# *Managing massive wind integration in islands with battery storage*

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# Agenda

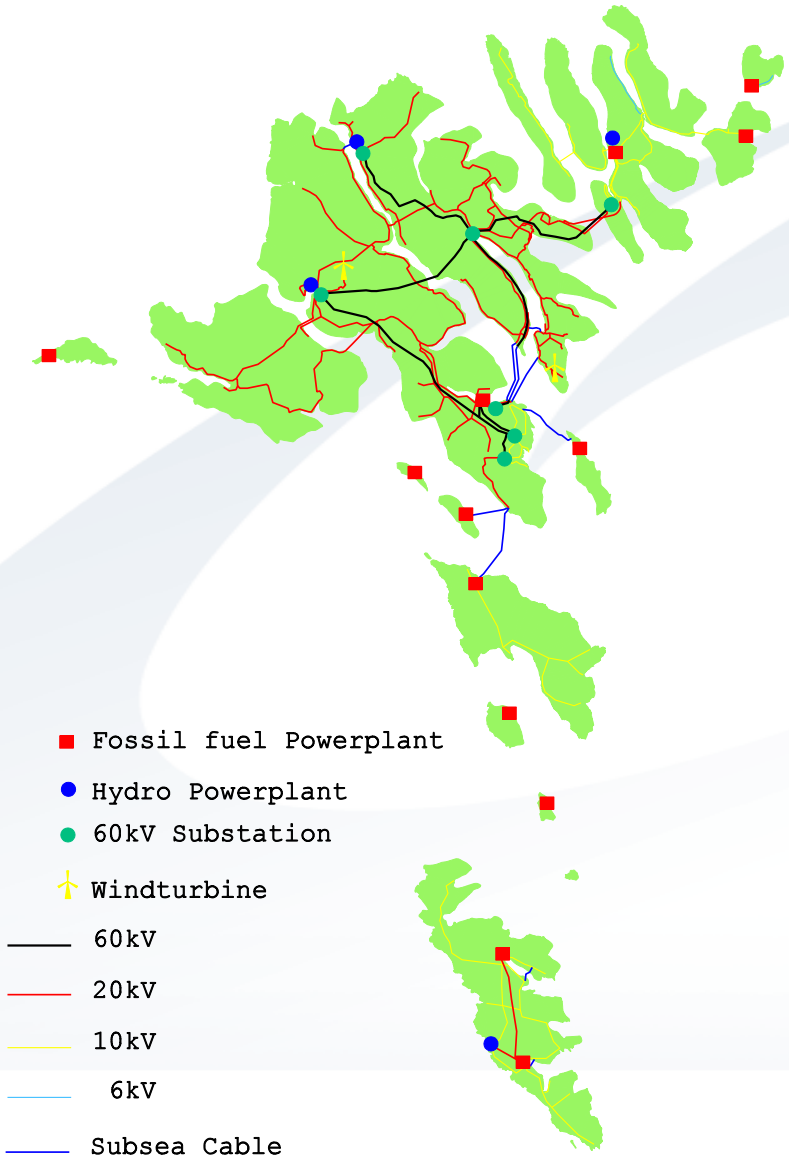
- General about SEV and SEVs Green vison
- Renewable resources in the Faroe Islands
- Challenges with integration of wind in isolated power systems
- Battery system in Húsahagi Wind Farm

# Faroe Islands


# Faroe Islands


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

# Electrical Company SEV

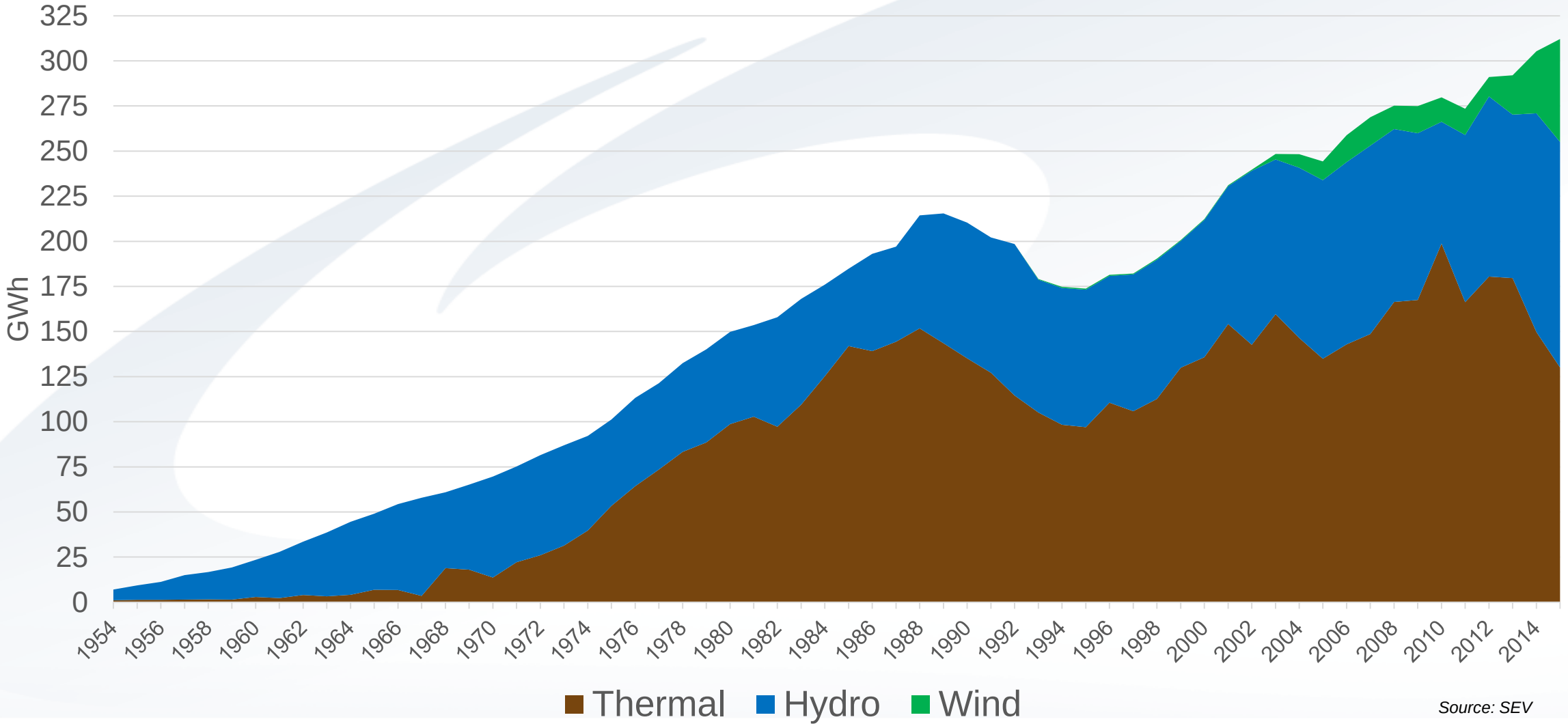



- **General company facts:**
  - Non-profit, founded 1st October 1946
  - 100 % owned by all Faroese municipalities
  - Vertically Integrated Company
  - Joint and several price structure

  - Isolated Hybrid Power System
  - Monopoly on grid operation *(transmission & distribution)*
  - "*De facto*" monopoly on production (98%)

  - *"Micro isolated system" in EU terms* *( < 500 GWh in 1996)*
    - *Directive 2009/72*
      - *Derogation from relevant provisions in different chapters about unbundling, third party access etc.*

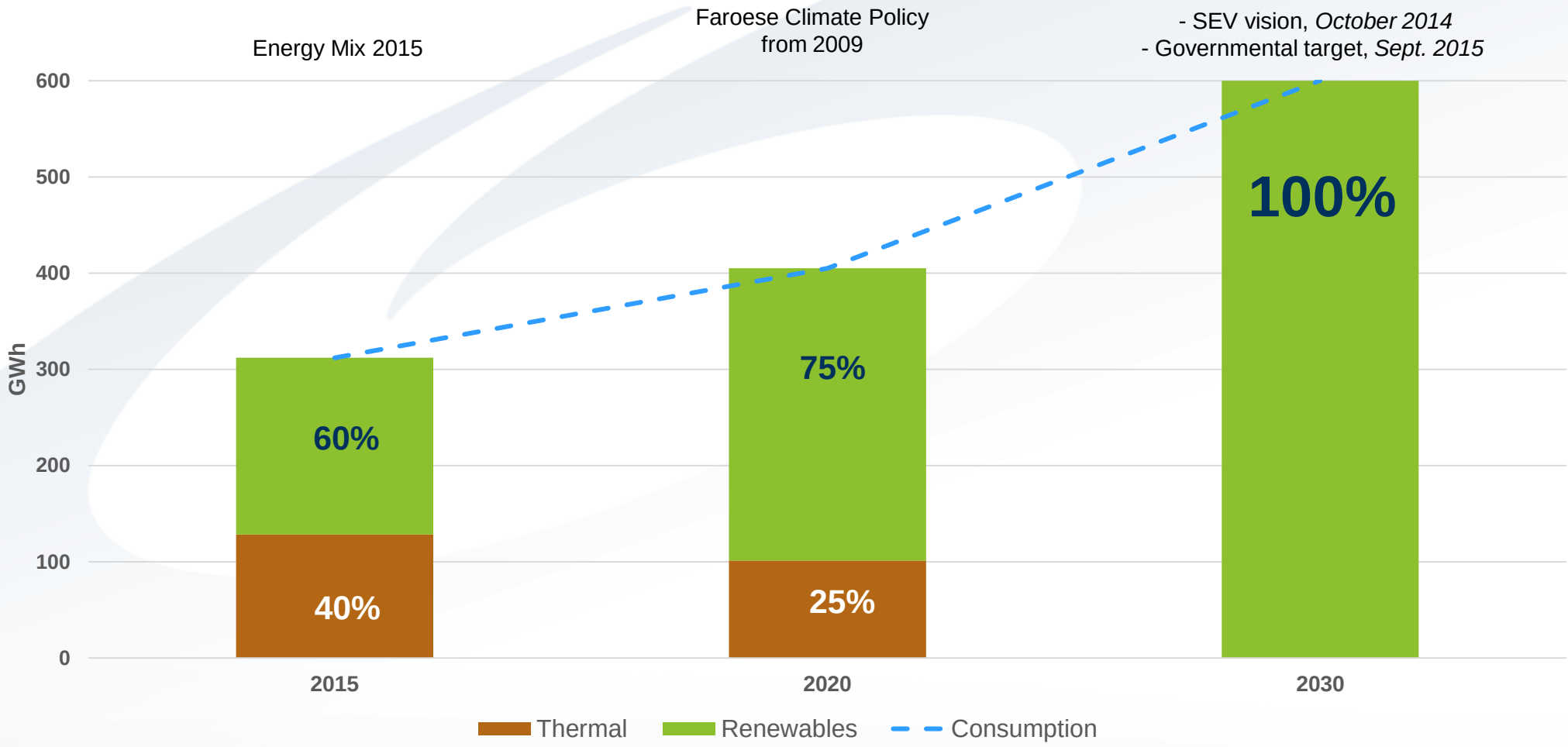
# Energy Mix 1954 - 2015




*Source: SEV*

# Main drivers for renewable energy in the Faroe Islands

# Carbon free electricity by 2030




*Assumptions:*
- *2% increase in consumption annually*
- *Linear electrification of Heating 2016 – 2030*
- *Linear electrification of transport on land*

# Renewable resources in the Faroe Islands

# Renewable resources

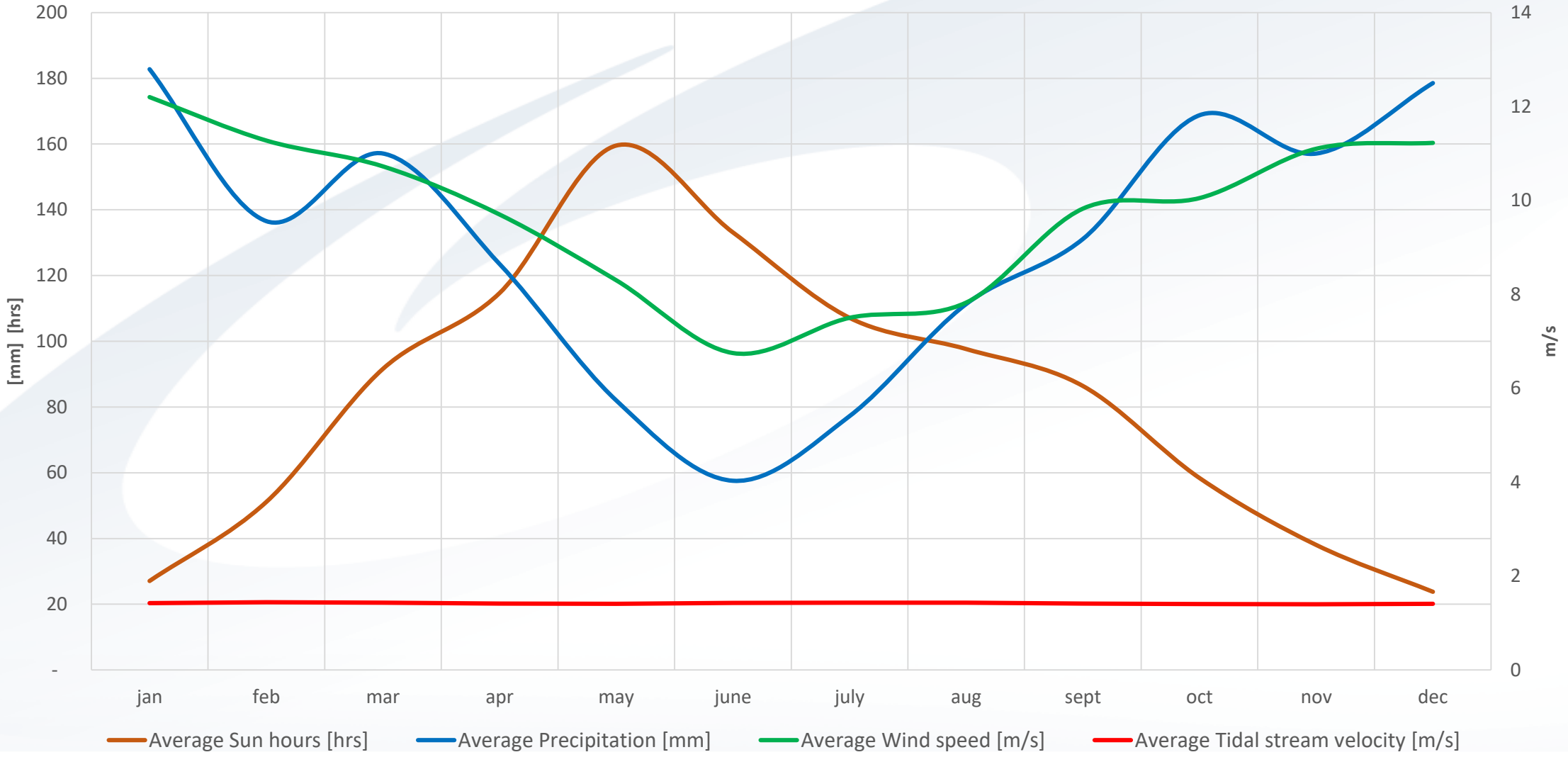
Average wind speed: > 10m/s

Precipitation: > 1284 mm/year *DK: 712 mm/year*
*NO: 1000 mm/year*

Peak tidal velocities: ~ 3.5 m/s

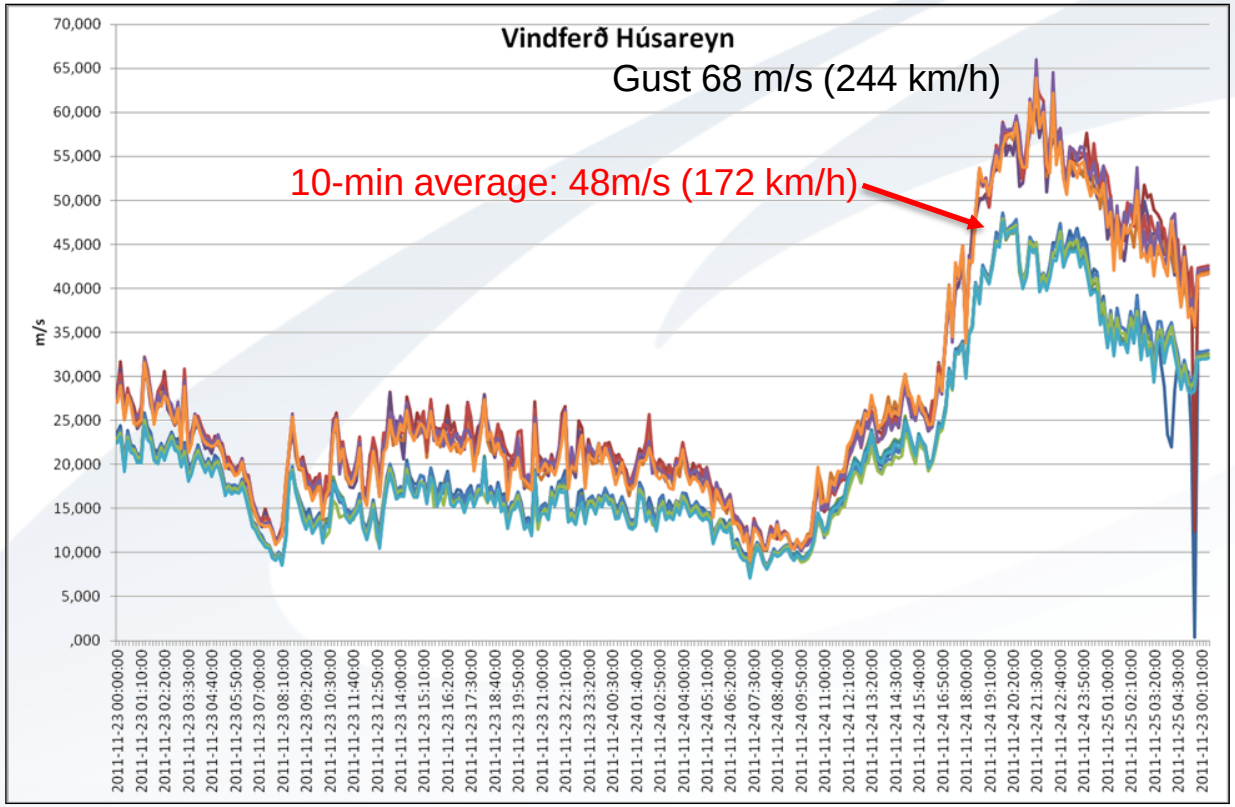
Average sun hours: ~ 1000 hrs/year (DK: 1495 hours)

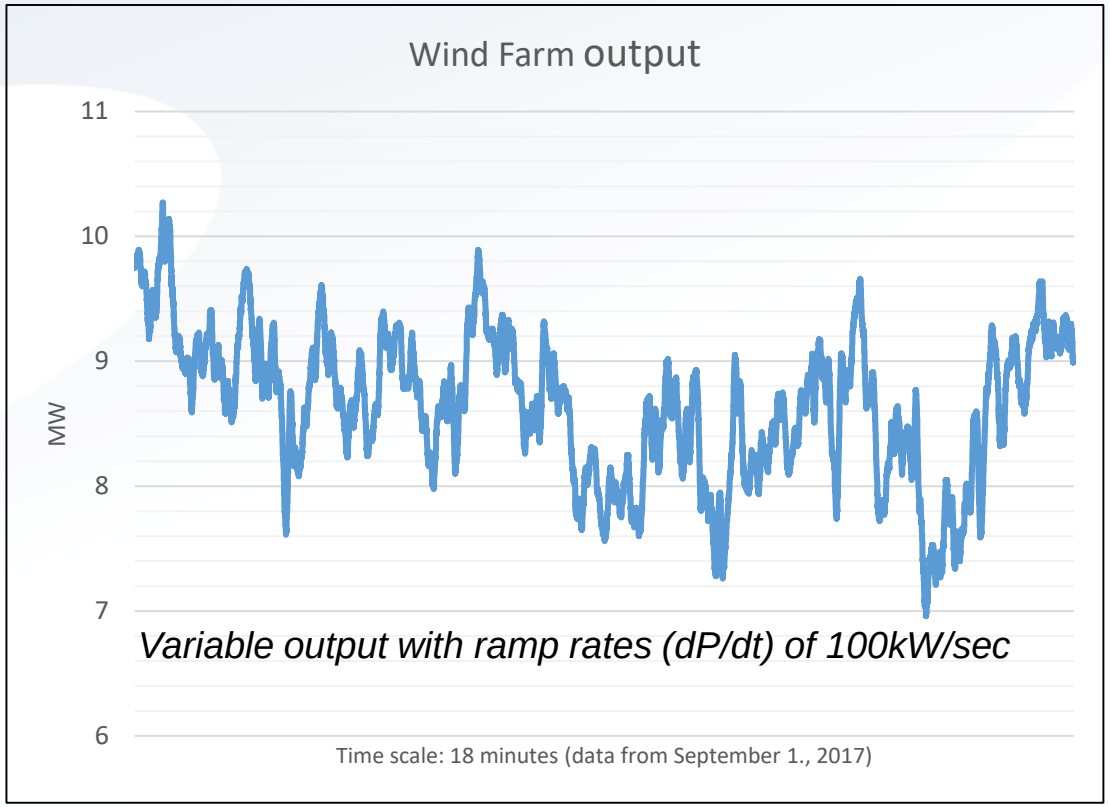
# Correlation between the resources



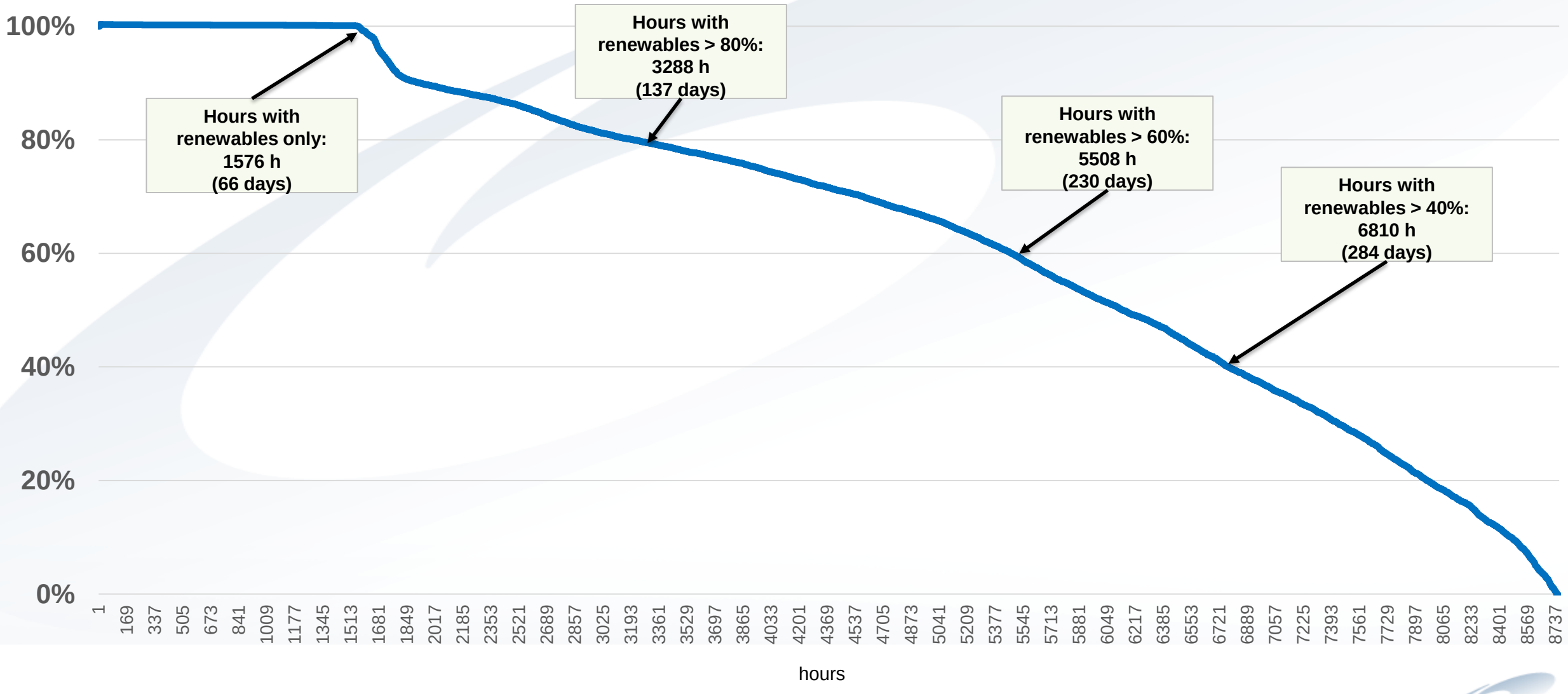
# Wind energy

# High and variable windspeeds



# Renewable energy duration curve 2015



# 100% RE generation

# The Neshagi Wind farm

**Project specification:**

- *3 pcs ENERCON E44/900kW (2,7MW)*
- *Capacity factor: 45%*
- *Annual production: 10,6 GWh*
- *Building phase: 2011-2012*

**Economical figures:**

- *Total cost: 3.5 MEUR*
- *Oil savings: 2.300 ton/year*
    - *approximately 1 MEUR/year*

**Carbon footprint:**

- *Annual $CO_2$ reduction: 7.000 ton/year*

# The Húsahagi Wind farm

**Project specification:**

- *13 pcs ENERCON E44/900kW  (11.7MW)*
- *Capacity factor: 42%*
- *Annual production: 41 GWh*
- *Building phase: 2013-2014*

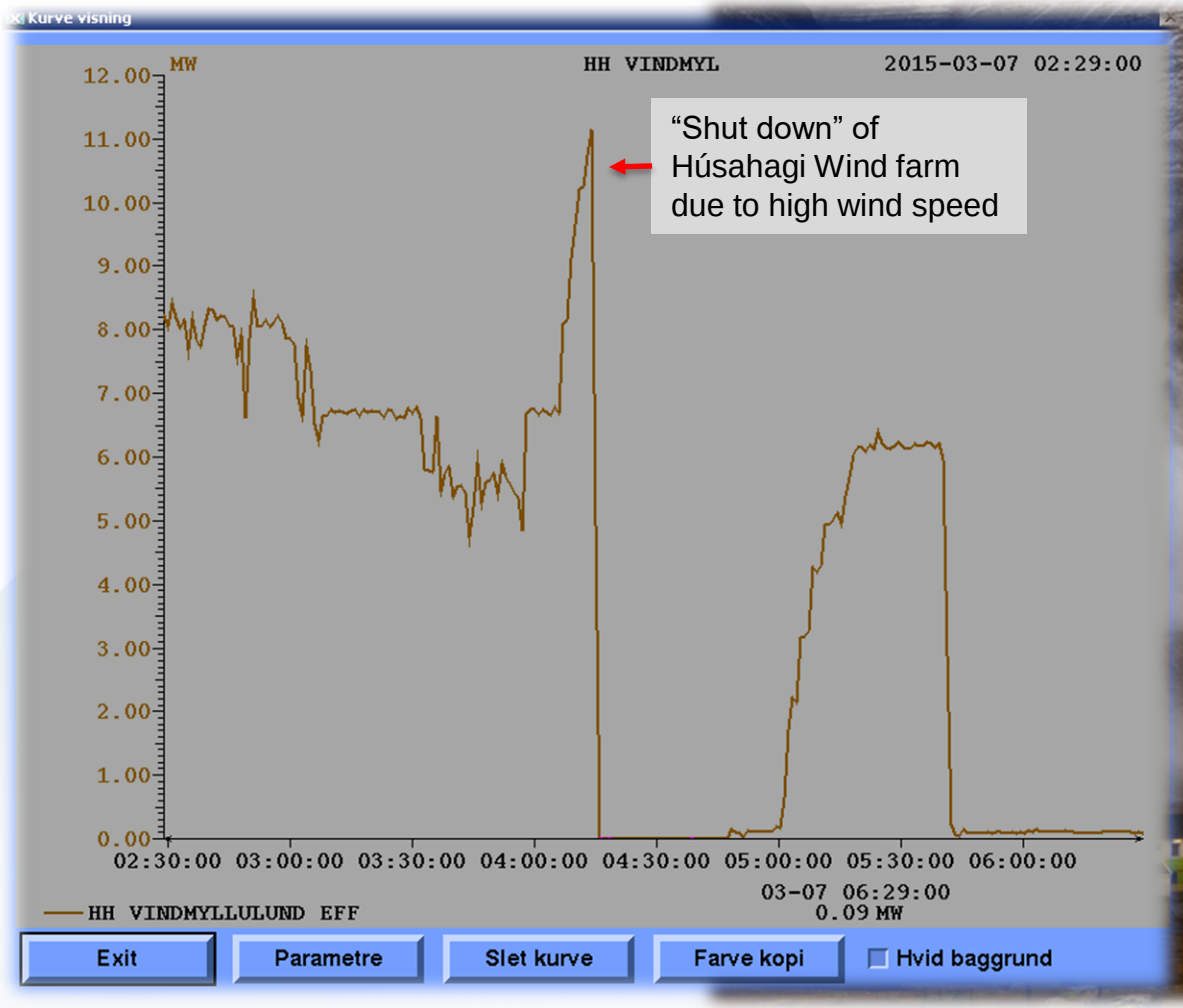
**Economical figures:**

- *Total cost: 13,6 MEUR*
- *Oil savings: 8.000 ton/year*
    - *approximately 3 MEUR/year*

**Carbon footprint:**

- *Annual $CO_2$ reduction: 28.000 ton/year*

# Challenging weather conditions




"Shut down" of Húsahagi Wind farm due to high wind speed

# Batteries to mitigate the intermittency of Wind Power

# Schematic overview of battery system

**WTGs: 11.7 MW**
13x E-44 900kW

$P_{WTG}$

$P_{total}$

Main Grid

20/60kV

20MW – 53MW

**BESS**

***Li-Ion Battery***


**2014**

**2016**

$P_{BESS}$

20kV
AC

***Inverter***
*(Smart Container)*

DC
Bus


**L-EMS**
controller

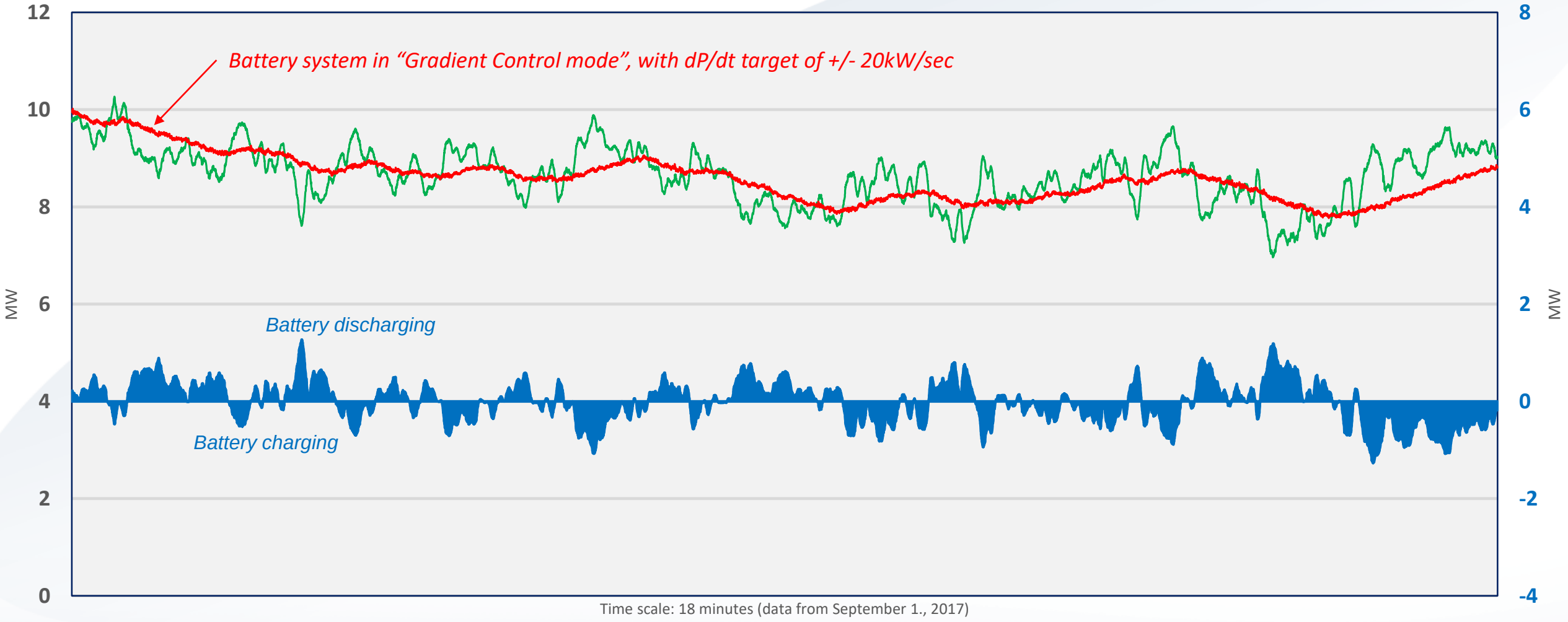
# Battery system specifications

- **Key features:**
  - 2 Intensium® Max 20” containers
  - DC bus 10” container
  - Nominal 620V DC
  - 700 kWh
  - 2.3 MW
  - ENERCON 2.3 MVA power conversion and control system (40” container)

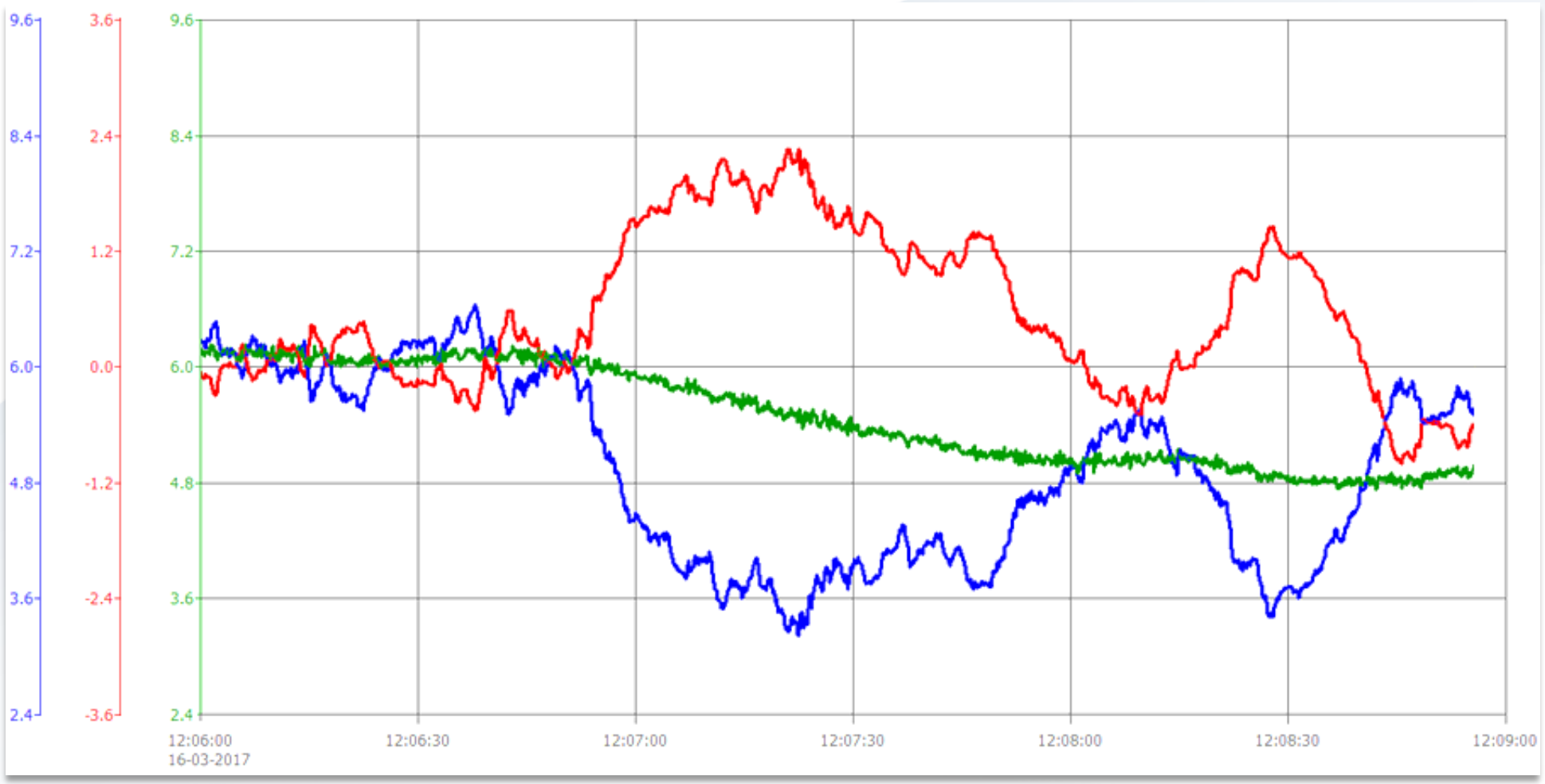
- **Key benefits:**
  - Enhanced grid stability
  - Smoothing ramp rates
  - Frequency control
  - Minimizing curtailment

*Battery system in Húsahagi, Faroe Islands*

# Battery system in operation



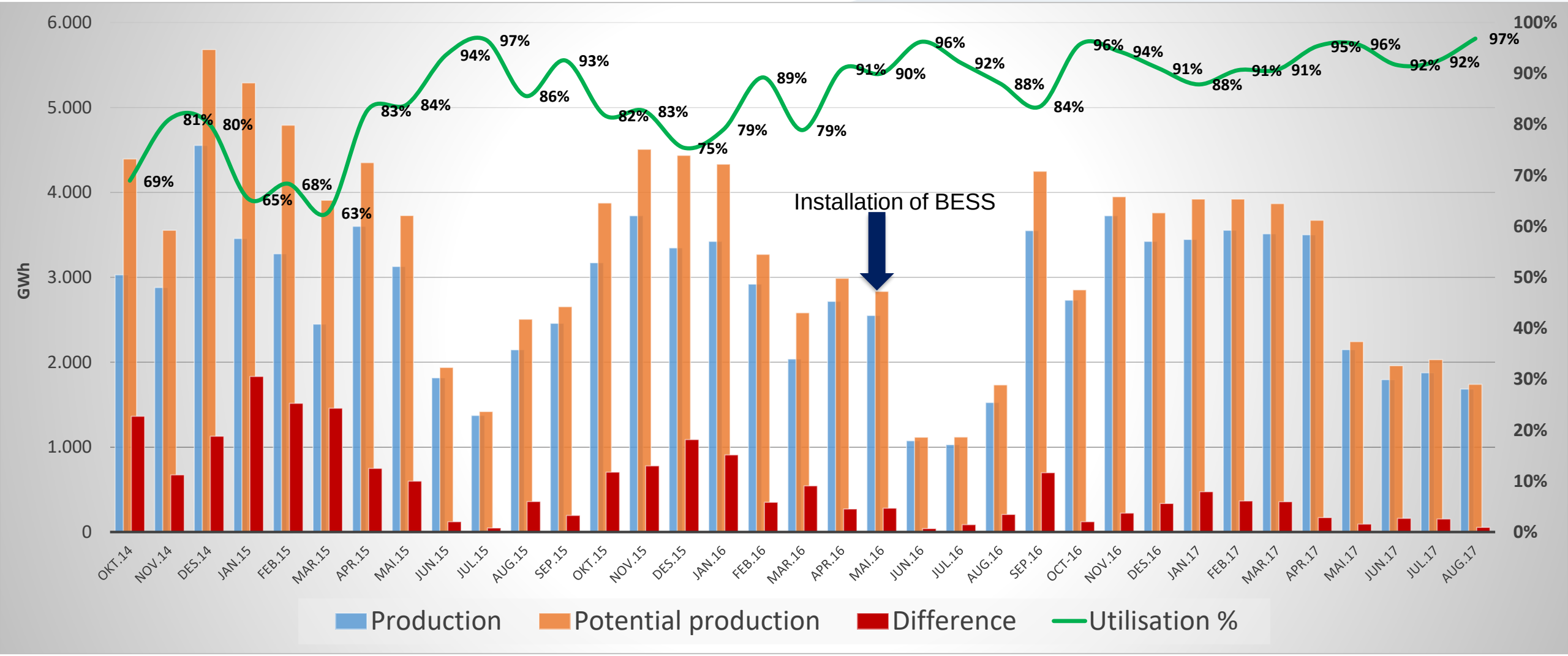
# Battery system in operation




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

# Utilisation of Húsahagi Wind Farm

Curtailment in 2015: 22%
Curtailment in 2016: 12%
Curtailment in 2017: 7%



# Conclusion (after 1.5 years operation)

- The installed battery system does mitigate the variability of the intermittent wind power
- Utilisation of the wind farm has increased since the installation of battery storage.
- If we assume that the increased utilisation displaces the same amount of energy production from fossil fuel generation, the payback time on the BESS capital costs are approximately 4-5 years.
  - *Cost of 1kWh produced by oil used in the payback time calculation: 0.09 €/kWh*

*” We simply must balance our demand for energy with our rapidly shrinking resources.*
*By acting now we can control our future instead of letting the future control us”*

*Jimmy Carter 1977*

# Thank you!

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