Summary of the Hybrid Power Systems Workshop in Tenerife, Spain

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solutions for sustainable development

3rd International
Hybrid Power Systems Workshop

8 - 9 May 2018
Tenerife, Spain

by Thomas Ackermann
Energynautics, Germany

www.energynautics.com

Number of Participants of the 3rd Hybrid Power Systems Workshop – 56 Speakers

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Country	Number	Country	Number
Germany	42	Gambia	2
Spain	21	Zambia	2
United States of America	9	Niger	2
France	6	Latvia	2
Belgium	4	Cameroon	2
Netherlands	4	Madagascar	2
Portugal	3	United Kingdom	2
Japan	3	Mauritania	2
Netherlands Antilles	2	Canada	2
Switzerland	2	Cape Verde	2
Denmark	2	Kenya	2
Greece	2	Other Countries *	7
		TOTAL	**129**

* Cyprus, Faroer Islands, Austria, Italy, Nigeria, Sweden, Burkina Faso

Group of Participants

Overview of the Session

- Keynote Session – Canary Islands Experience
- Project Experience
- Simulation Tools
- Storage Issues
- System Control Aspects
- Economic Issues
- Modelling Issues
- System Design Aspects
- Forecasting &
- Integration Issues
- System Design Aspects
- Stability Issues
- Micro Grid Design
- Aspects

Sources of the following slides:

Towards a New Energy Model: Challenges and Solutions to Enable Large RES Penetration in the Canary Islands' Isolated Power Systems

P. Santos (Red Eléctrica de España [REE], Spain)

Gorona del Viento Wind-Hydro Power Plant – Results, Improvement Actuations and Next Steps

A. Marrero Quevedo (Technological Institute of the Canary Islands [ITC], Spain)

Location of Tenerife

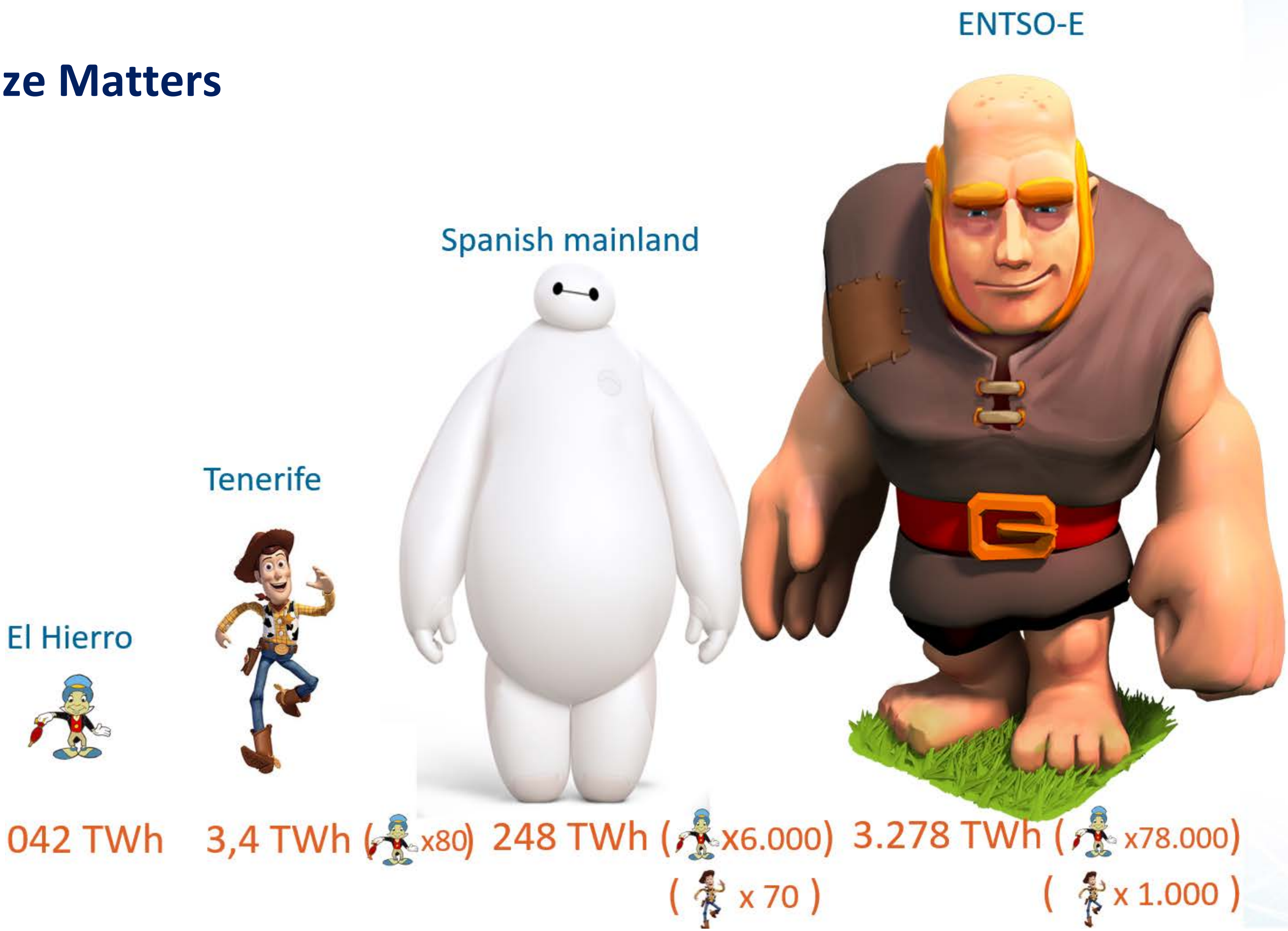
Source: Towards a New Energy Model: Challenges and Solutions to Enable Large RES Penetration in the Canary Islands' Isolated Power Systems P. Santos (Red Eléctrica de España [REE], Spain)

The Canary Islands Electrical Systems - Today

- 6 isolated electrical systems on 7 islands
- Generation mainly based on fossil fuels
- Low meshed weak infrastructure
- High wind and solar potential

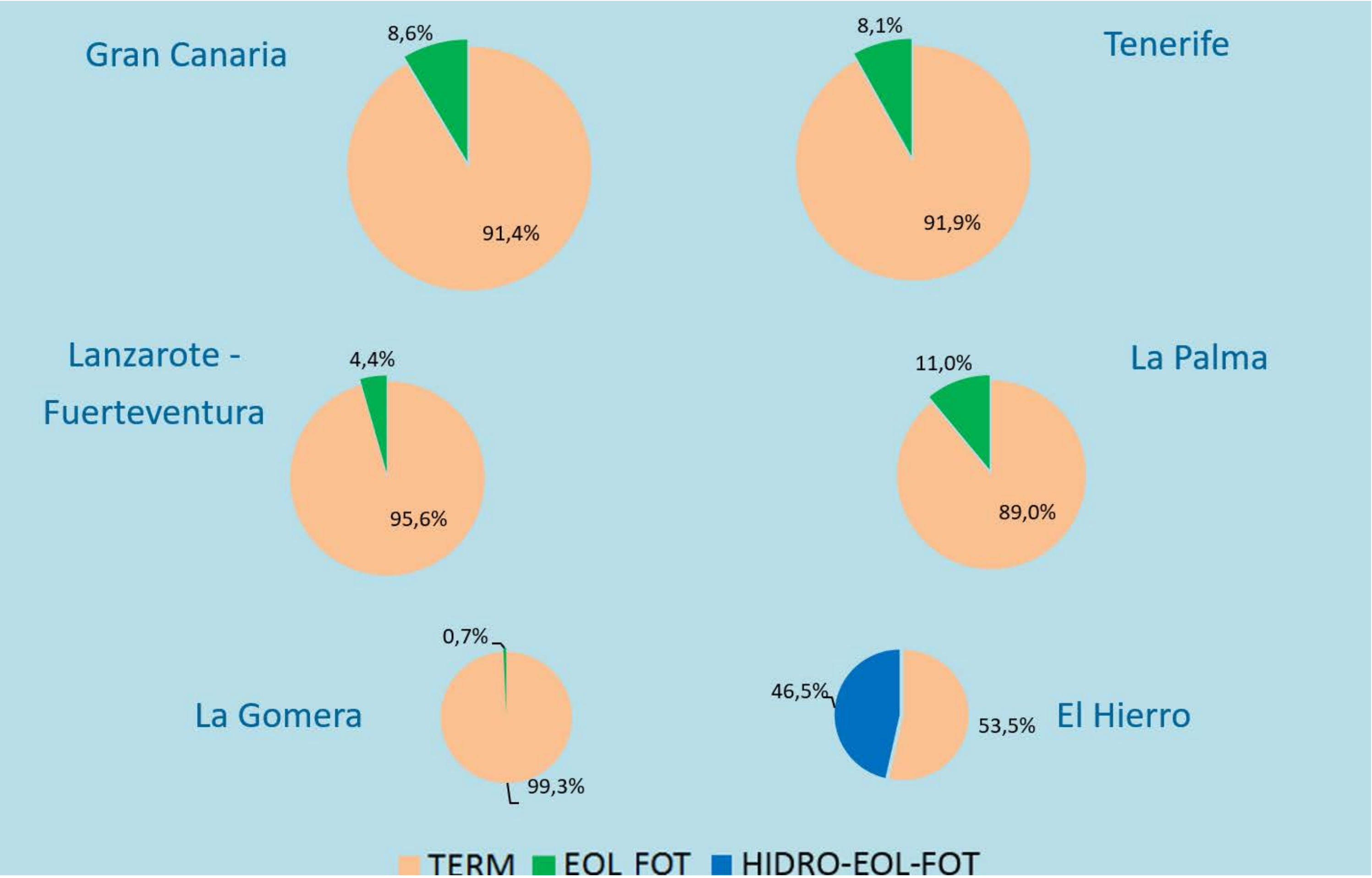
Source: Towards a New Energy Model: Challenges and Solutions to Enable Large RES Penetration in the Canary Islands' Isolated Power Systems P. Santos (Red Eléctrica de España [REE], Spain)

Size Matters



Source: Towards a New Energy Model: Challenges and Solutions to Enable Large RES Penetration in the Canary Islands' Isolated Power Systems P. Santos (Red Eléctrica de España [REE], Spain)

Annual Demand covered by RES (2017)



Source: Towards a New Energy Model: Challenges and Solutions to Enable Large RES Penetration in the Canary Islands' Isolated Power Systems P. Santos (Red Eléctrica de España [REE], Spain)

Interconnectors

Source: Towards a New Energy Model: Challenges and Solutions to Enable Large RES Penetration in the Canary Islands' Isolated Power Systems P. Santos (Red Eléctrica de España [REE], Spain)

Storage: Central Hidroeólica de el Hierro (CHE)

El Hierro island:

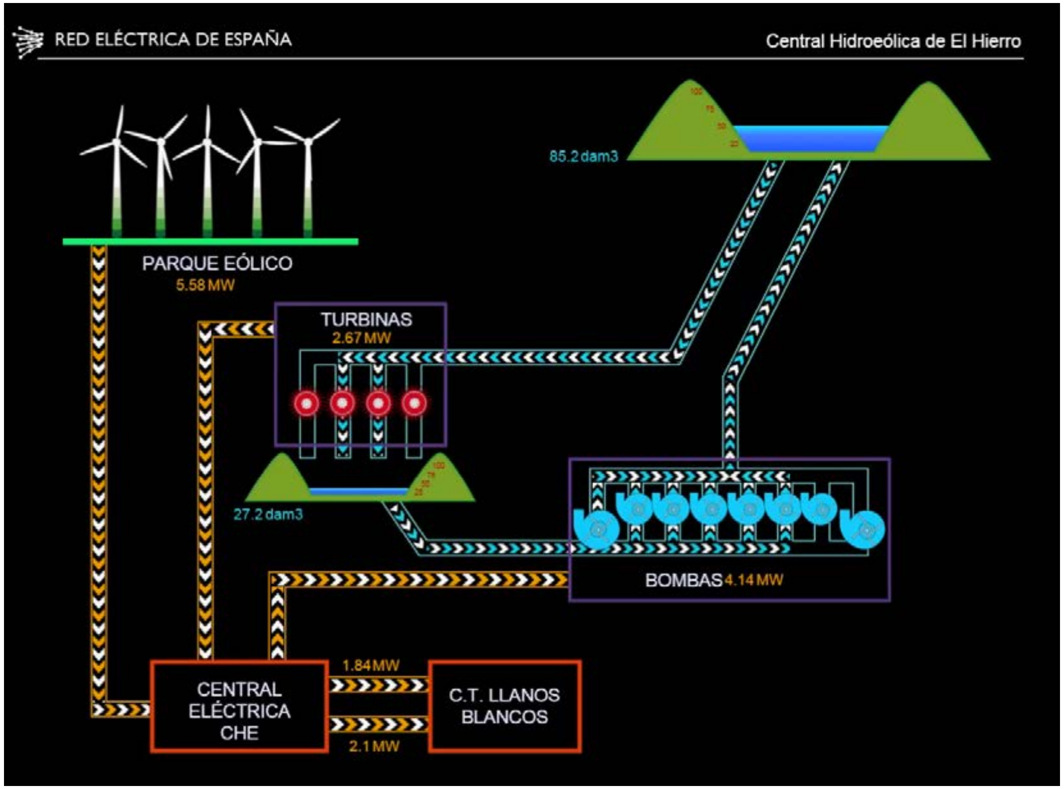
- Peak demand: 7 - 8 MW
- Lowest demand: 3.5 - 4 MW

CHE:

- Owned by Gorona del Viento:
  - Cabildo de El Hierro
  - ENDESA
  - Instituto Tecnológico de Canarias
- Dispatched by the TSO

Technical specs:

- Wind: 11.5 MW
- Pumps: 6.4 MW
- Turbines: 11.4 MW
- Upper reservoir: 380 dam3
- Lower reservoir: 149 dam3
- Roundtrip efficiency: 50%



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Gorona del Viento Wind Hydro Power Plant

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- **Wind Farm; 5 Enercon 2.3 MW turbines.**
- **Water reservoirs.**
  - **Lined with high density polyethylene membrane**
  - **Higher reservoir 380.000 m^3**
  - **Lower reservoir 149.000 m^3**
- **Penstocks.**
  - **Turbine pipe of 2.3 km and 1 m of diameter**
  - **Pump pipe of 3 km and 0.8 m of diameter.**
- **Hydro turbine station. 4 Andritz Pelton turbines of 2.83 MW (flow 0.5 m^3/s).**
- **Pump Station.**
  - **2 pump units of 1.6 MW (0.178 m^3/s), controlled by frequency converters.**
  - **6 pump units of 0.54 MW (0.058 m^3/s), started by 2 frequency converters**

Cabildo de El Hierro
La Isla del Meridiano
endesa
itc INSTITUTO TECNOLÓGICO DE CANARIAS
Gobierno de Canarias

Source: Gorona del Viento Wind-Hydro Power Plant – Results, Improvement Actuations and Next Steps
A. Marrero Quevedo (Technological Institute of the Canary Islands [ITC], Spain)

Overall Results

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- 8 consecutive days covering 100 % of the Island demand in June 2017.
- 79 % of renewable integration into power system in July 2017.
- 18 consecutive days covering 100 % of the Island demand in January-February 2018.

RED ELÉCTRICA DE ESPAÑA

- Continuous improvement process.
- Stakeholders sharing information
- Gorona --> Plant improvements
- REE –> Operational changes
- ITC, Endesa, Enercon, Andritz.

Year	Saved Diesel (tons)	CO_2 reduction (tons)	Integration into power system (%)
2015 (From July up to the end of the year)	2099	4352.57	19.4
2016	5366	11629.56	40.7
2017	6070	13150.87	46.4

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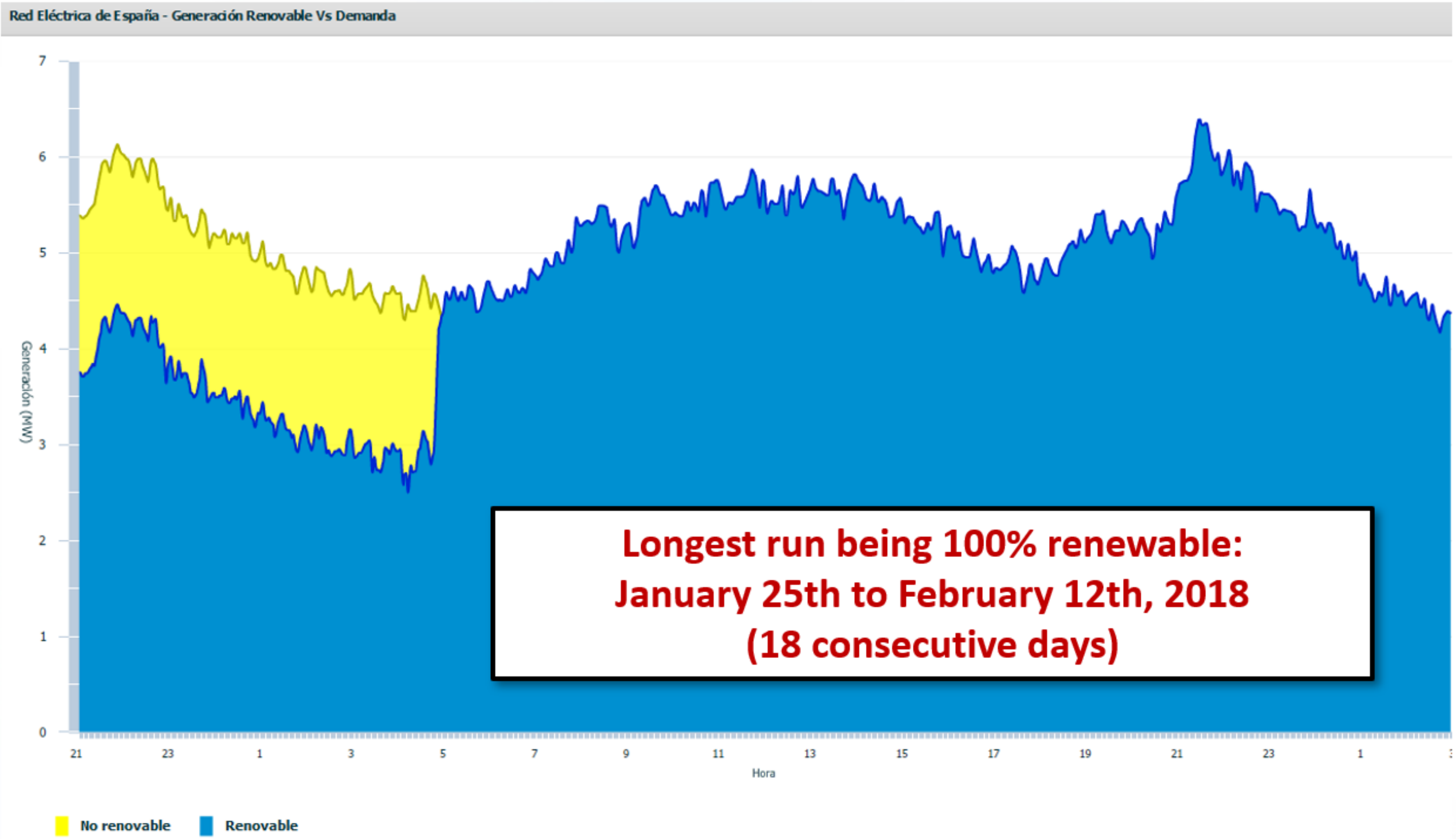
Storage: Central Hidroeólica De El Hierro: 100% Renewable



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Overall Results

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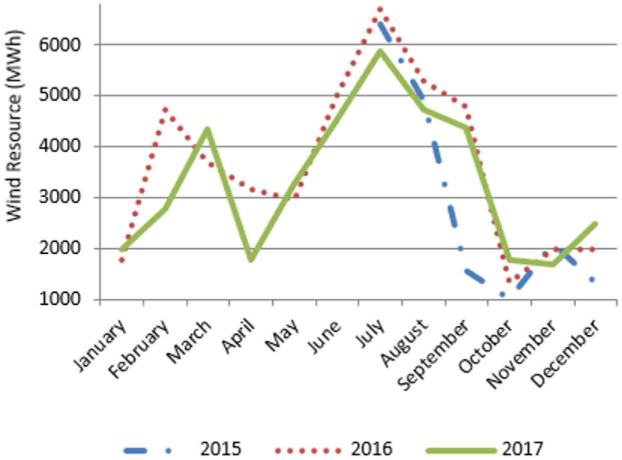
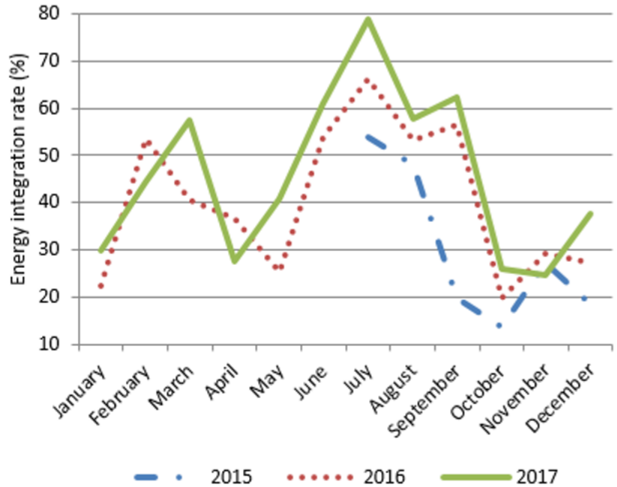


Wind Resource



Energy integration into El Hierro power system

2018 integration			
Jan.	Feb.	March	April
66 %	57 %	49 %	71 %

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Wind Ramps - Frequency Control

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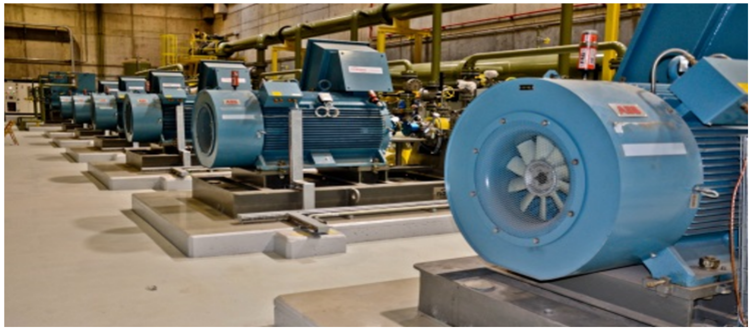
- **11.5 MW Wind Farm > 7 MW of El Hierro Peak load → The wind ramps have a big impact on the system**
- Tertiary regulation, the TSO, REE provides a weekly/daily/hourly power dispatch
  - System Security and Stability
  - Economic criteria.
  - Modified with the real time wind resource.
- Secondary regulation – Response time → seconds to minutes.
  - REE sends an active power setting for wind farm, that is given to the Farm Control Unit.
  - Hydro and pump units receive active power setting in their speed governors and frequency converters according to the dispatch and an automatic generation control device corrections.
- Primary regulation – Response time → few seconds.
  - Hydro turbines and diesel generators, through speed governors.
  - Pumps, through frequency converters (case of pump units driven by converters)
  - Wind farm primary regulation is, nowadays deactivated
- Pump shedding – Response time → 100 ms.
  - Underfrequency
  - ROCOF; df/dt



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Pump Shedding

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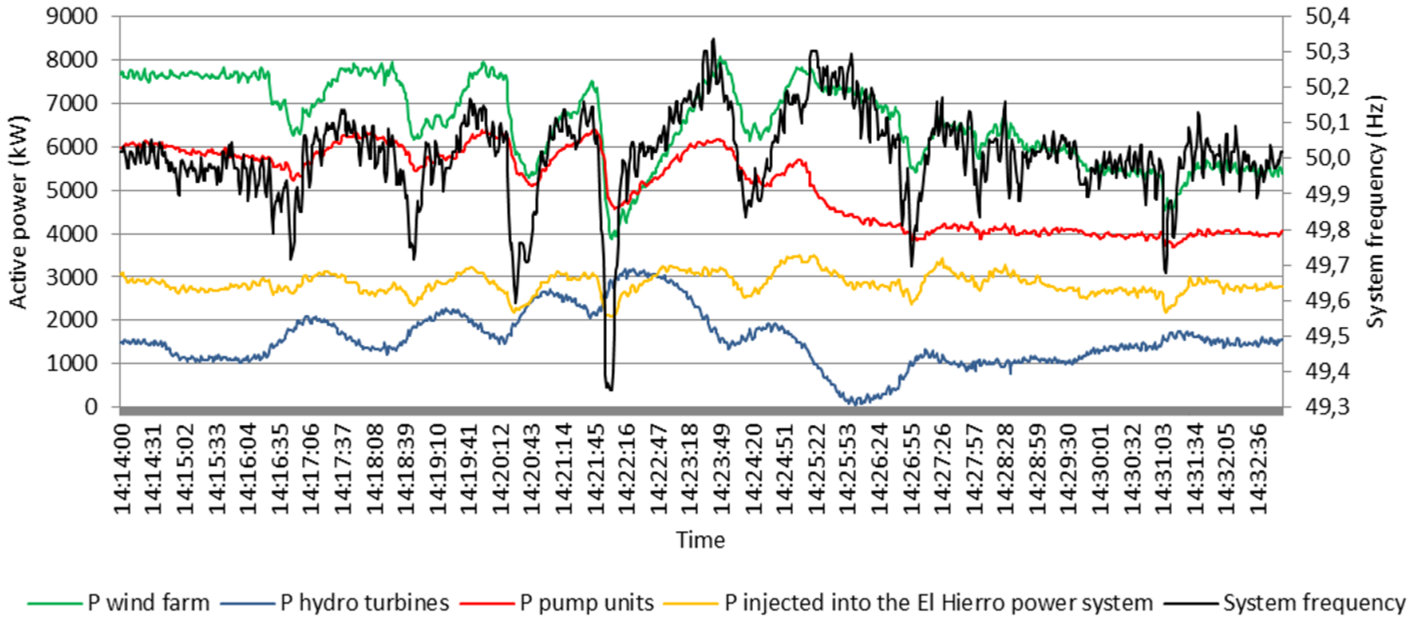
Primary regulation in Hydro turbines <u>was</u> not enough

- Pump shedding necessary to ensure the security of the system
- Impact to system performance (50%)
- Pumps life -- More than 700 trips due to underfrequency in 2017!!



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Actuations - Improvements

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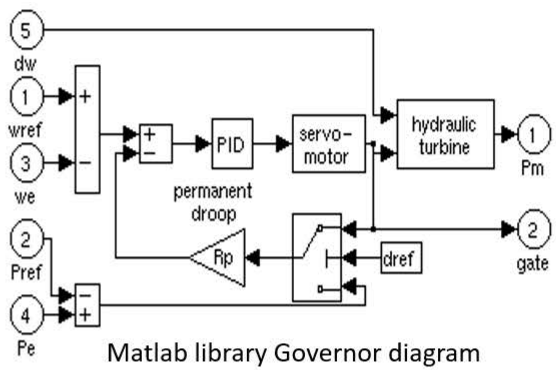
- Speed Governor Logic
- Wind farm Active Power setting treatment



Matlab library Governor diagram

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Conclusions and next Steps

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- Continuous analysis of the system. Collaboration between REE and Gorona is better for the system, because it is easy for the actors to detect, analyze and solve problems.
- More confidence in the plant frequency regulation.
  - 80 % of pump shedding reduction (more reduction with more than 2 Pelton Turbines dispatched)
  - Performance increases →Same system security with less pumps
  - It seems production increases
- Next steps
  - Synchronous compensator
    - Response improvement (damper)
    - Diminish water consumption
  - Wind farm;
    - FCU enhance
    - Primary regulation
  - Short term forecasting; Machine learning.

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Gobierno de Canarias

Source: Gorona del Viento Wind-Hydro Power Plant – Results, Improvement Actuations and Next Steps
A. Marrero Quevedo (Technological Institute of the Canary Islands [ITC], Spain)

Faroe Islands

Source:

Towards 100% Renewables in the Faroe Islands: Wind and Energy Storage Integration

T. Nielsen (Electrical Power Company [Elfelagið] SEV, Faroe Islands)

Faroe Islands

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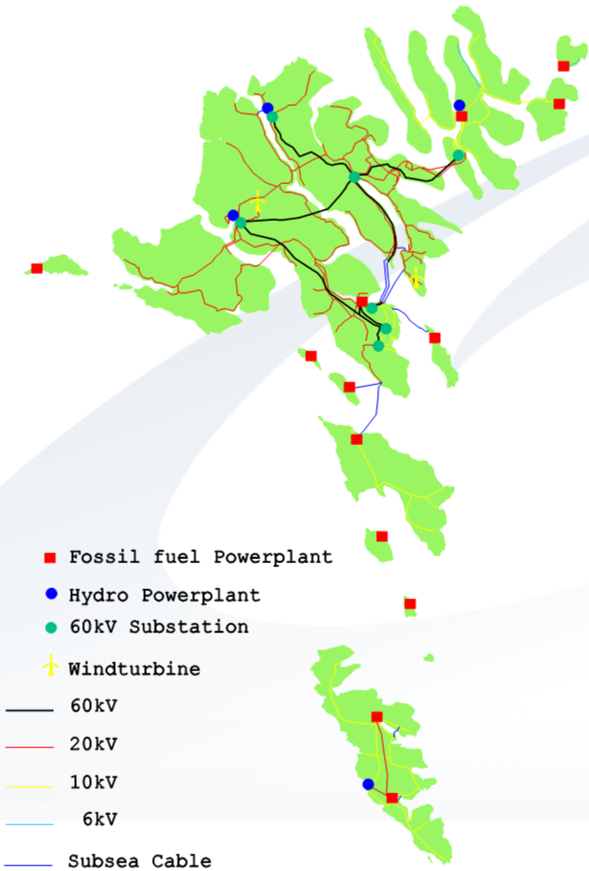
T. Nielsen (Electrical Power Company [Elfelagið] SEV, Faroe Islands)

Electrical Company SEV



- **General company facts:**
  - Non-profit, founded 1st October 1946
  - 100 % owned by all Faroese municipalities
  - Vertically Integrated Company
  - Joint and several price structure

Source: Towards 100% Renewables in the Faroe Islands: Wind and Energy Storage Integration
T. Nielsen (Electrical Power Company [Elfelagið] SEV, Faroe Islands)

Identification of Renewable Resources

Average wind speed: > 10m/s

Precipitation: > 1300 mm/year *(Tenerife: < 250 mm/year)*

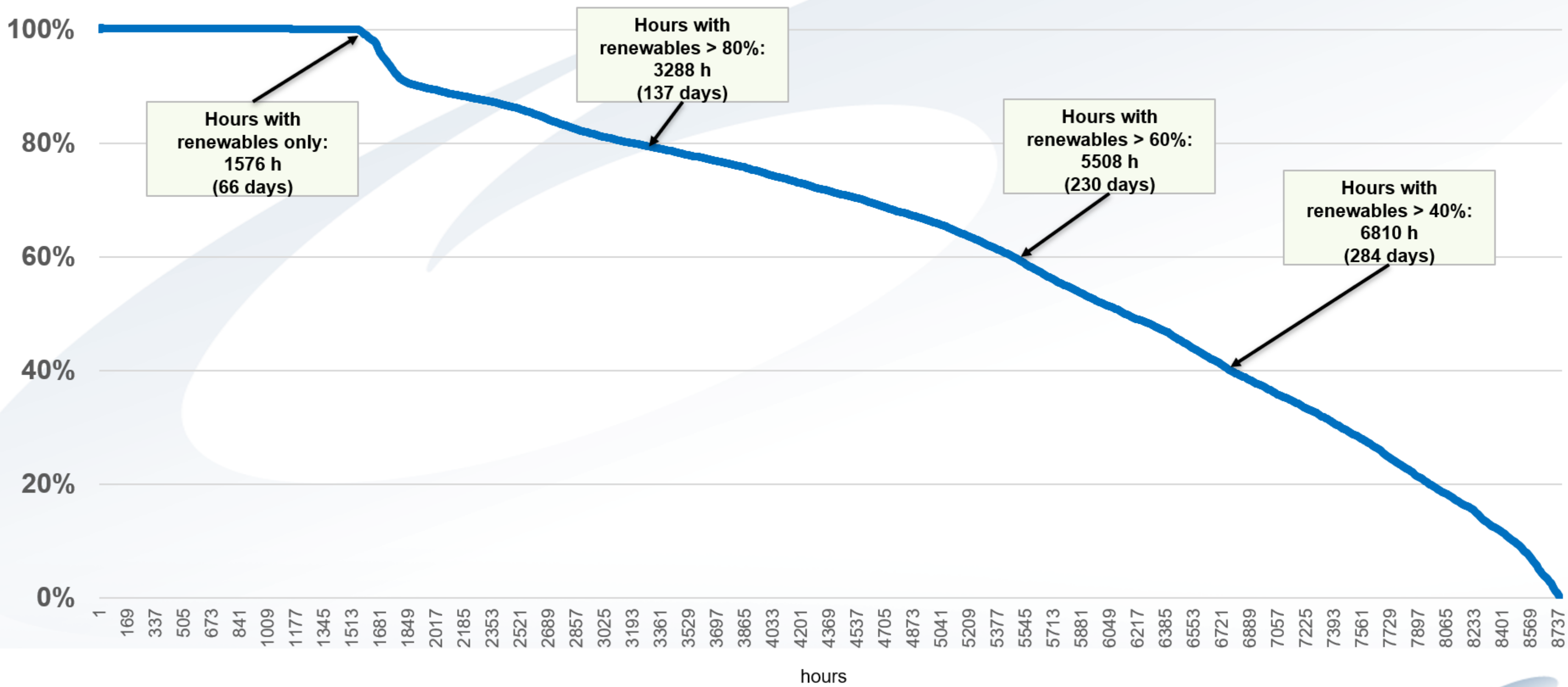
Peak tidal velocities: ~ 3.5 m/s

Average sun hours: ~ 1000 hrs/year (Tenerife: ~3000 hours)

SEV

Source: Towards 100% Renewables in the Faroe Islands: Wind and Energy Storage Integration
T. Nielsen (Electrical Power Company [Elfelagið] SEV, Faroe Islands)

Renewable Energy Duration Curve 2015



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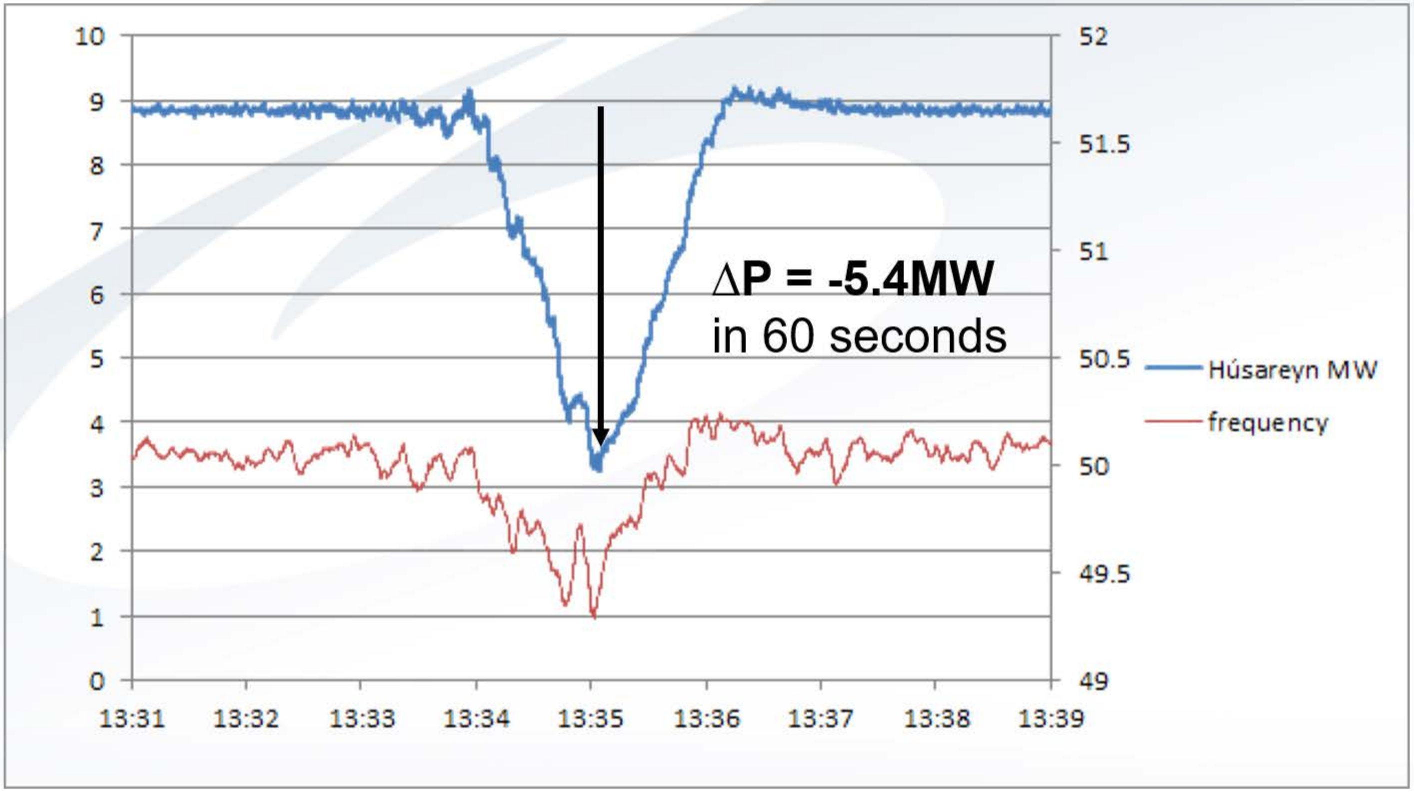
Extreme Ramp Rates (Húsahagi WF)



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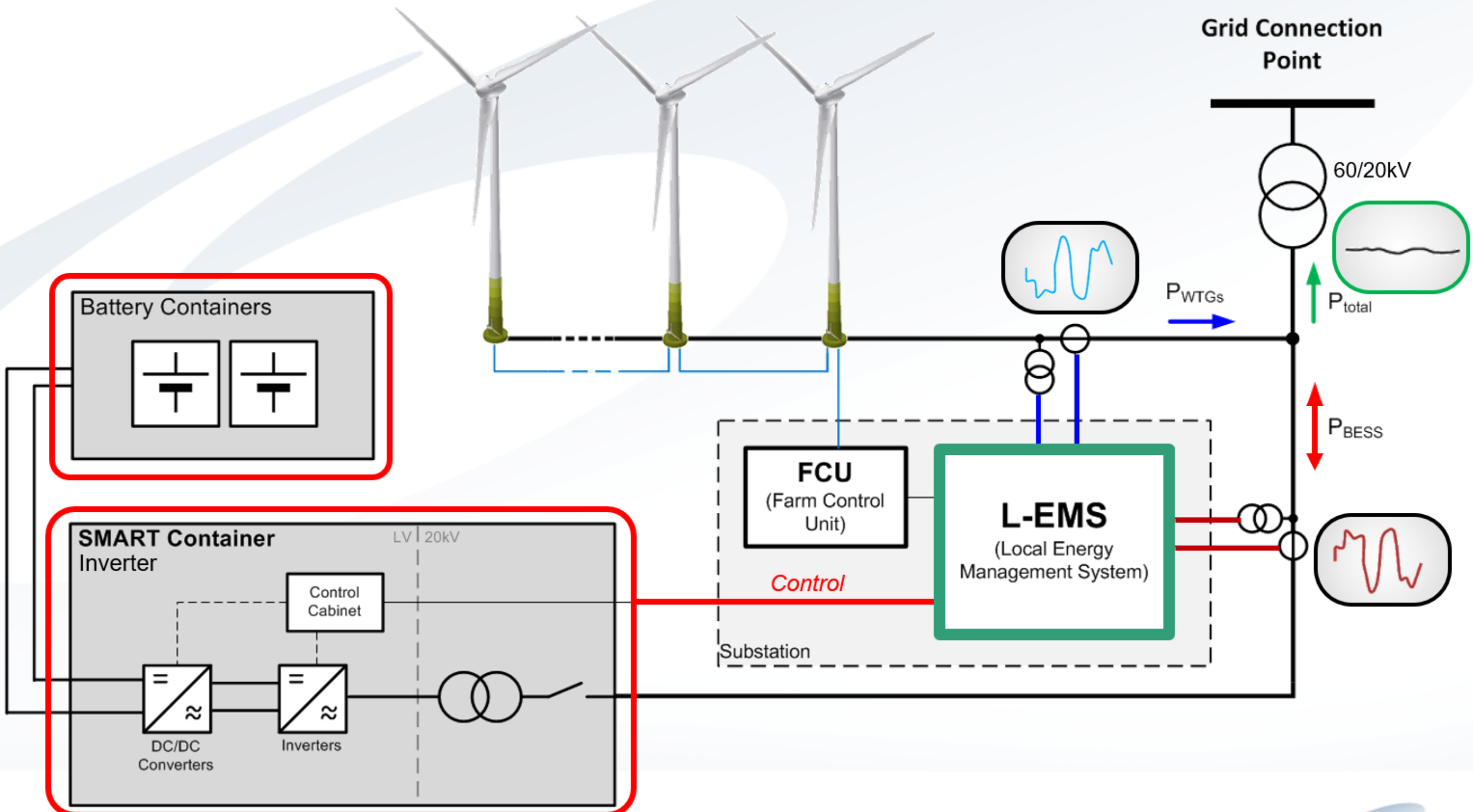
Wind Farm Block Diagram

SAFT

2 Intensium Max 20P	
Energy	707 kWh
Continuous discharge power	2 400 kW
Continuous charge power	1 500 kW
Nominal voltage	623 V
Voltage range	525V – 700V

ENERCON
ENERGIE FÜR DIE WELT

ENERCON E-Storage 2300	
Apparent power	2300 kVA
AC Voltage	LV: 400V MV: 20 kV
DC Power	2 400 kW
DC Voltage Range	345 – 705 V
DC Current	3325 A



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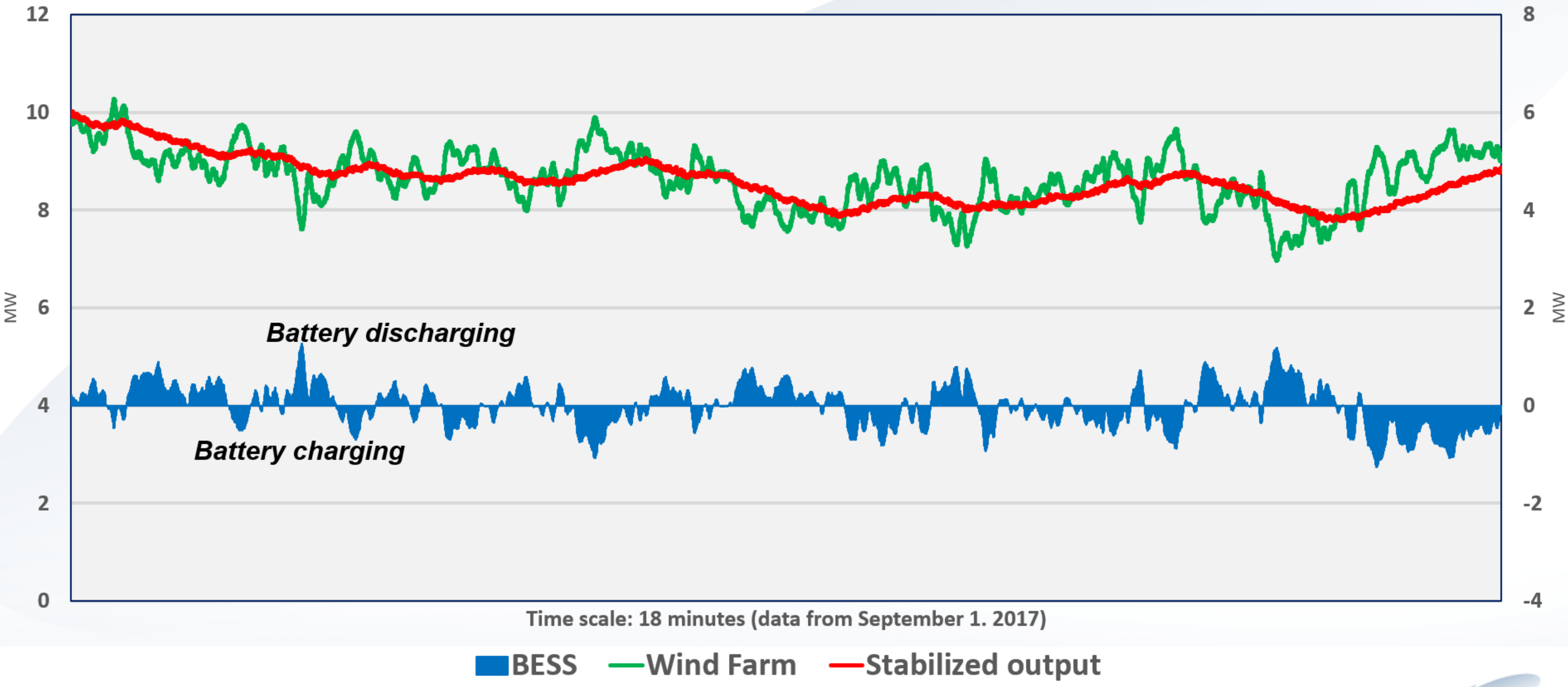
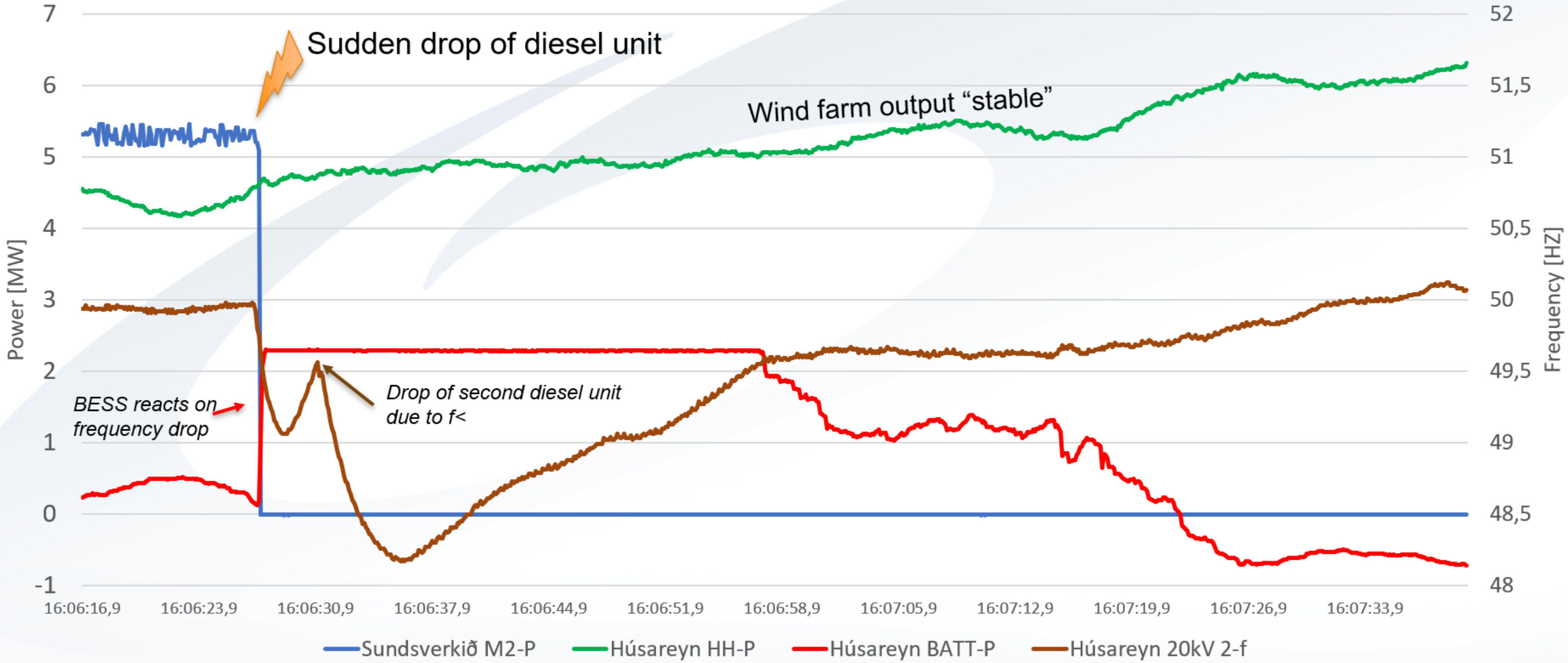
Battery System in Operation



Source: Towards 100% Renewables in the Faroe Islands: Wind and Energy Storage Integration
T. Nielsen (Electrical Power Company [Elfelagið] SEV, Faroe Islands)

Fast Frequency Support from the BESS



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All Papers & Posters are available here:

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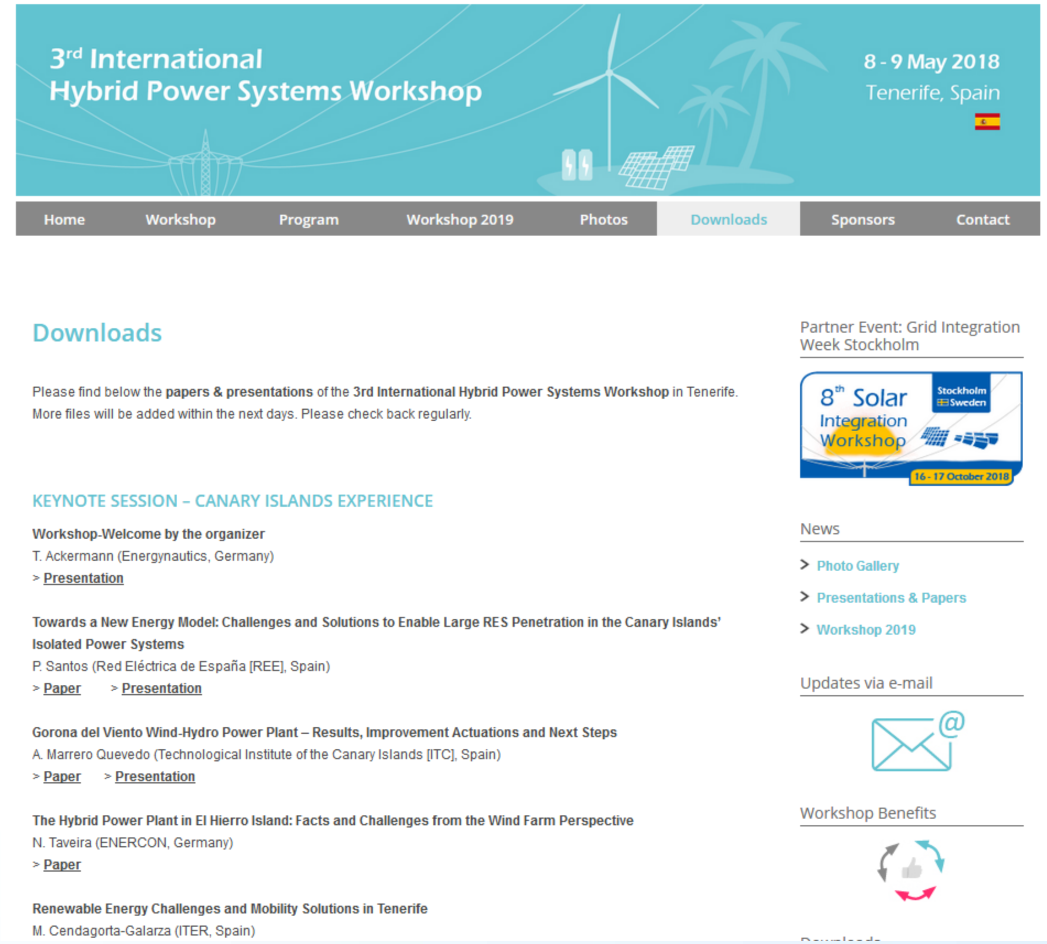

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Hybrid Power Systems Workshop

8 - 9 May 2018
Tenerife, Spain

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Downloads

Please find below the **papers & presentations** of the **3rd International Hybrid Power Systems Workshop** in Tenerife. More files will be added within the next days. Please check back regularly.

KEYNOTE SESSION – CANARY ISLANDS EXPERIENCE

Workshop-Welcome by the organizer
T. Ackermann (Energynautics, Germany)
> Presentation

Towards a New Energy Model: Challenges and Solutions to Enable Large RES Penetration in the Canary Islands' Isolated Power Systems
P. Santos (Red Eléctrica de España [REE], Spain)
> Paper > Presentation

Gorona del Viento Wind-Hydro Power Plant – Results, Improvement Actuations and Next Steps
A. Marrero Quevedo (Technological Institute of the Canary Islands [ITC], Spain)
> Paper > Presentation

The Hybrid Power Plant in El Hierro Island: Facts and Challenges from the Wind Farm Perspective
N. Taveira (ENERCON, Germany)
> Paper

Renewable Energy Challenges and Mobility Solutions in Tenerife
M. Cendagorta-Galarza (ITER, Spain)

Partner Event: Grid Integration Week Stockholm

8th Solar Integration Workshop
Stockholm Sweden
16 - 17 October 2018

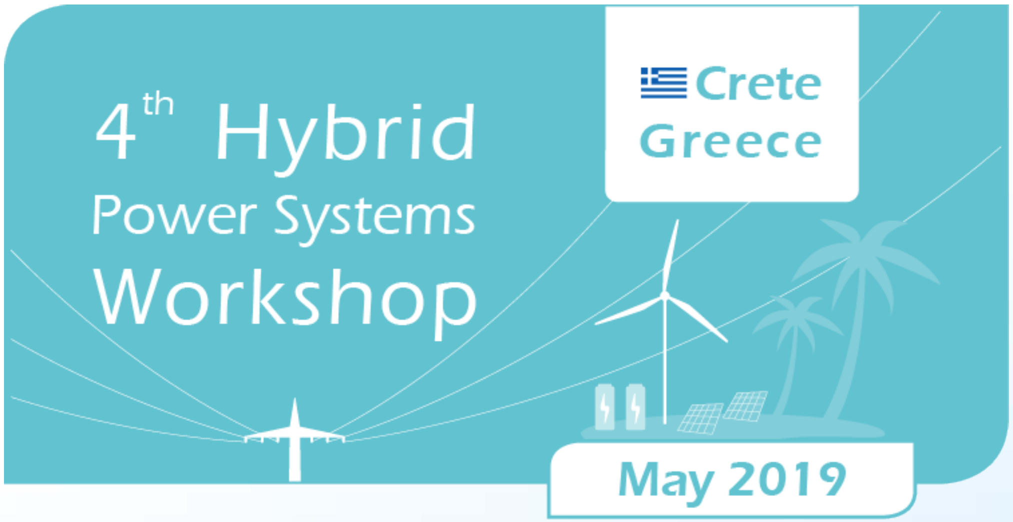
News
> Photo Gallery
> Presentations & Papers
> Workshop 2019

Updates via e-mail

Workshop Benefits

http://hybridpowersystems.org/tenerife2018/downloads/

Crete 2019



Call for Paper starts soon!