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

Terji Nielsen

Head of R&D department

Dipl.Ing. E.E. (Hons)
MBA Renewables

Agenda

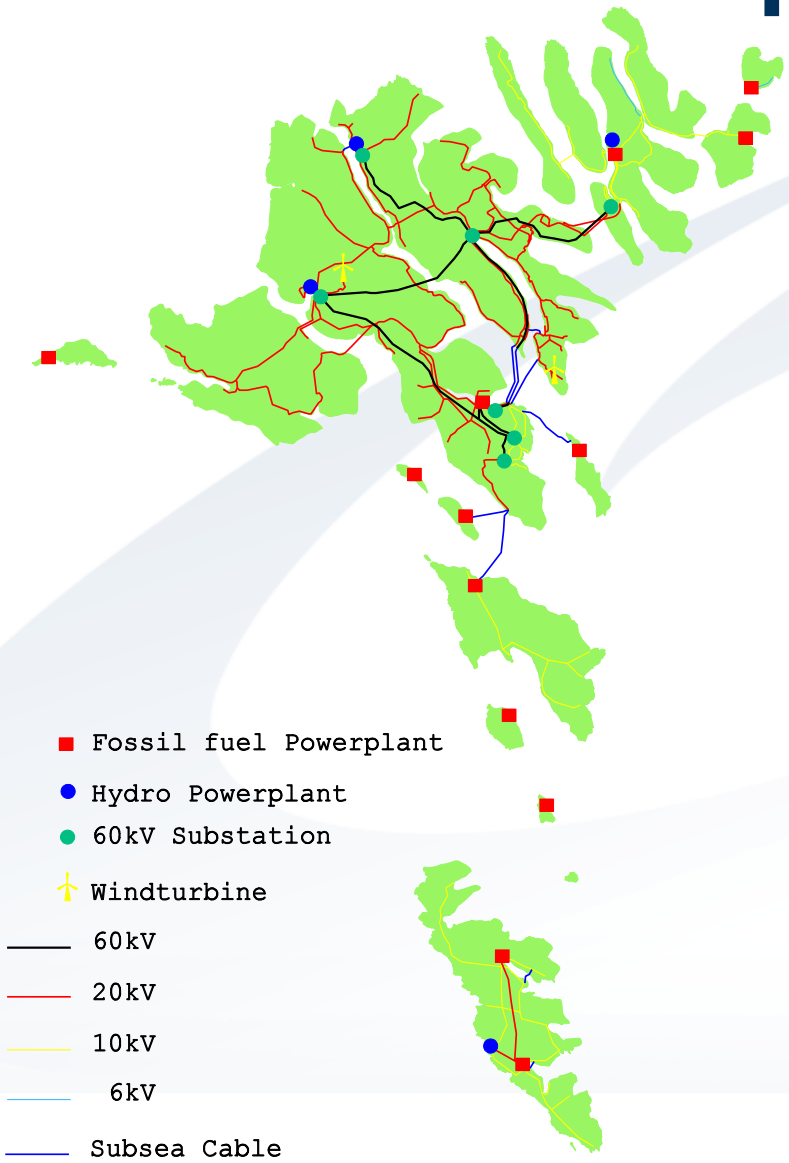
- Introduction
  - General about SEV, Energy mix, Projected energy demand, Renewable resources
  - 100by2030 vision, 2030RoadMap
- Battery as enabler for increased wind integration
  - Schematic design, System data, Operational experiences, Business case
- 2030 Outlook

Faroe Islands

Faroe Islands

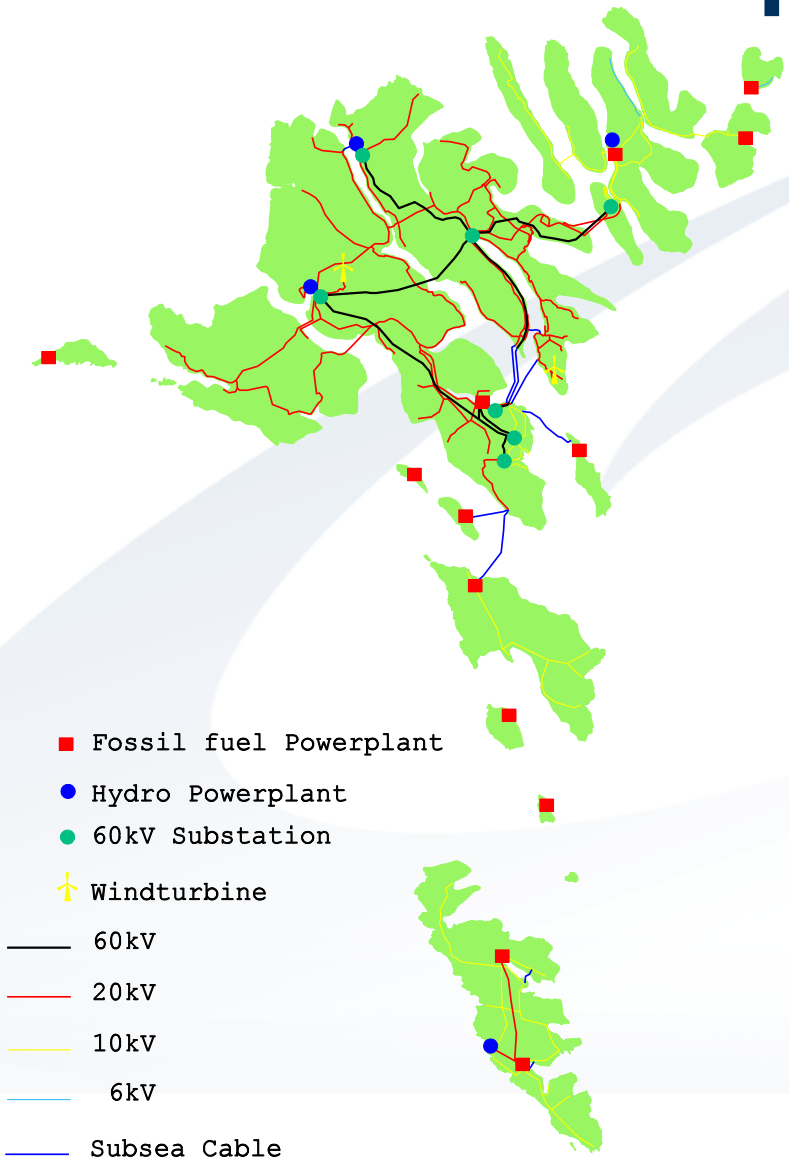
- **General data:**
  - 18 islands (17 are populated), electrically isolated
  - 51.000 inhabitants
  - Area of 1.399 km^2
  - Main export: Fish and fish products

Electrical Company SEV



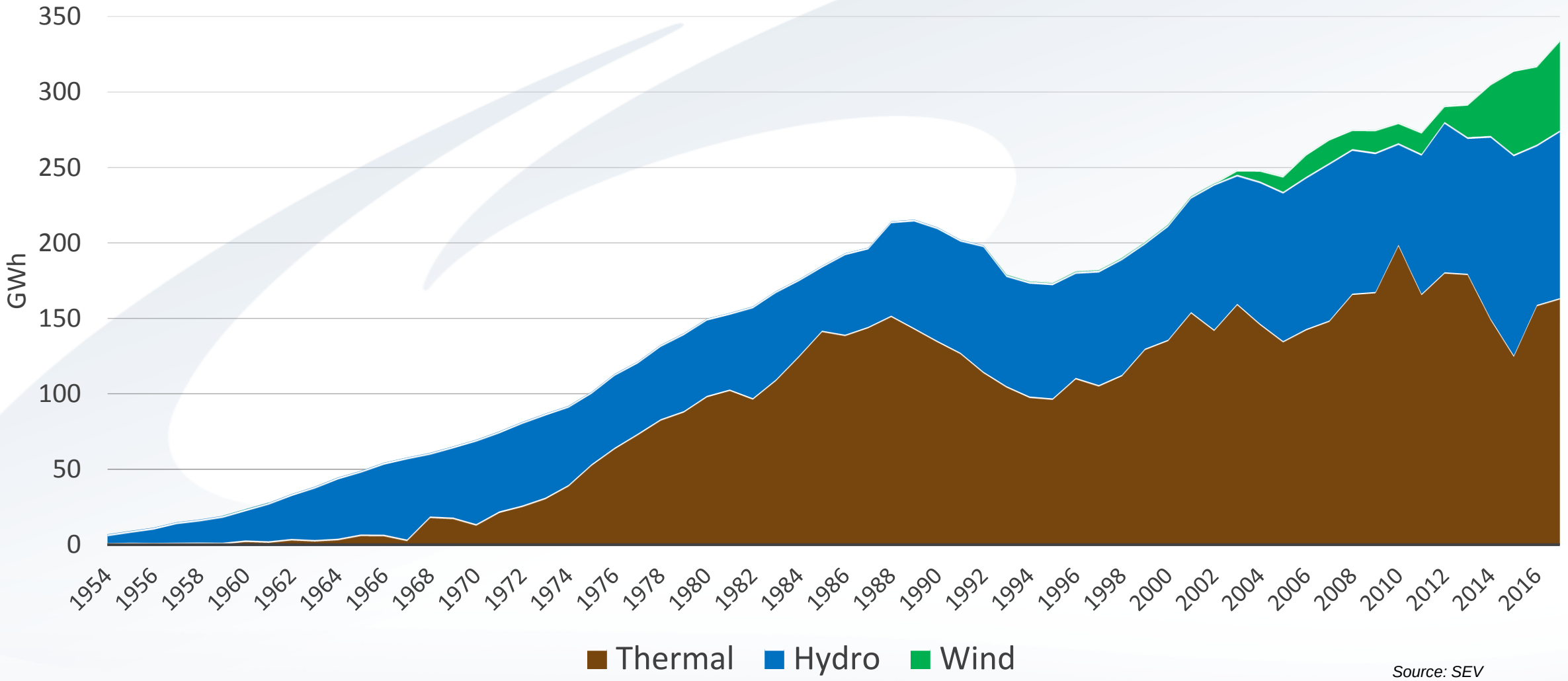
- **General company facts:**
  - Non-profit, founded 1st October 1946
  - 100 % owned by all Faroese municipalities
  - Vertically Integrated Company
  - Joint and several price structure
  - Monopoly on grid operation *(transmission & distribution)*
  - "*De facto*" monopoly on production (98%)
  - *"Micro isolated system" in EU terms* *(< 500 GWh @ 1996)*
    - *Directive 2009/72*
      - *Derogation from relevant provisions in different chapters about unbundling, third party access etc.*

Electrical Company SEV



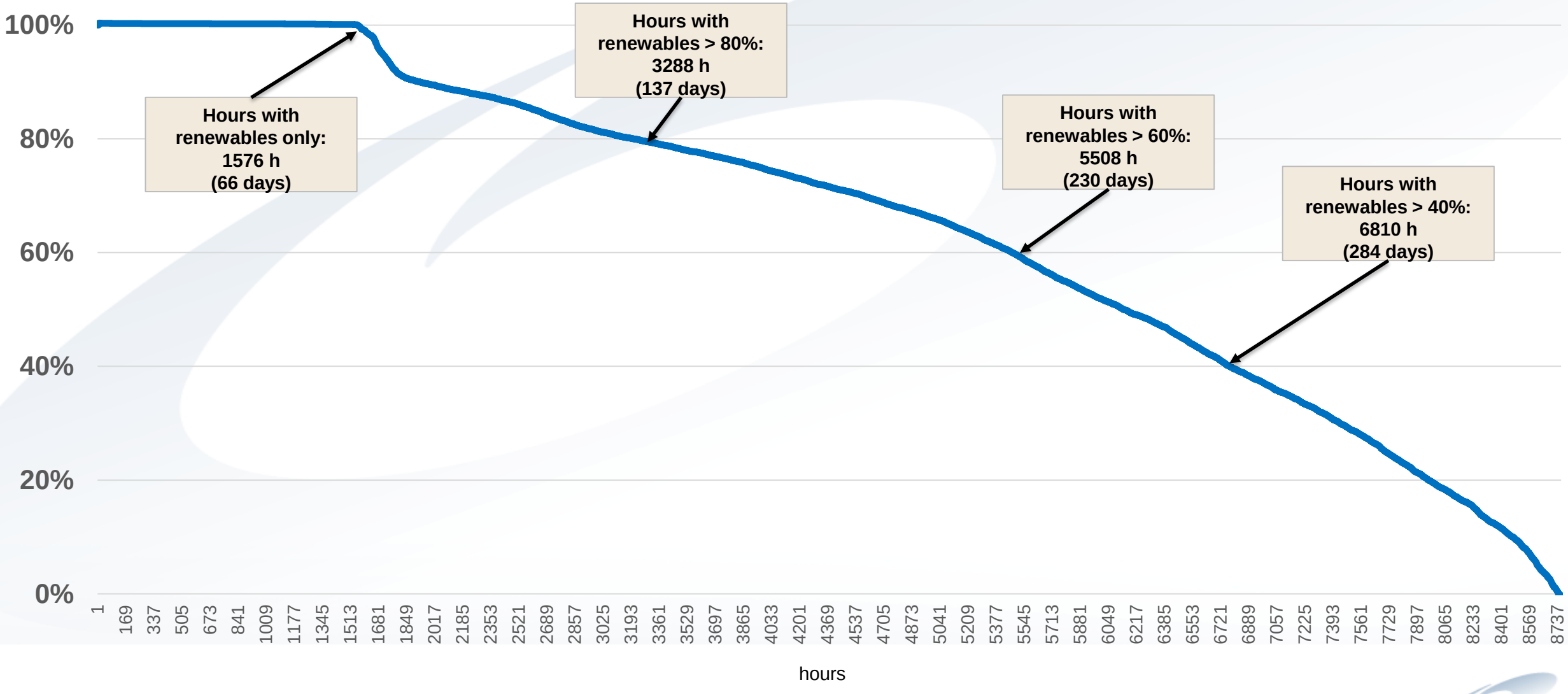
- **Key figures and characteristics:**
  - Peak demand: 55 MW
  - Low load: 25 MW
  - Annual consumption: 340 GWh (2017)
  - Electrically isolated from neighboring countries
  - Installed capacities:
    - Fossil fueled power plants: 65 MW
    - Hydro power: 40 MW
    - Wind power: 18 MW
    - Photovoltaics: < 0,1 MW

Energy Mix 1954 - 2017



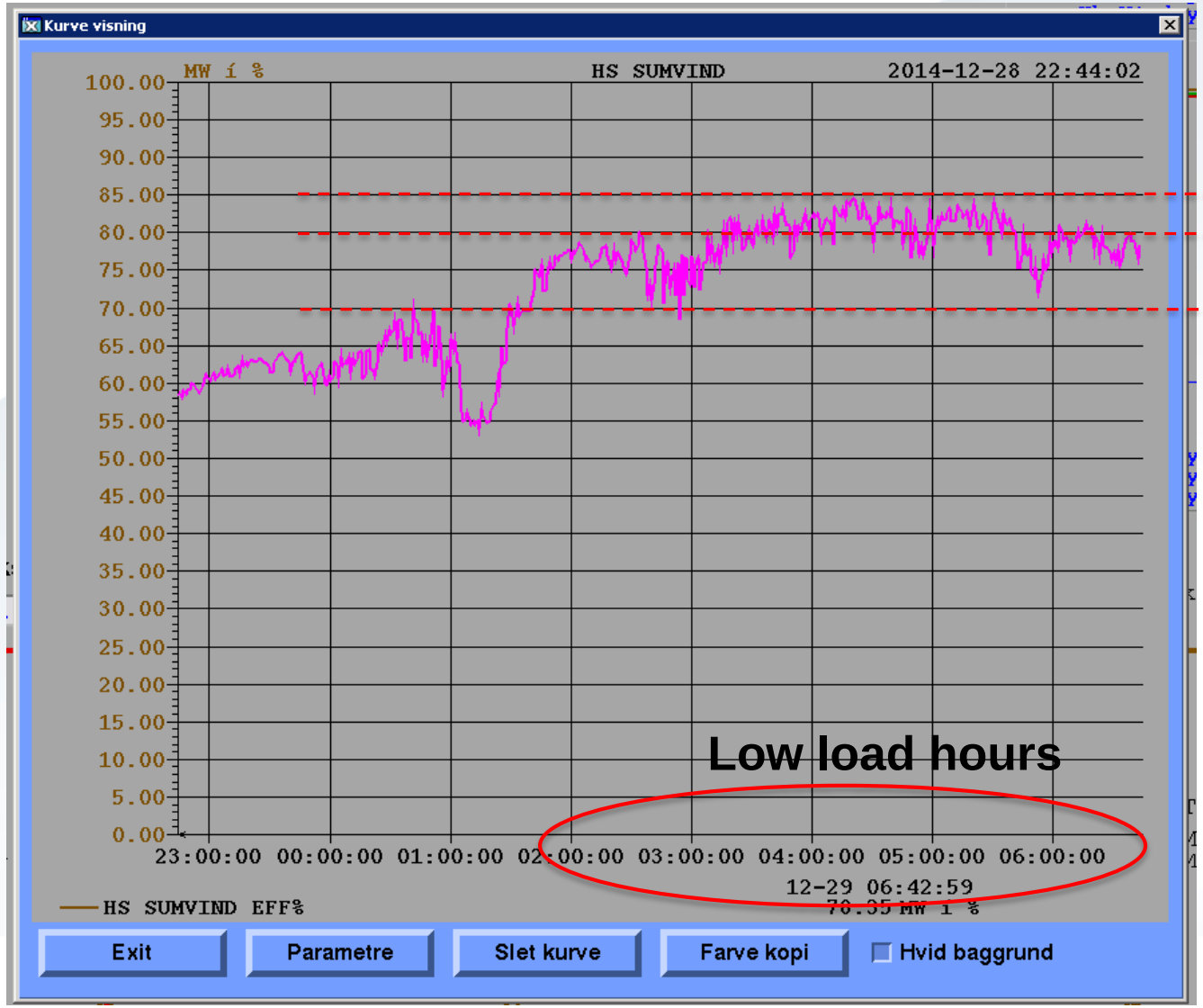
Source: SEV

Renewable energy duration curve 2015



100% RE generation

Instantaneous Wind penetration



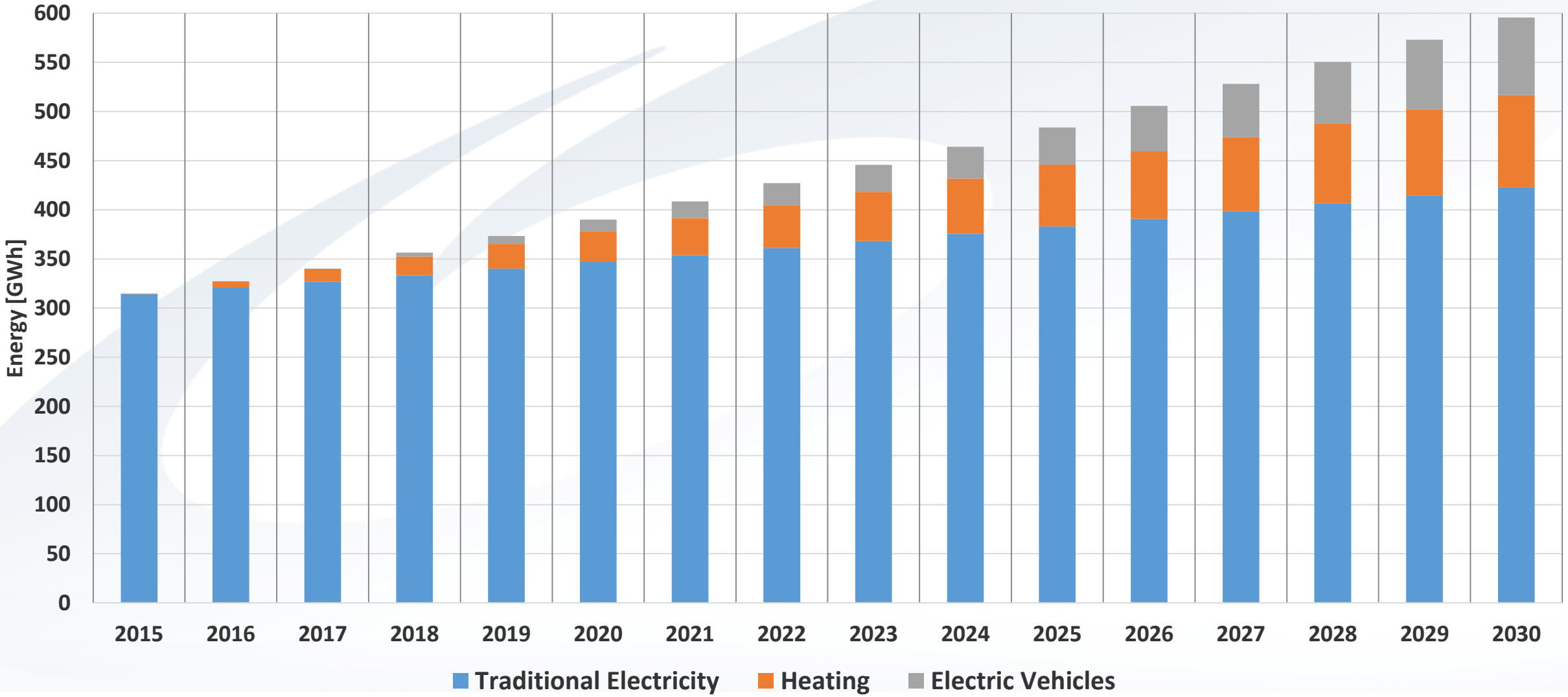
Max instantaneous penetration: 85%

80% Wind penetration

70% Wind penetration

From SEVs SCADA system (BECOS32)

Projected Energy Demand 2015-2030



Renewable resources in the Faroe Islands

Renewable resources

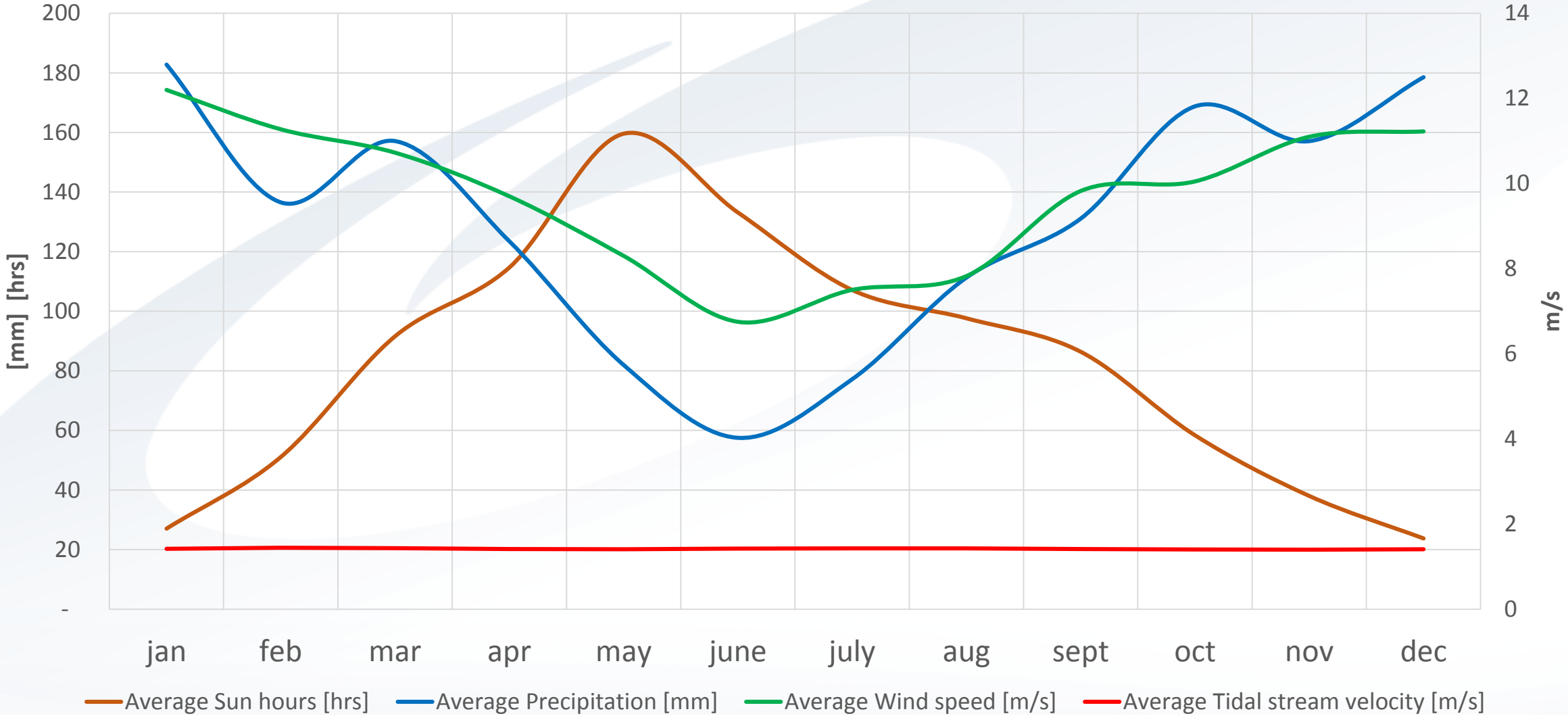
Average wind speed: > 10m/s *(Colorado: 4 m/s)*

Precipitation: > 1284 mm/year *(Tenerife: < 250 mm/year)* *(Colorado: < 370 mm/year)*

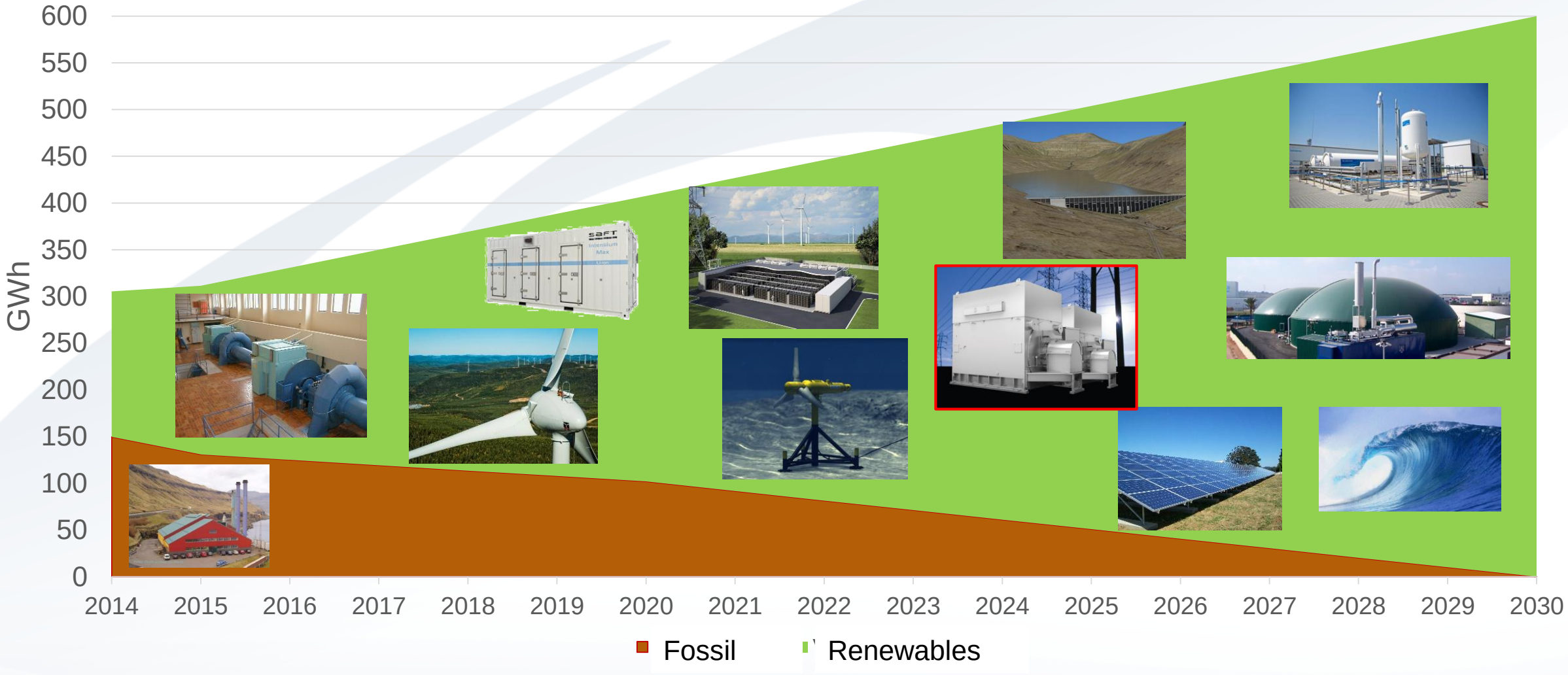
Peak tidal velocities: ~ 3.5 m/s

Average sun hours: ~ 1000 hrs/year (Denver: ~3100 hours)

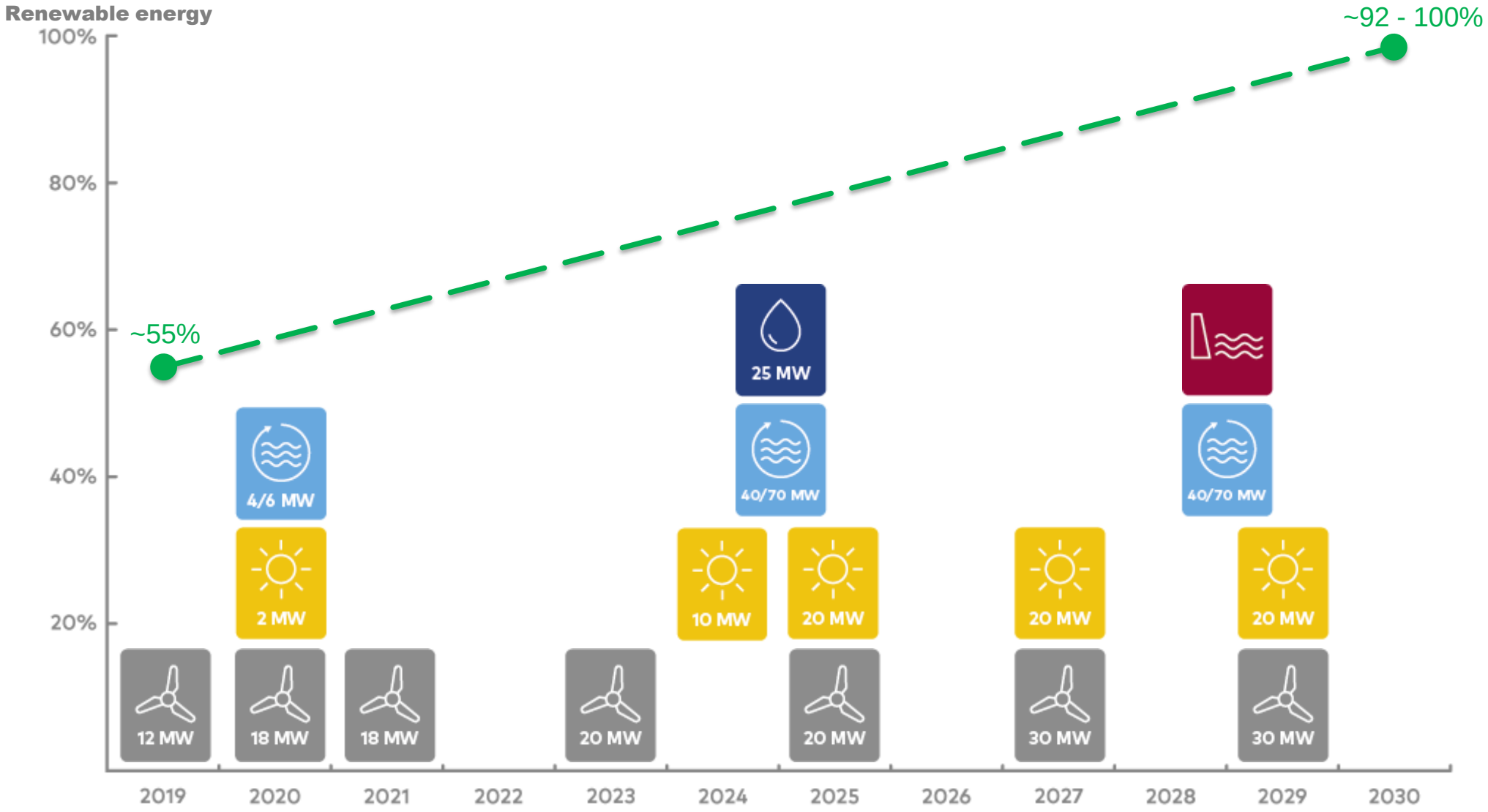
Resource complementarity



Our Vision: “100by2030”



2030 RoadMap



Reservoirs

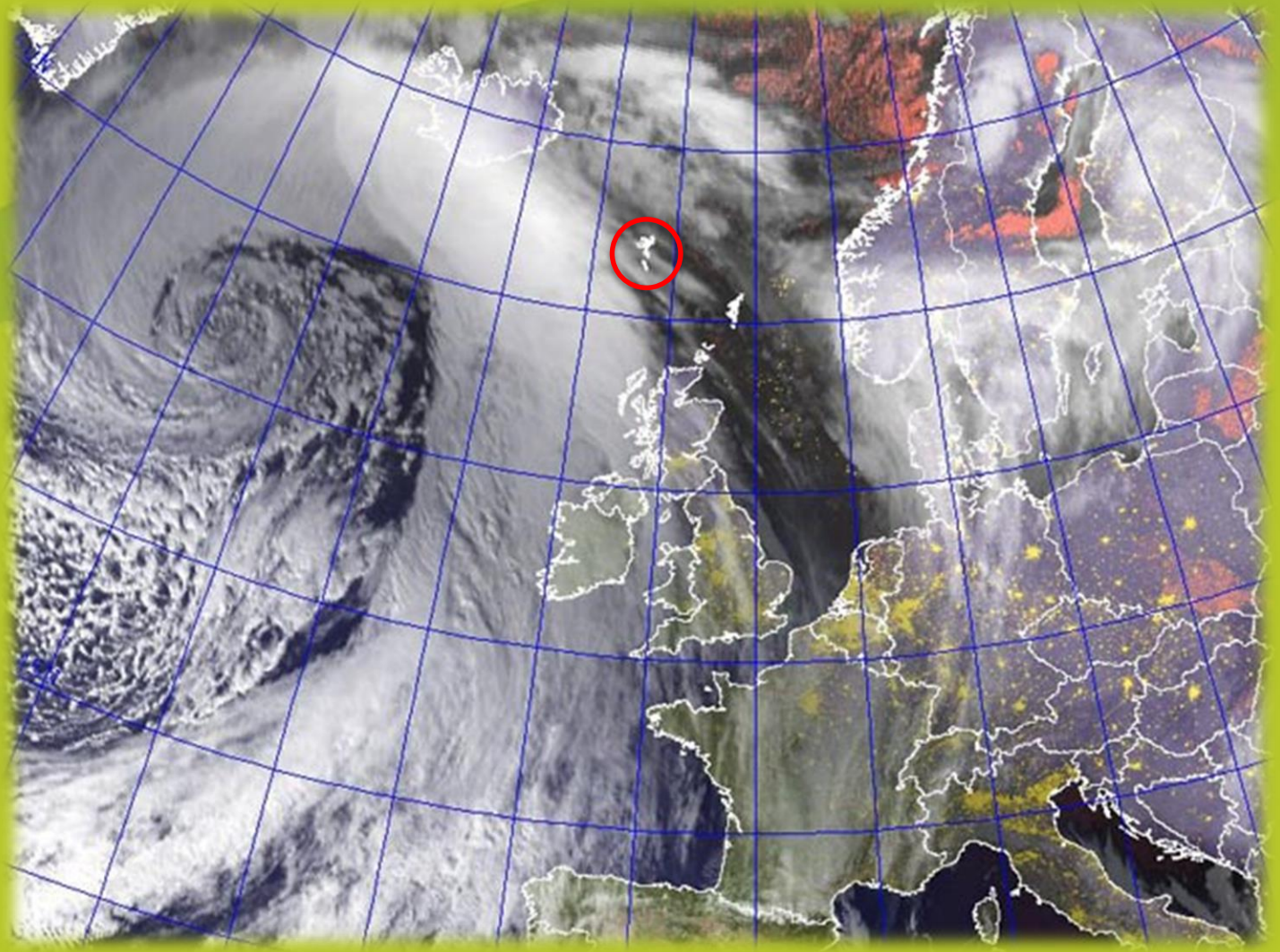
Hydro power

Pumped Storage

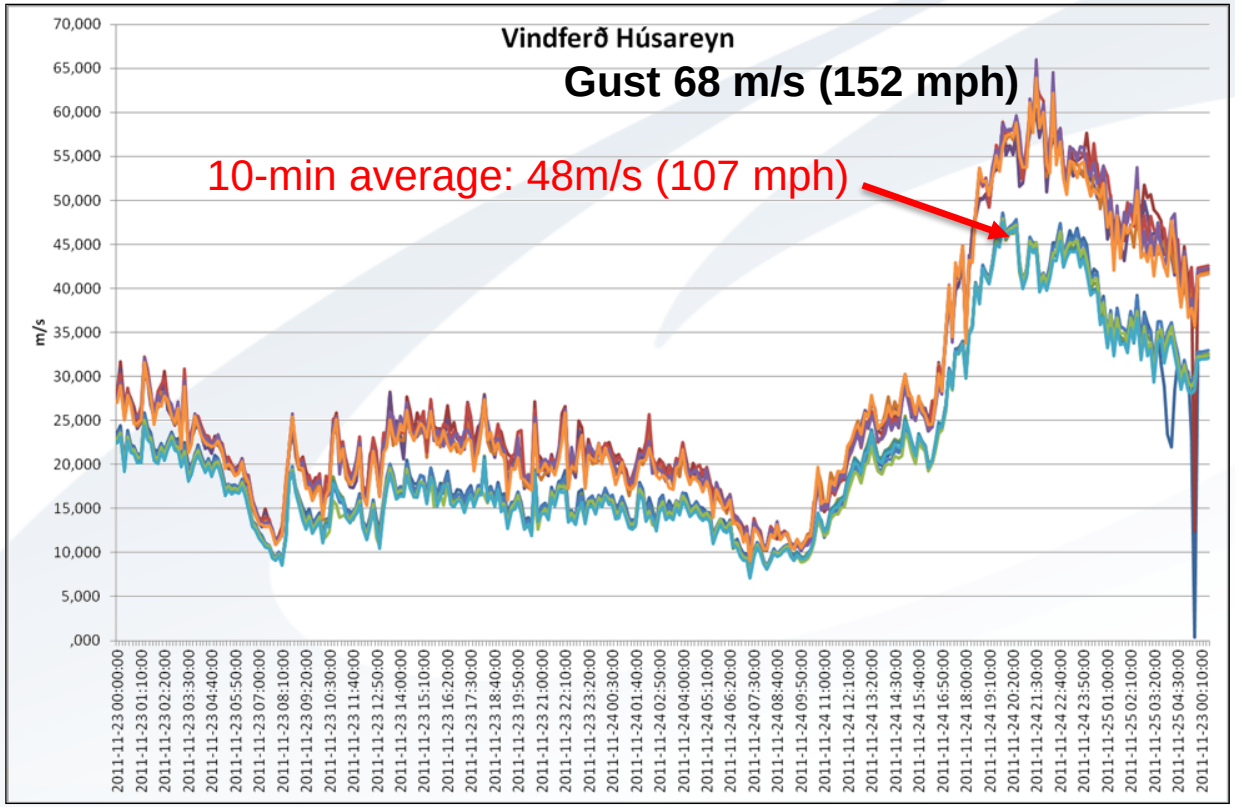
Photovoltaic

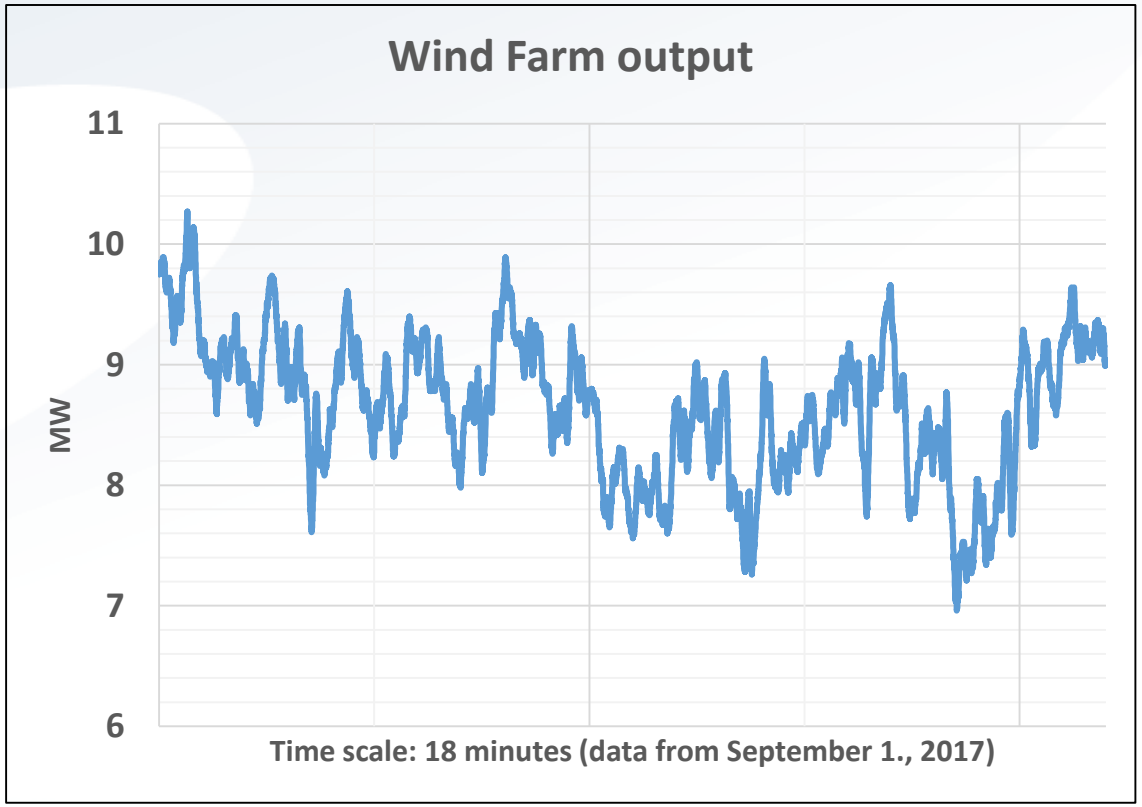
Wind power

Unstable weather conditions

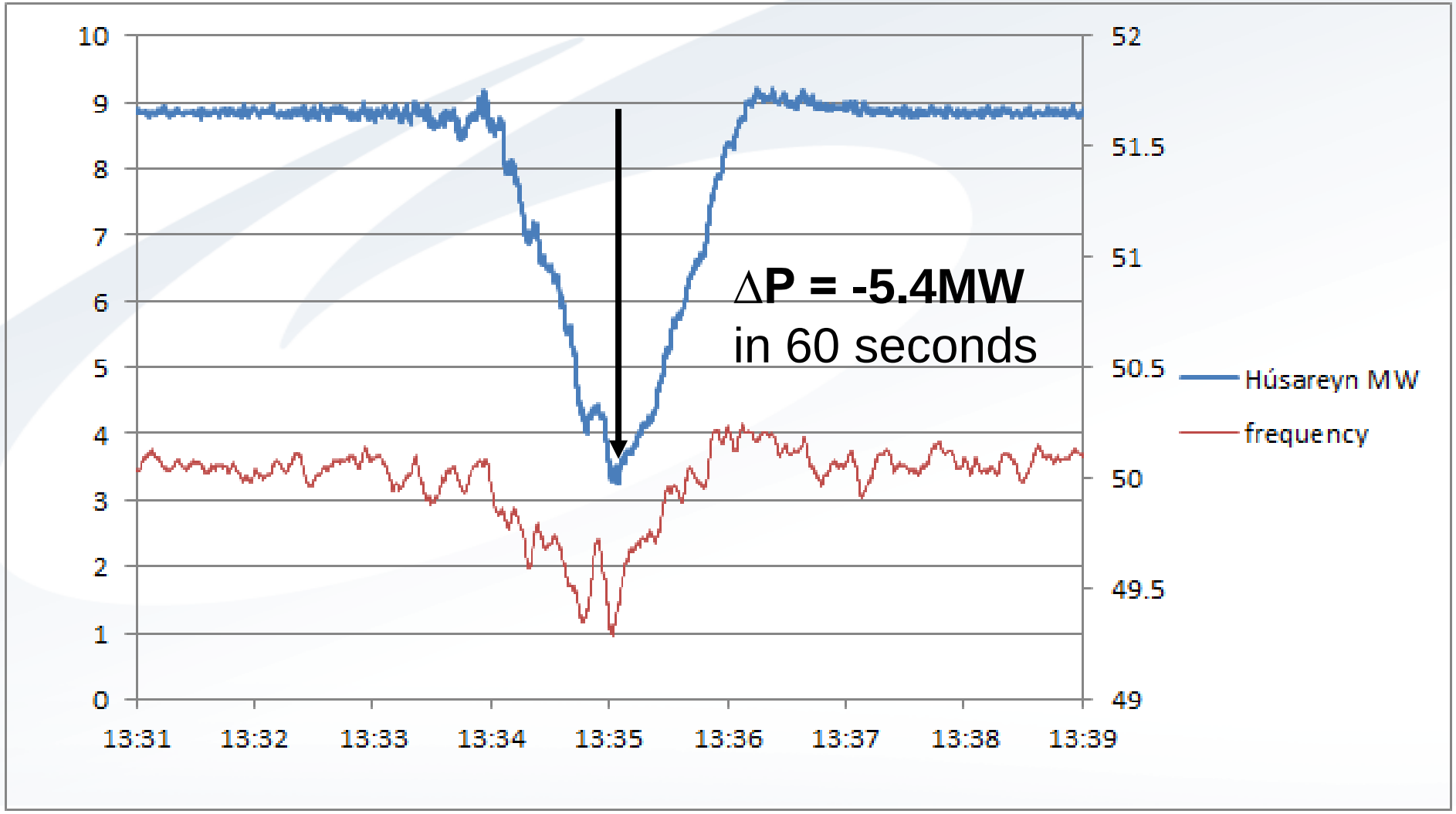


Wind conditions

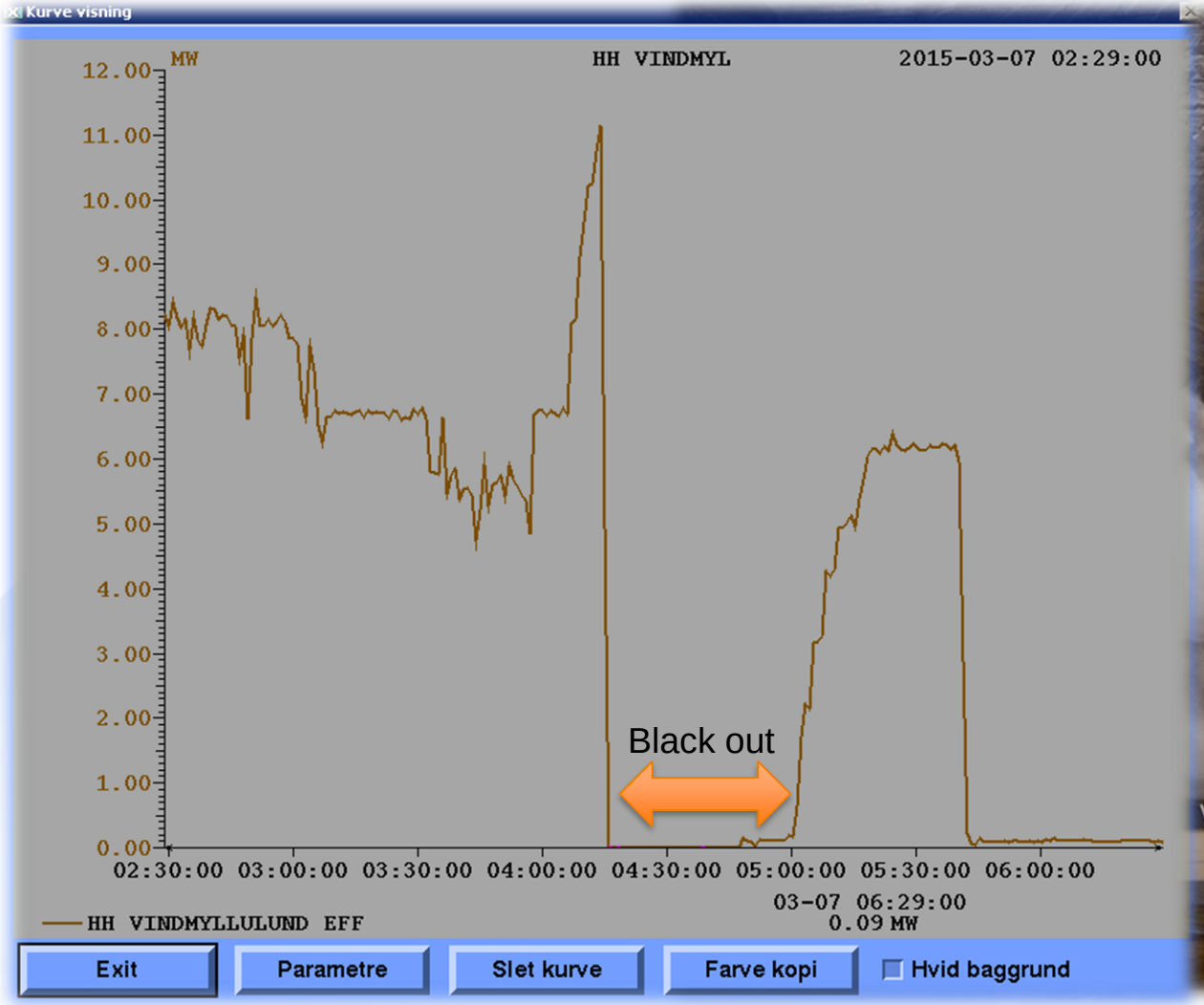




Extreme ramp rates (Húsahagi WF)



Challenging weather



“The best way to predict the future is to create it”
Abraham Lincoln

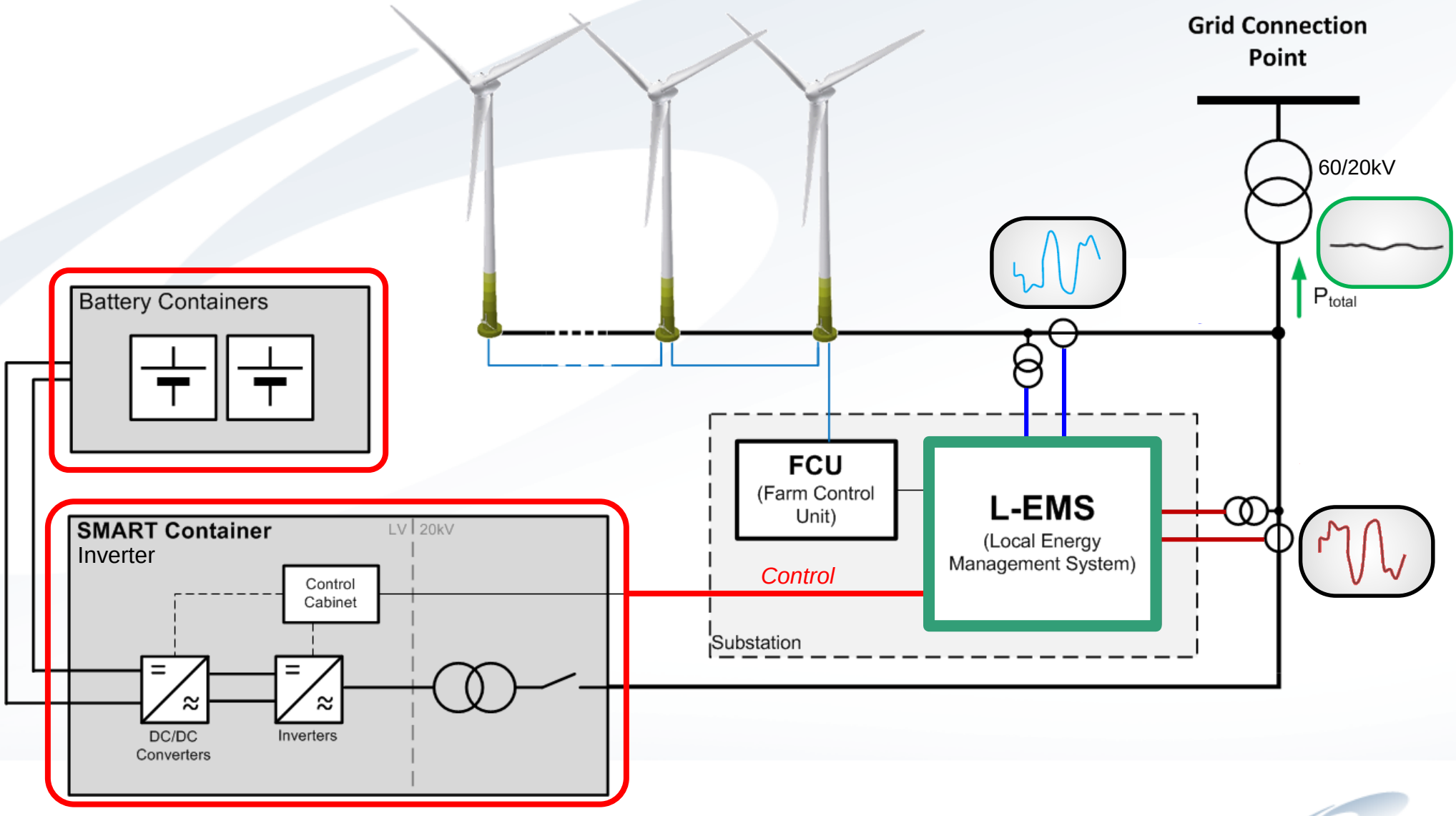
Battery Energy Storage system

smooth the variability of wind

Wind farm block diagram

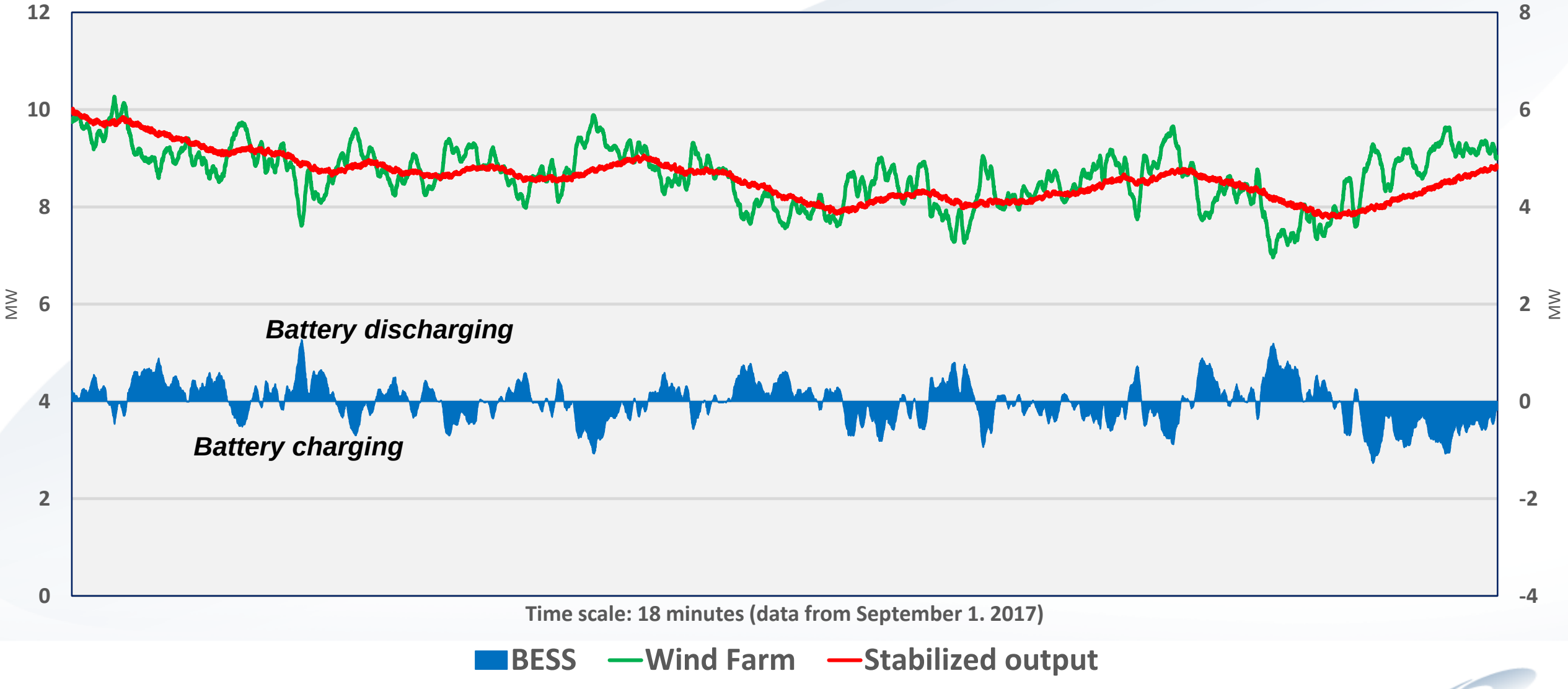
2 Intensium Max 20P	
Energy	707 kWh
Continuous discharge power	2 400 kW
Continuous charge power	1 500 kW
Nominal voltage	623 V
Voltage range	525V – 700V

ENERCON 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

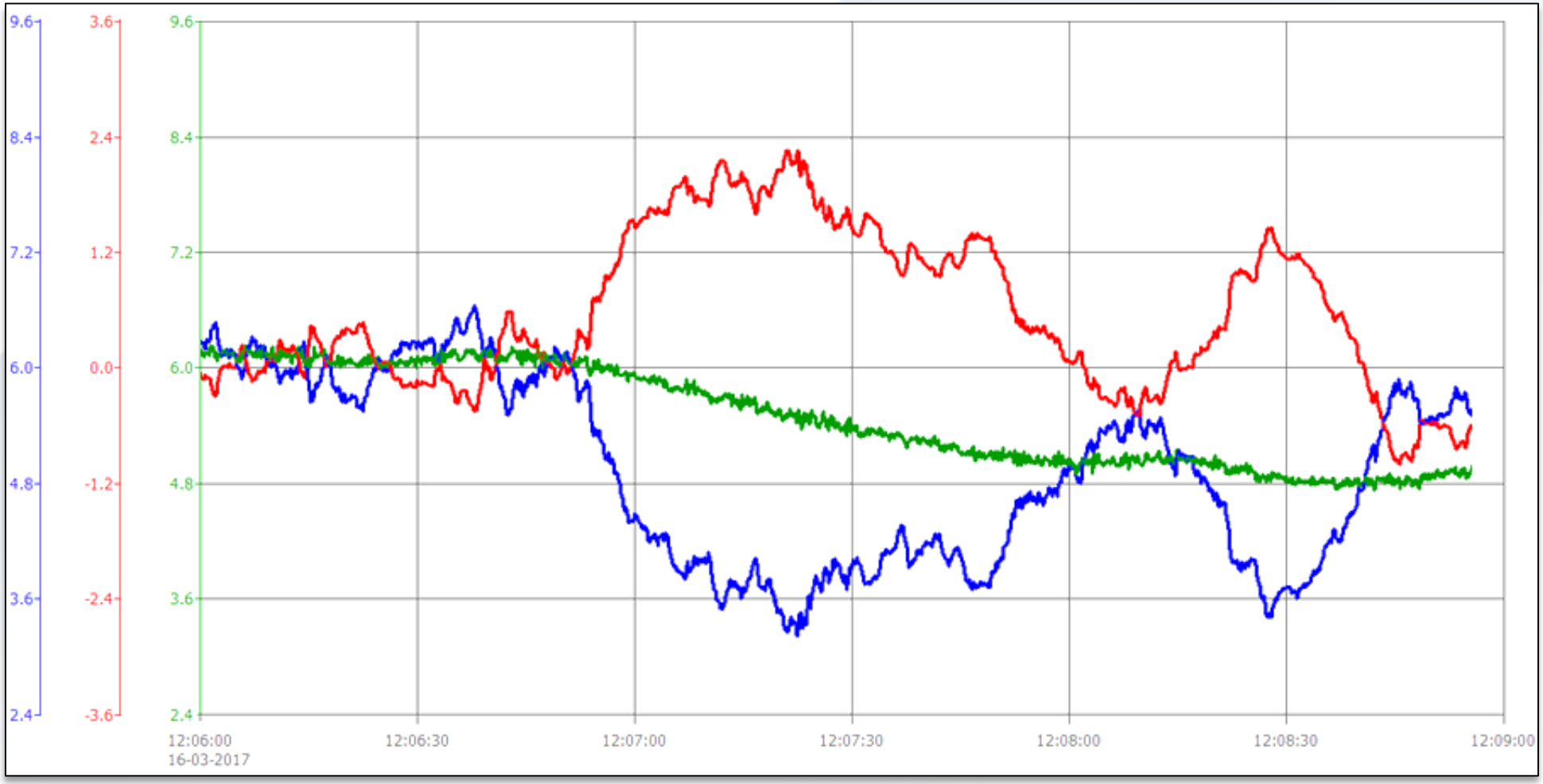



saft
Intensium Max
FKFU 500003 8

Battery system in operation

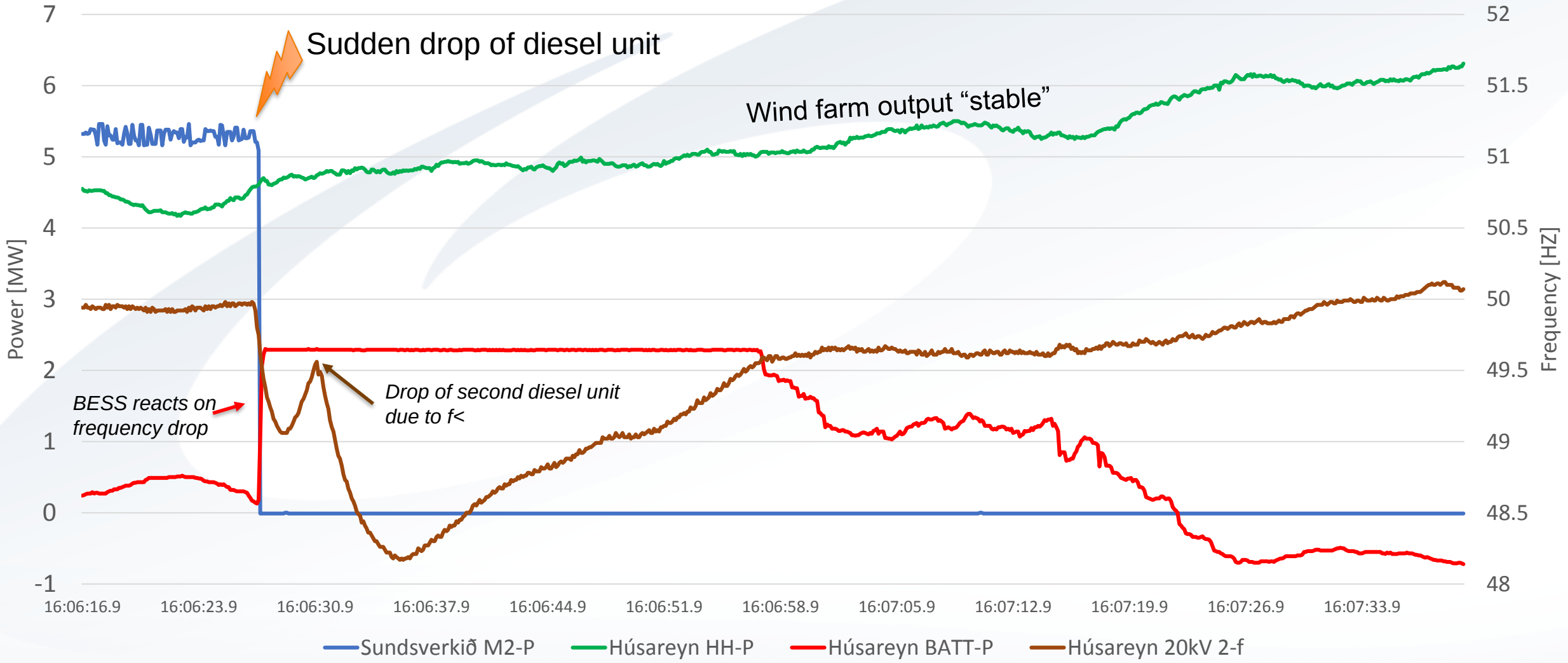


Battery system in operation



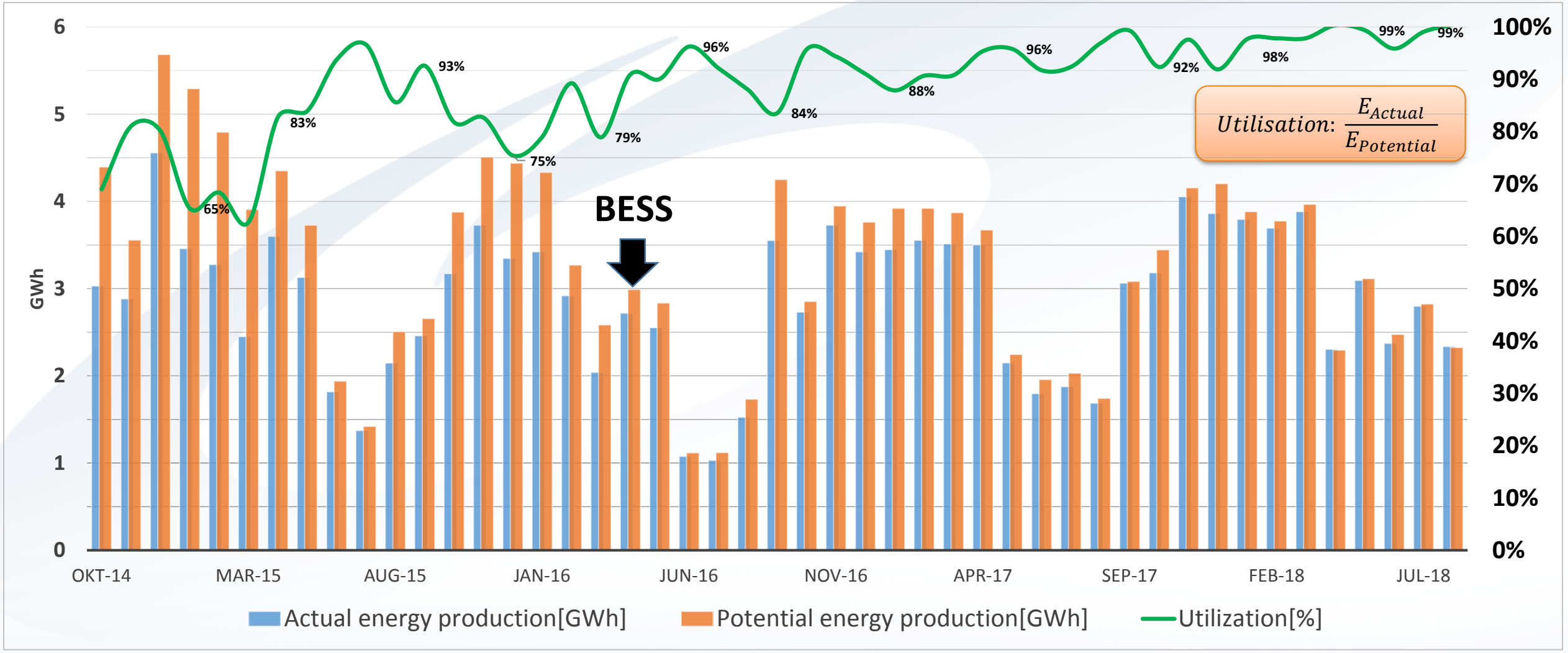
P_{Wind} [MW] P_{BESS} [MW] P_{total} [MW] = P_{Wind} + P_{BESS}

Fast frequency support from the BESS



Utilisation of Húsahagi Wind Farm

Curtailment in 2015: 22%
Curtailment in 2016: 12%
Curtailment in 2017: 6,7%
Curtailment in 2018: 1,8%



Business case for the BESS

- Assumptions
  - Increased wind utilisation is displacing oil production
  - Fuel oil cost: 0,09 €/kWh (not including other O&M costs)
  - Energy yield estimation based on wind measurements: 40 GWh/year
  - Cost of BESS (Batteries, ENERCON E-Storage, L-EMS): approximately 2 M€

- Simple payback time is calculated to 4.5 years.
- Estimated lifetime of batteries is 20 years.

Other renewable resources

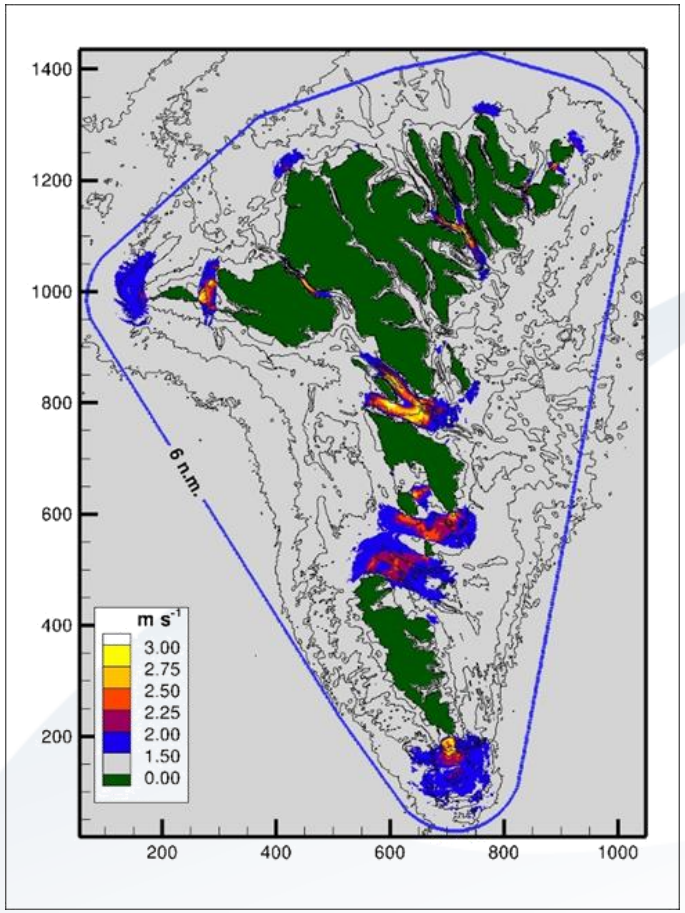
Hydropower

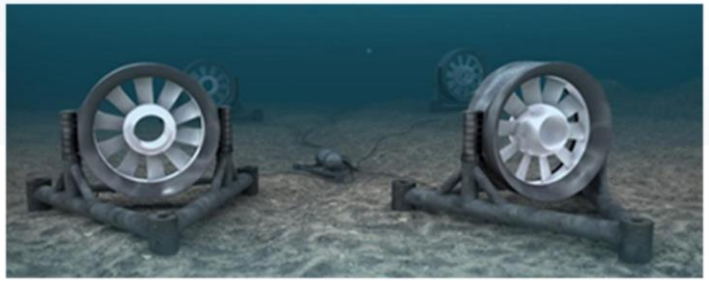
6 Hydropower plants

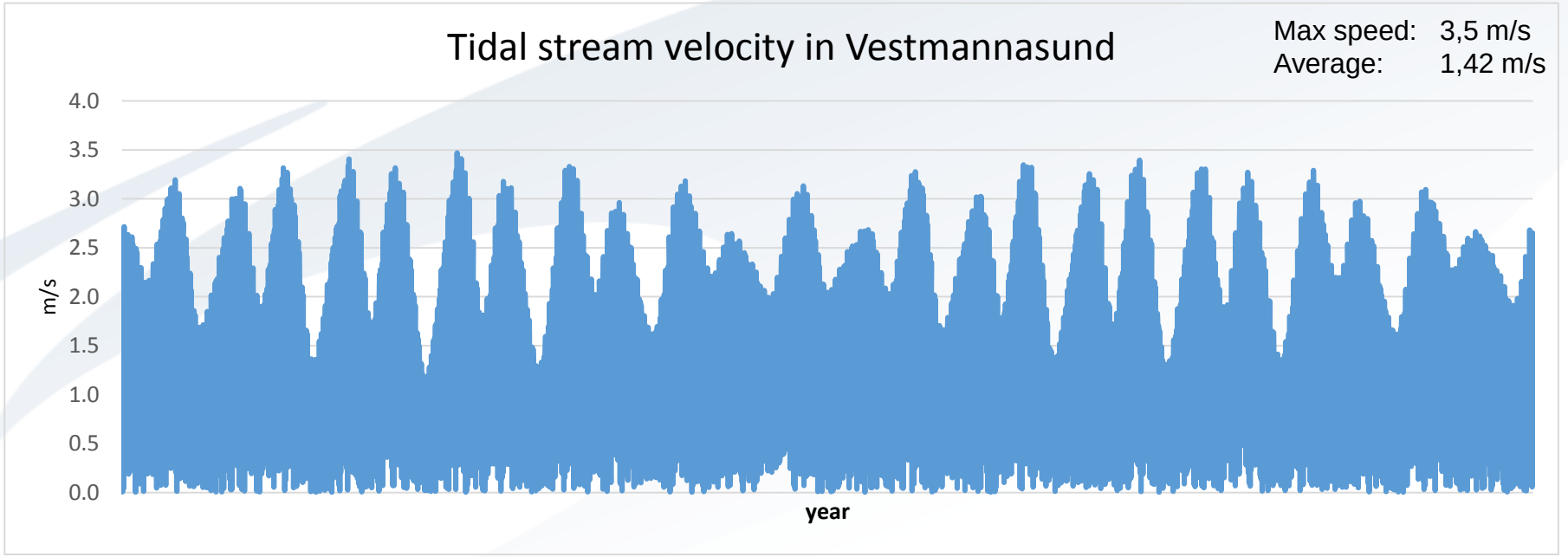
Total installed capacity: 37MW

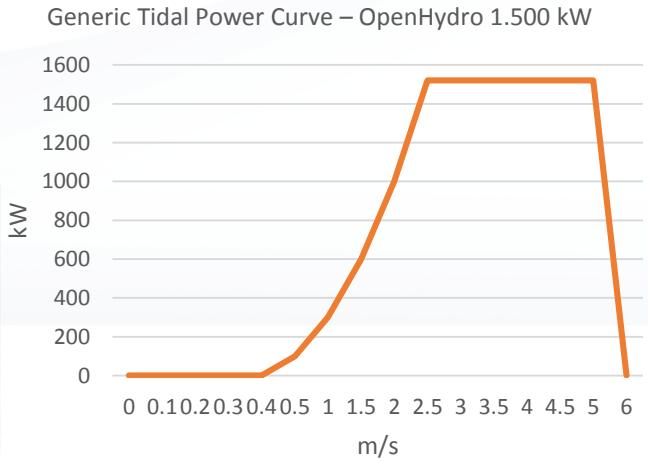
First installation in 1921

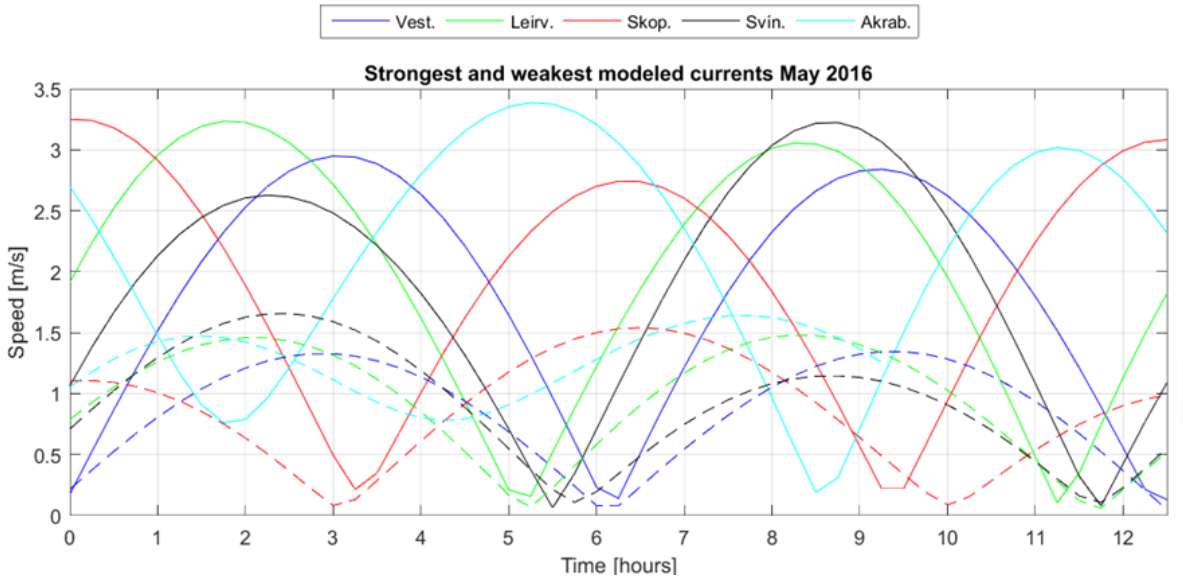
Tidal energy



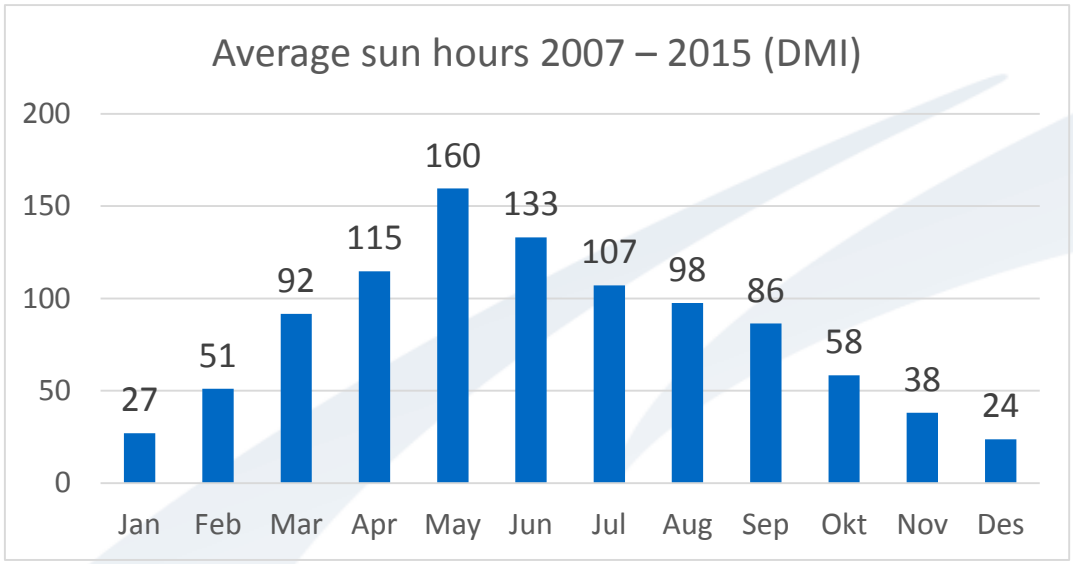


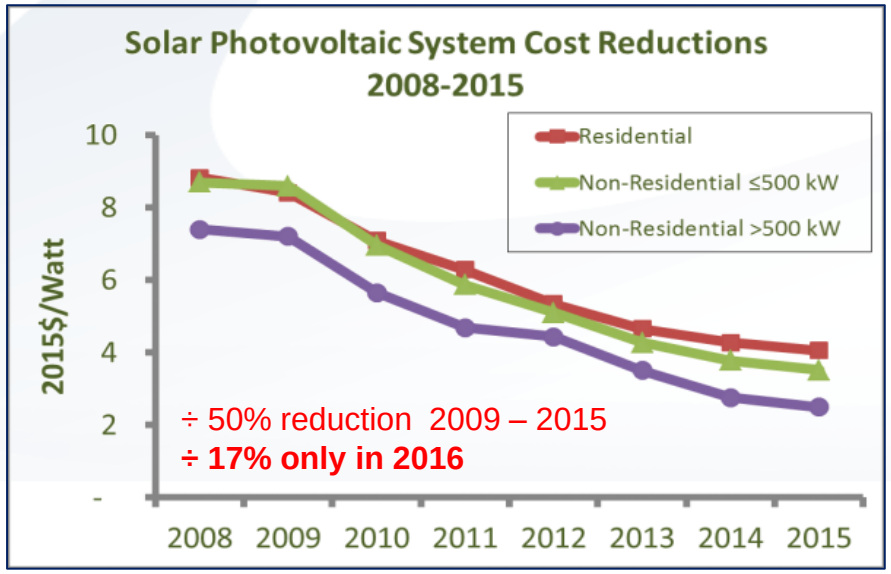


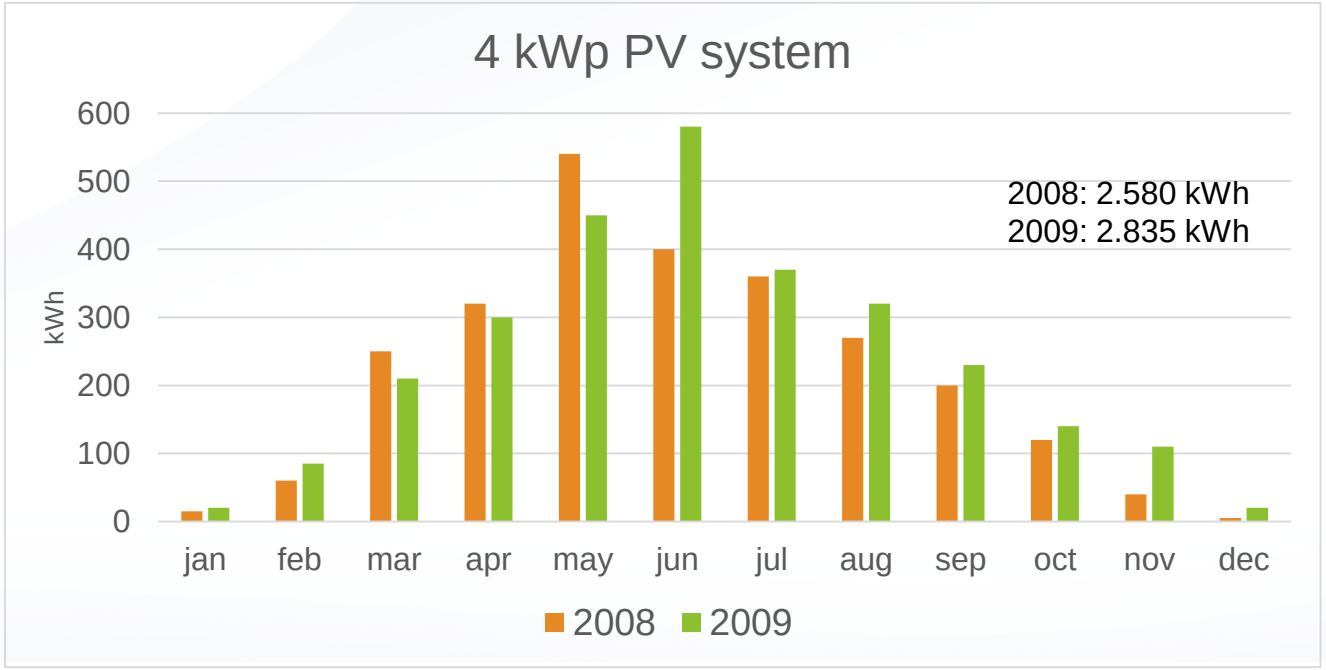




Photovoltaic







2030 Outlook

- Further integration of wind (projected 20-30MW every second year until 2030)
  - Batteries for short term storage (ms, sec, hrs) (10-20MW in 2020)
  - Synchronous compensators (separate units or retrofitted into existing prod. units)
- Integration of solar PV (Approximately 80MW until 2030)
  - Business models to incentivize private to invest in rooftop solar (distributed installations)
- Optimization of existing hydro power plants
  - Establishing Pumped Hydro energy storage for long time storage (hrs, days, weeks)
  - Increasing reservoir sizes
- Following tidal stream technologies and costs
  - High potential, predictable and with phase shifted tidal streams between the islands can provide base load generation
- Intelligent and autonomous overall control system
- Continuous optimization and updates of the transmission and distribution system

Thank you!

Terji Nielsen

Dipl.Ing. E.E. (hons)
MBA Renewables
tn@sev.fo