systems** for energy applications and to provide complementary adjustment services to the electrical system

**Design and development of energy management systems** for optimum energy storage operation and extension of its lifetime

#### Analysis of Transmission and Distribution Networks

Analysis and mathematical modelling of electrical infrastructures for the development of electrical systems power studies

**Development of studies for the integration of (variable) renewables** in distribution networks and assessment on the necessary additional hardware to provide ancillary grid services

**Provision of technical assistance** to fulfill the requirements of the grid operator in renewable energy integration





#### Energy efficiency and saving, demand management

**Design and development of energy management systems (EMS)** to adapt the renewable energy resource to the applicable tariff

**Development of demand management solutions** associated to manageable loads, incl. process automatization

**Deployment of Smart Grid and ICT network solutions** for a coordinated real time management

Modelling of thermal loads for minimization of energy consumption in buildings

#### **Energy (Systems) Planning, Feasibility Studies**

Development of Energy Planning studies and strategies (different levels) Development of techno-economical feasibility projects of energy projects Assessment and promotion of energy saving and energy effciency strategies





# Development and testing of renewable energy systems components and complementary technologies

Test of renewable energy systems components

**Development of electronic devices** for renewable energy systems' optimization

Assessment and analysis of resources of organic origin for the development of biorefinery

concepts



- > Power Electronics Laboratory
- > Solar Thermal Collectors Testing Laboratory
  - > Distributed Generation Laboratory
- > Biomass Laboratory and Biodiesel Production Plant

- > Renewable Hydrogen Facilities
- > 800 m<sup>2</sup> Workshop
- Experimental Microgrid that integrates wind, PV, hydrogen systems, batteries, desalination plants, EV charging points, etc.

### **Pozo Izquierdo Facilities (Gran Canaria)**

#### **ITC Renewable Energies**

**Technological** 

Infrastructure



- > Equipment for solar thermal and PV systems testing, incl. performance/quality control
- > Advanced Solar Radiation and Wind measurement equipment
- 125 kVA Grid simulator, inductive/resistive loads, and equipment for micro-, mini-grids analysis
  - > Inverter test bench
  - Equipment for battery analysis and monitorization
    - Power/Grid Analysers

- > Electric and Hydrogen Powered Vehicles
- > Solar absortion cooling system

#### SOFTWARE

- > PSS©/E: electrical grid (stability) analysis
- > TRNSYS: thermal energy systems modelling
- Variety of programs/software packages (incl. own/customized developments) for energy systems modelling and energy planning



# **Technological Services**

#### (see also lines of work/research)

- > Assistance/Consultancy to public institutions: energy planning and technical support in the definition of energy policies (focus: islands, remote areas, less developed regions)
- Electrical grid stability analysis (aimed primarily at determining maximum RES penetration levels, particularly in weak electricity systems), and solutions to increase RES penetration
  - > Grid modelling using PSS/E
  - Development of power electronic components to optimize RES integration in weak/small/isolated electrical grids
- Design of innovative energy generation systems (distributed generation, micro- and mini-grids, hybrid systems) integrating technologies related to renewable energy production, energy storage and Demand Management.

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# **Technological Services**

(cont.)

- > Energy Planning, Thermal and Electrical Energy Systems Modelling
- > Monitoring and Quality control of PV systems
- > Test of solar thermal, PV-systems, and its components
- > Test of energy systems which include variable renewables and manageable and non-manageable loads (e.g. pumps, RES driven desalination systems, electric vehicles, electrolyzers, etc.)
- Characterization of renewable energy resources and meterological forecasting
- Study of the integration of variable renewables in (weak) electrical grids, aiming at maximum renewable energy penetration
- > Study of energy storage solutions
- Training / Capacity Building

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## The Canary Islands: Natural Laboratories of Clean Energy Technologies

Initiatives & Highlights





## **ITC Expertise**

# Renewable Energy & Sustainable Water Technologies





### **RES-Driven Desalination Desalination Systems (ITC)**

#### Case 1. Off- grid wind farm coupled to 3 desalination systems (1998-2002)

 SDAWES project (Seawater Desalination with Autonomous Wind Energy System), connection of 3 different desalination systems to an off-grid wind farm.



2x230 kW off-grid wind farm.



EDR plant (from 3 to 7.9  $m^3/h$ ).



Synchronous machine (100 kW) & flywheel.



8 RO desalination plants (1 m<sup>3</sup>/h each).



VVC plant (2 m<sup>3</sup>/h).

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### **RES-Driven Desalination Desalination Systems (ITC)**

#### <u>Case 2. Seawater - PV desalination unit</u> (since 1999)

• Autonomous PV-RO system, designed to satisfy small water demands (up to 1,000 inhabitants) isolated from the electric grid. DESSOL<sup>®</sup> is an ITC patent.



RO unit - <3.5 kWh/m<sup>3</sup>.

**PV** field

PV-RO system



Battery back-up system



Average operation 8 h/d (summer); 6 h/d (winter).







#### **DESSOL® PATENT**

Once the concept became a mature product, it was possible to transfer the system from the ITC lab facilities to the real world. 5 systems installed in Africa:

**System in Tunisia**: it was the first installed and is located in the village of **Ksar Ghilène**. This system has been operating without problems since the commissioning in June 2006.



**Systems in Morocco**: 4 PV-RO units were installed in inland rural communities of Morocco. Commissioned in May 2008.



Amellou



Tazekra



Tangarfa



Azla











#### **RES-Driven Desalination Desalination Systems (grid-coupling)**





### Maximizing PV/RES Penetration in islands and off-grid areas

#### Governance





Operation

Singular Electricity

Smart and Sustainable Insular Electricity Grids Under Large-Scale Renewable Integration

Enhancing Effective Implementation of Sustainable Energy Action Plans in European islands through Reinforcement of Smart Multilevel Governance

www.sustainableislands.eu www.smilegov.eu Distributed Generation (Microgrids)

- La Graciosa
- TILOS
- La Gomera
- West Africa





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### **Frontrunners in Energy Storage solutions**







Large PV systems with battery storage for stable generation

### Technical Solutions (I) HV/MV: Pumped Hydro (where possible)





### El Hierro: 100% RES Island









#### Record: +20 consecutives day covering 100% of the demand



Example of a 100% RES DAY – JULY 2017

- Wind power: 8.5 MW
- Hydro power: 2.5 MW
- Pump load: 4.7 MW
- Island load: 6.3 MW

#### JULY 2017: 80% demand coverage

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#### **Technical Solutions (II)**

#### ■ MIV//LV:

- Distributed Generation, esp.:
- Mini- & Microgrids with high renewable energy penetration, incl. energy storage, management of critical loads (e.g. seawater desalination) and electrical mobility





### La Graciosa 100% RES

**On-going** 



La Graciosa: 650 inhabitants 0.7 MW peak 2 GWh/y demand



- 15 MW peak
- Multi-microgrid approach









Smart Microgrid with high RES penetration, energy storage and electric vehicles fleet



### Marine RES: preparing the future





Test of wave energy devices





wind energy prototypes

Promotion of marine areas for testing and developing innovative marine energy solutions



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**ITC Renewable Energies** 

## **International Cooperation**

Technology Transfer to less developed regions/countries

# +20 years experience in Africa and insular regions worldwide

> Wind atlas, Creation of RES & desalination training centre, installation of desalination plants (Mauritania).

> Energy Efficiency and Renewable Energy Plan, electrification of villages, installation of RES powered desalination plants (Morocco).

- > Identification of CDM projects in Sub-Saharan Africa.
- > Energy Plan, Support to the creation of a RES training centre in the University, quality
  - control of PV plants, installation of a microgrid (Cape Verde)
  - > Capacity Building (Morocco, Senegal, Cape Verde, Mauritania)

 Collaboration with the ECOWAS Center for Energy Efficiency and Renewable Energy (ECREE, ECOWAS)

# ITC also participates in excellence projects funded by the European Commission

> El Hierro 100% RES, CDM for sustainable Africa, RES2H2, ISLE-PACT, TILOS, SINGULAR, etc.





#### **Collaboration with ECREEE**



#### International Conference on Renewable Energies

#### *in West Africa and the Canary Islands* Canary Islands Institute of Technology

Pozo Izquierdo, Gran Canaria - Canary Islands, Spain, oct 2104

TRAINING WORKSHOP: Integration of Renewable Energies in Weak Electrical Grids

#### TECHNICAL VISIT: WIND PUMPED HYDRO POWER STATION OF EL HIERRO

The island of El Hierro (one of Spain's Canary Islands) will become the first in the world to be fully powered by wind and hydroelectric power. The basic concept is to inject as much wind energy into the grid as possible to reduce diesel consumption.

www.goronadelviento.es

Participants: West African Countries

ECOWAS Regional Centre for Renewable Energy and Energy Efficiency

*Centre Régional pour les Energies Renouvelables et l'Efficacité Energétique de la CEDEAO* 

Centro Regional para Energias Renováveis e Eficiência Energética da CEDEAO





Renewable energy in West Africa







We develop technologies that allow to:

- Electrify rural/remote/isolated areas (with no or weak grids), minimizing fossil fuel use
- Supply drinking water by means of water desalination and treatment/purification

We contribute to reduce the **energy dependence** through endogenous and renewable energy resources





**ITC** has accumulated more than 20 years experience in the development of **sustainable solutions** for **ENERGY** and **WATER** supply of isolated/remote areas

We have carried out consultancy and electrification/desalination projects using **RENEWABLE ENERGIES**, as well as capacity building and awareness activities in several African countries



Mauritania (since 1996) Morocco (since 1998) Tunisia Cape Verde Senegal ECOWAS



#### **Sustainable Technologies for LDC**





Mobile and rapid response/commissioning solution for ENERGY, WATER and COOLING supply in refugee camps and emergency situations



### WHY CLIMARISK?



- Without a reliable energy access, it is almost impossible to cover the basic needs to live:
  - Lighting
  - Cooking
  - Health Centers
  - Communication stations
  - Food (and vaccines) conservation
  - Water access
  - ...
- Access to water, food, housing, medical care is the highest priority for those that are forced to abandon their houses, either because of natural disasters, war conflicts or consequences of climate change (the origin of the majority of these problems)
- Access to **energy** is another key factor, which has not received the necessary attention in the past; it plays a central role in the refugees life
- According to UNHCR, there were in 2017 more than 68 million displaced persons worldwide due to different causes.







- The average settlement period in a refugee camp is 17 years.
- Every year more than 64,000 ha are "burned" in refugee settlements and neighbour zones for cooking and/or heating. This creates tensions among the local population as well as security problems in women and children.
- The access to fuels and to efficient cooking and heating technologies is key: solutions have to be efficient, healthy and secure
  - Efficient: to reduce the environmental impact (new systems allow to save up to 50% of forest biomass, ...)
  - Healthy: to avoid intoxications due to smoke
  - Secure: to reduce fire risks, time to look for biomass (women, children)
  - Loss of food: on average, 3 meals per week are lost
- Access to electrical energy, necessary for:
  - Public lighting in roads, ways and accesses (higher security)
  - Houses
  - Administrative facilities (that account for approx. 15% of the refugee camp area)
  - Health centers, hospitals
  - Schools
  - · Warehouses, store of food (food conservation)
  - Sanitation/residues (ideally: 1 latrine per family, at least 1/20 persons, close to the refuge, illuminated ...)
  - Drinking water (at least 7 liters/person/day) (2,4 kWh/day for 750 persons)
  - Communications





- Development of an integrated solution, mobile and of rapid commissioning for energy, water and cooling supply
- 20 feet standard containers (ideal for the first months/years of a refugee camp, or emergency situations that last several months)
- Optimization of the components to optimize the use of space and reduce transport costs
- Intelligent energy management system to optimize operation







#### **ELECTRICITY SUPPLY Subsystem**









#### 15 kW of power

- Can generate approx.:
  - 120 kWh/day (100% renewable energy)
  - 220 kWh/day (60% renewable energy)
  - 320 kWh/day (30% renewable energy)
- Renewable energy technology: **solar photovoltaics (PV)**
- No need of civil works to install PV modules, that can be mounted on any surface
- Rapidly/easily scalable (up to two containers) to build a single power station of 30 kW.
- Intelligent energy management system (meteorological prediction, load optimization, communication with the other containers, artificial intelligence)

#### Fast installation and commissioning:

- Installation of PV system ready to operate in **2 hours**.
- Able to provide supply in **15 min**
- Dismantling time: 2 hours.
- Generates enough energy to (simultaneously):
  - Produce more than 12 m<sup>3</sup> water/day (1000 persons)
  - Maintain the refrigerator at **5** °C (15 m<sup>3</sup>)
  - Supply energy to a **120 beds** hospital
  - Supply energy to 1000 2000 persons

- Drinking and distilled water production system
- Containerized solution.
- The system incorporates **two technologies**:
  - Production of **atmospheric water**: distilled water, suitable for hospitals, higiene, batteries, ...(500 liters/day)
  - Purification (or desalination) planta: 24.000 liters/day (2000 persons)\*
- **Plug&Play system**: the electrical power station recognizes the water system as soon as it is connected electrically and adjusts the energy control in order to guarantee the energy supply at the lowest cost

\* ITC can also offer a containerized solution of a desalination plant powered by photovoltaics (DESSOL©, ITC patent)









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Two different systems:

- System for storage of medicines at ambient temperature (+20 °C) (requested by UN World Food Program)
- Innovative refrigeration system (+5 °C) prepared for integration of renewable energies (termal storage)













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Gonzalo Piernavieja R&D&I Director gpiernavieja@itccanarias.org





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# **THANK YOU!**