# Section for Power-to-X and Storage

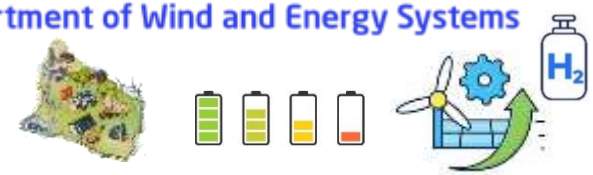
— *since 2022-05-01*


**PhD, Head of section, Chresten Træholt**

Section of PtX and Storage
Division of Power and Energy Systems
Department of Wind and Energy Systems
Technical University of Denmark

28/09/2022
ctra@dtu.dk

# Department of Wind and Energy Systems

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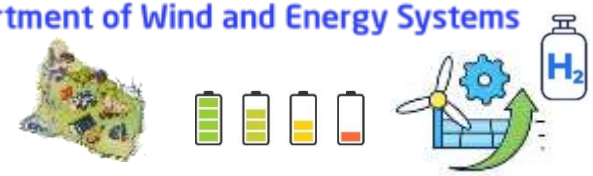
# The Energy Systems






Renewable Energy Generation

Smart Utilization of Available Energy

**Production vs Consumption**

**Main land vs island**

**Small scale vs large scale**

**AC vs DC**

**Power vs Energy**

**+**

**Short term vs long term**

**STORAGE**


***Mission:*** *DTU Wind & Energy Systems develops science and creates value for society for a sustainable and integrated energy system with wind energy as the backbone.*

# GWh, GW and ramp rate

***Getting it "straight"***

- Energy
- [J], [GWh], [cal]

- E = ∫Pdt

- Power
- [J/s], [GW]

- P = ∫(ramp rate)dt

- Ramp rate
- [J/s$_2$], [GW/s]

- ramp rate = dP/dt


- Storage
- Storage size
- Storage capacity
- Storage duration

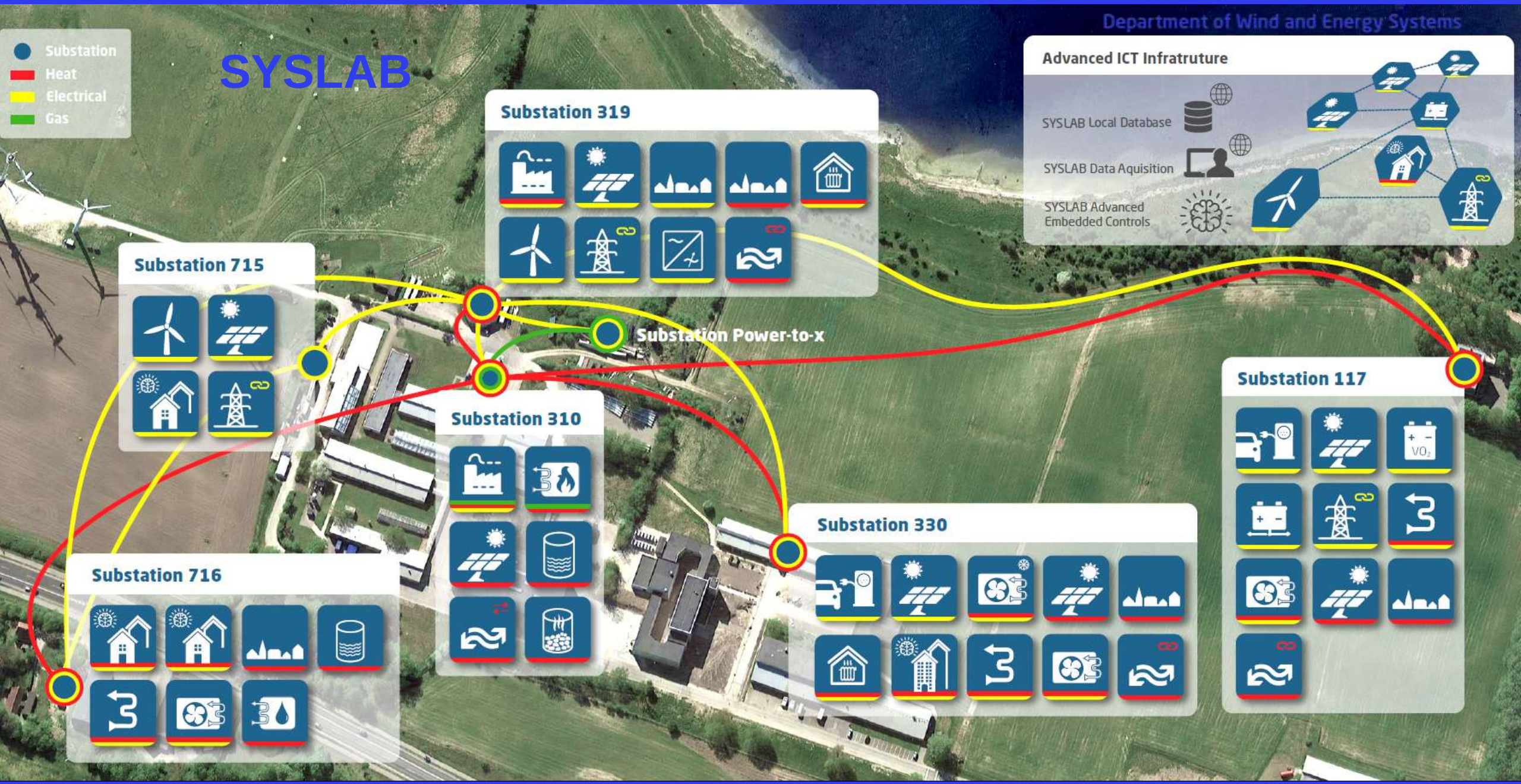
- Power injection ability
- Converter power
- Converter size
- Converter numbers

- BESS
- Capacitors
- Fly wheels,
- Synchr. condenser

- EV range

- EV acceleration

- Conventional plants
- Fuel cells
- Electrolyzers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SYSLAB
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SYSLAB Local Database
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Substation 715
Substation Power-to-x
Substation 310
Substation 716
Substation 330
Substation 117

# Supporting the grid with V2G

## *Frederiksberg Utilities, Copenhagen*

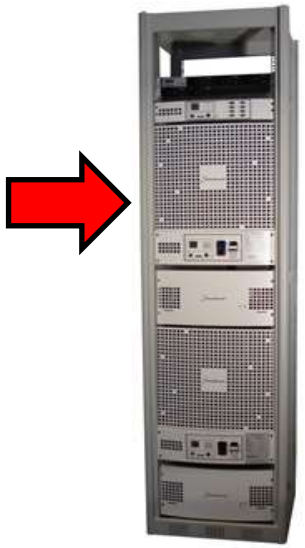
# Secure Power for Grid Control, SPGC

***Replacing lead acid batteries backup with Fuel Cells***

**(From 12-2017 to 12-2022, total budget: 9.5 mio. DKK;EUDP support: 4.6 mio. DKK; CEE 1.6MDKK)**

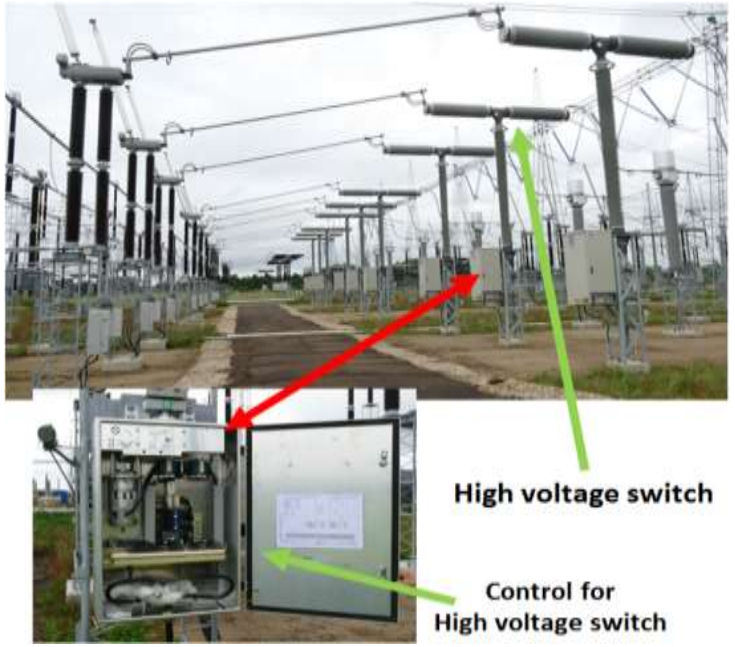
The project **aims** to demonstrate **fuel cells** for more than **24-hour** backup power supply in critical TSO (e.g. *Energinet 400kV-station Idomlund*) & DSO (*e.g. Thy-Mors Energi 60kV-station Sindbjerg*) to **replace lead acid batteries** (*with only 4-6 hours backup power*) as a cost competitive & environmentally friendly solution.

Lead acid batteries



Ballard fuel-cell

Fcgen-H2PM 5kW/48V




## Project partners:

Ballard Power System Europe A/S
Energinet.dk
Thy-Mors Energi
DTU Wind and Energy Systems

# 100 MW Green Hydrogen

***Production in a replicable and scalable industrial environment***

GreenHy SCALE

https://greenhyscale.eu/

**Project information**

Funding: H2020-LC-GD-2020-1

Grant no.: 101036935

Duration: 1 Oct. 2021 – 30 Sep. 2026

Coordinator: GREENLAB SKIVE AS

Total budget: € 52 982 523,75

DTU budget: € 1 279 577,50

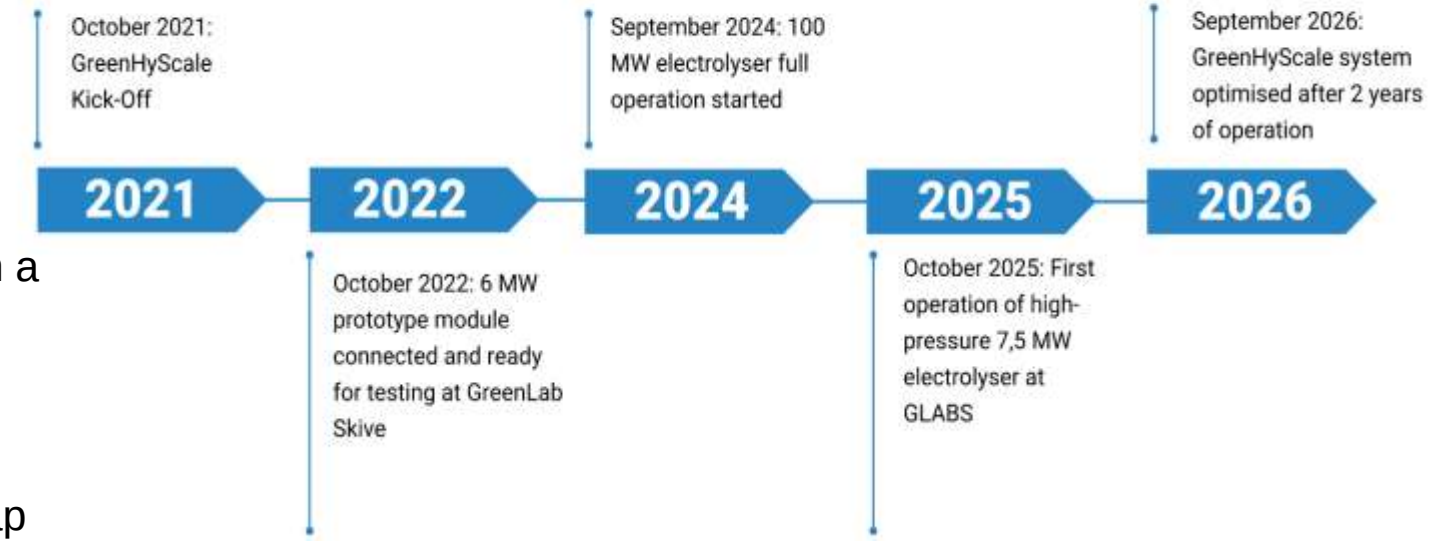
**Project objective**

Develop and demonstrate 100MW electrolyser plant in a replicable and scalable industrial hosting environment

**PTX's role**

Plant design, grid integration, grid services, H2 roadmap

## GLOBAL TIMELINE

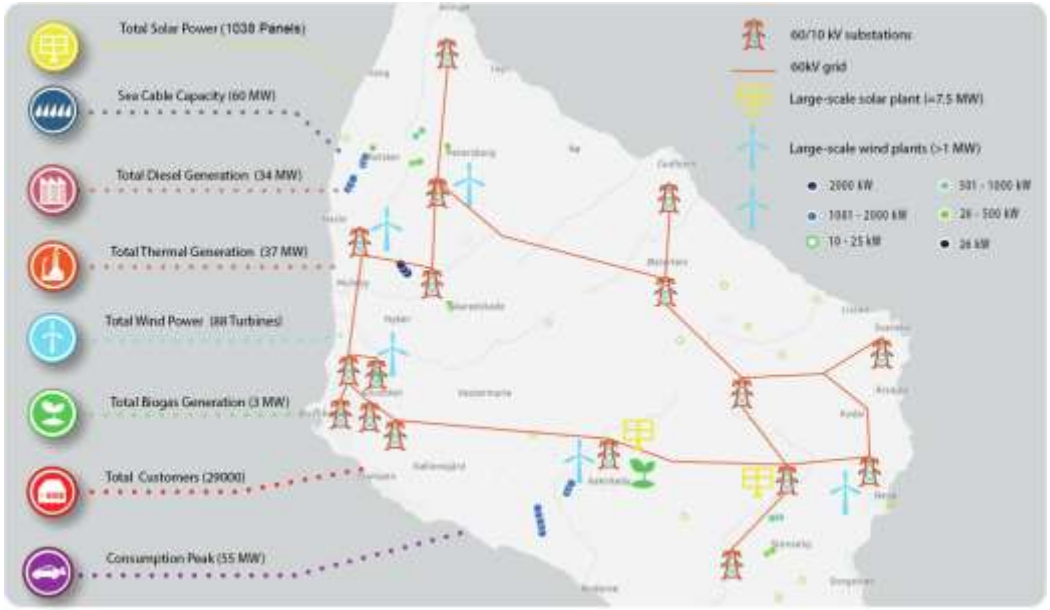


# BOSS – Danish battery demonstration

https://boss-project.com

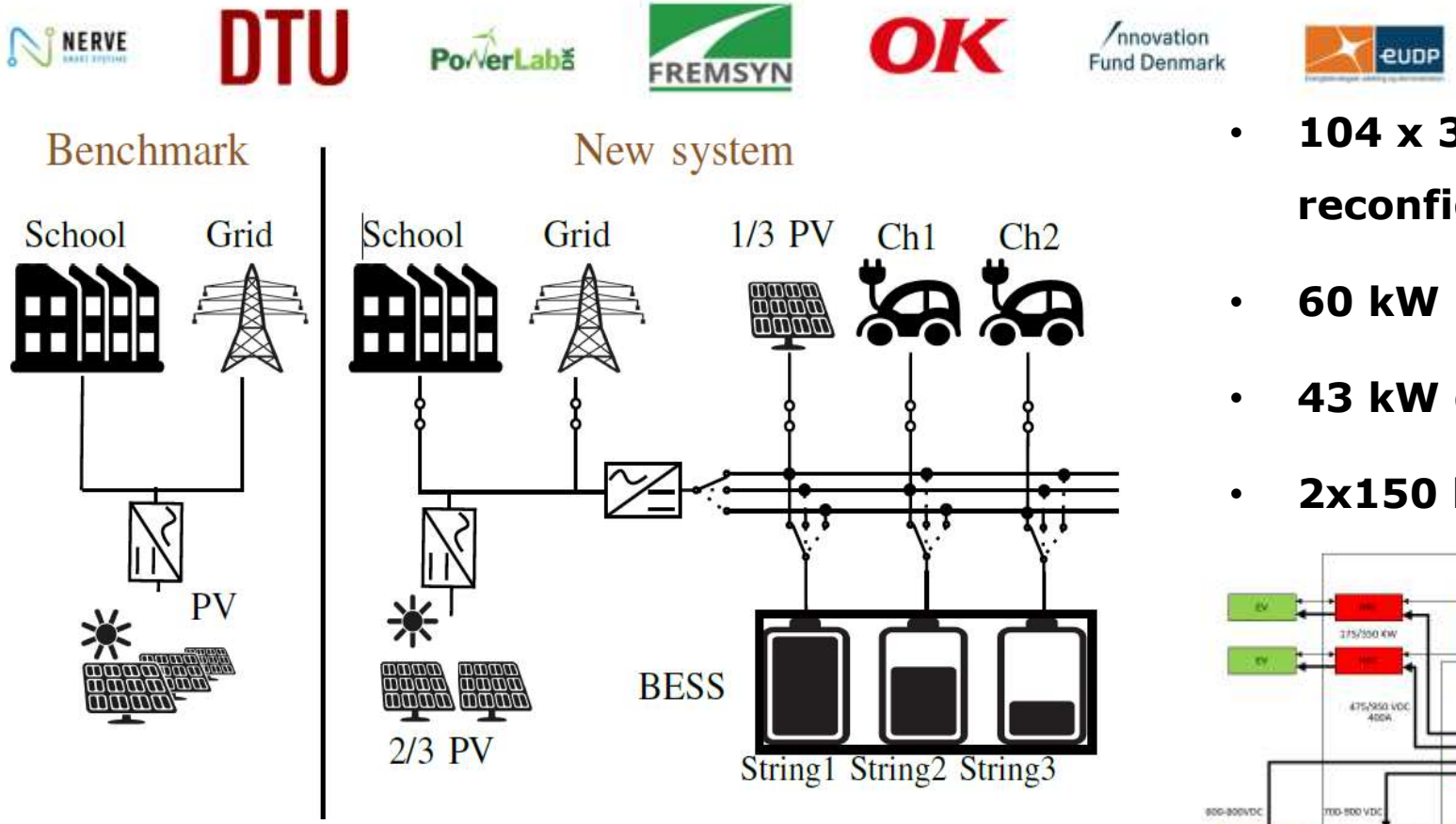
EL-NET ØST · Danfoss · DTU Center for Electric Power and Energy, Department of Electrical Engineering · EUROPEAN ENERGY · LITHIUM BALANCE · PowerLabDK · EUDP · BOSS GRID CONNECTED BATTERY SYSTEMS

79kWh/2x55kW Lithium-ion/NMC-battery + filter, grid connected 1MW/1MWh, Bornholm

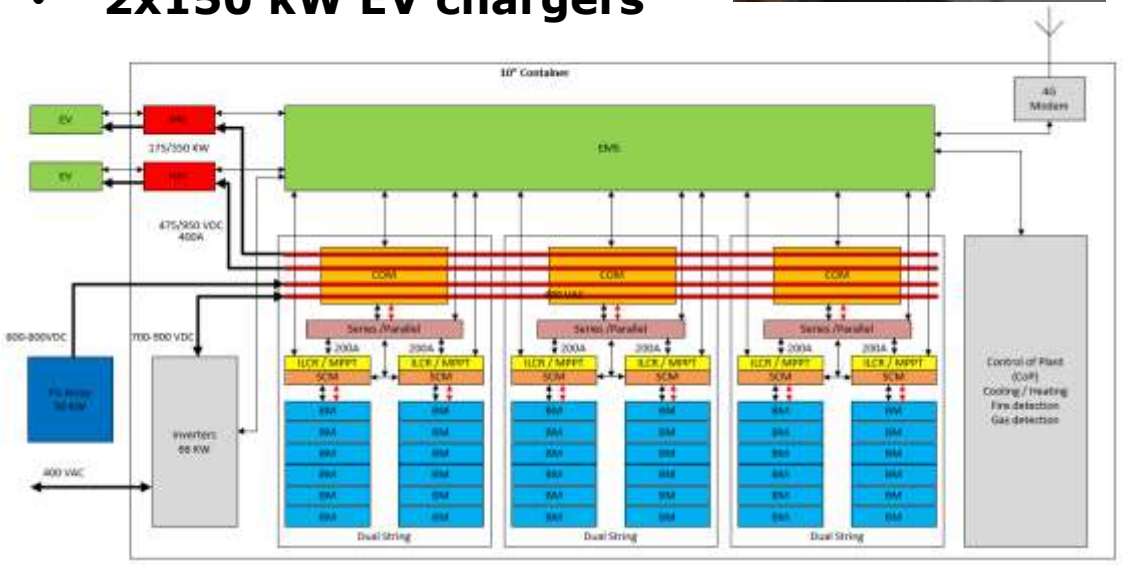




https://boss-project.com

# TOPChargE – reconfigurable topology




- **104 x 3 kWh reconfigurable LiFePo4**
- **60 kW PV**
- **43 kW grid connection**
- **2x150 kW EV chargers**

T. Gabderakhmanova, et al., "Demonstrations of DC Microgrid and Virtual Power Plant Technologies on the Danish Island of Bornholm," UPEC 2020

L. Calearo et al., "Optimal Management of a reconfigurable BESS - PV System to Reduce EV Fast Charging Impact on the Grid Connection"

# Intelligent Maintenance fo Transmission System

***System with a large share of AC Cables***

## InMaiT *project information*

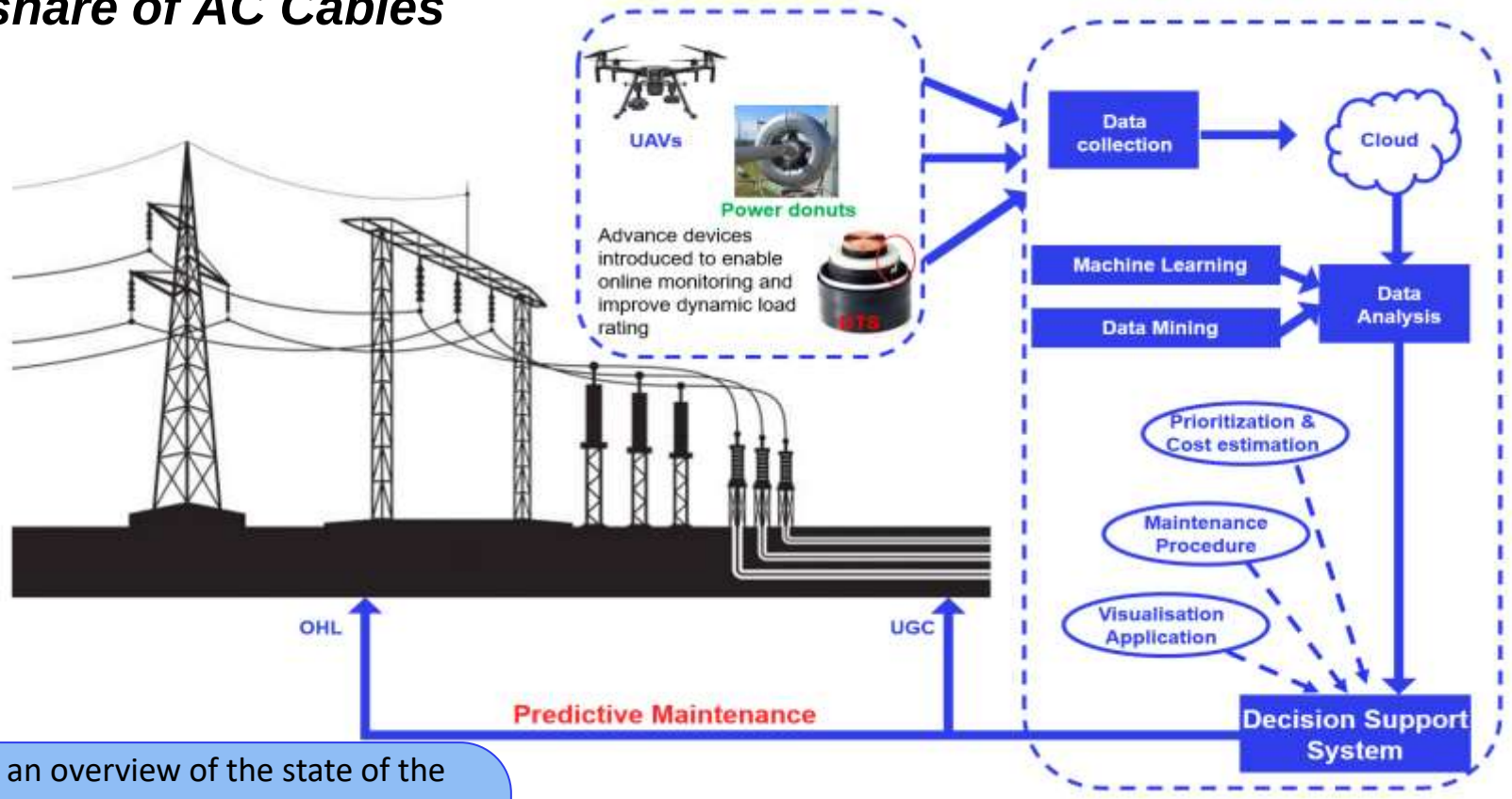
Funding: Energinet

Duration: 1 Jan. 2022 – 31 Dec. 2023

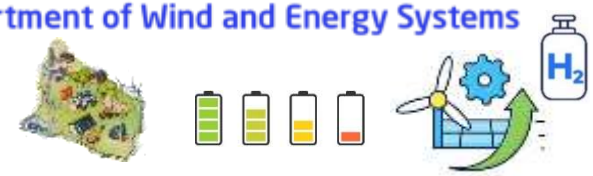
Coordinator: Energinet

### Project objective

To develop intelligent monitoring solutions for combined cable and overhead line systems supporting predictive maintenance.




- Provide input to a digitalized platform to provide an overview of the state of the hybrid system.
- Integrate multiple data-type from different sources to identify anomalies in operation characteristic
- Adapt Machine Learning to predict maintenance requirements and fault conditions.
- Examine value addition of new monitoring technology for a hybrid system lifetime cost perspective.




# The PtX & BESS field

## *Current interests apart from market and business aspects*

- ***P2H interest***
  - *Testing facilities in 100's kW range*
  - *Software tools for modelling in depth the electro-technical aspect of P2H plants, BoP & control*
  - *Software tools for modelling the cost aspect of P2H plants (merged with the electro-technical tools)*
  - *Integration in electric power system and hybridization with wind and PV*
  - *Hybridization with batteries; optimizing/sizing with respect to operational dynamics, cost and market aspects*

- ***BESS interest***
  - *Advanced diagnostics (ICA, EIS, Baysian, …)*
  - *Scale up of cell diagnostics methods to large scale BESS; from cell to large systems including BMS*
  - *BMS-converter interaction*
  - *Reconfigurable battery systems*
  - *PWM while charging and discharging*
  - *Coordinated operation of multiple BESS; grid impact, zero intertia grid, DC complementary grid*
  - *New battery systems including flow batteries such as Vanadium flow, all Fe, ….*

DTU

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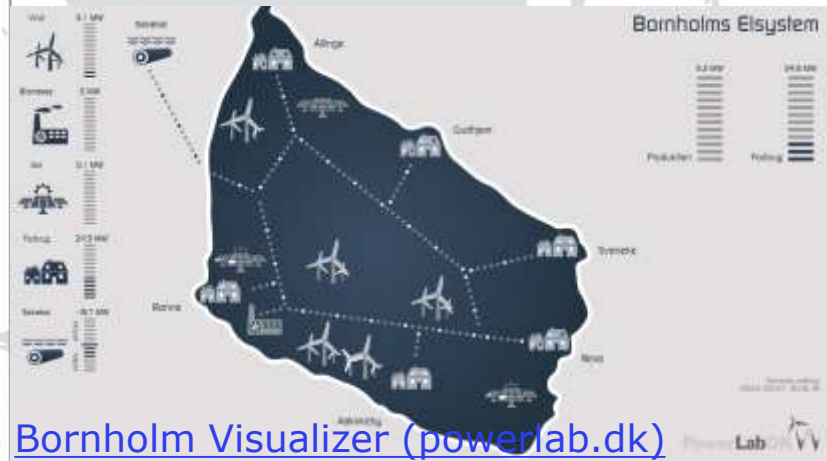
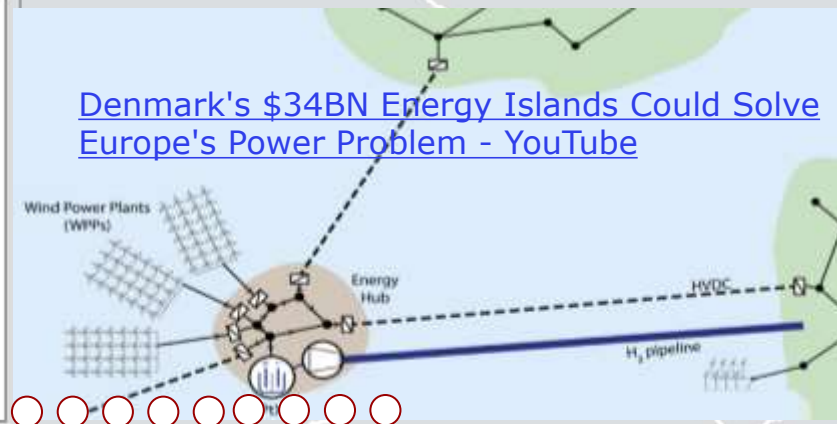
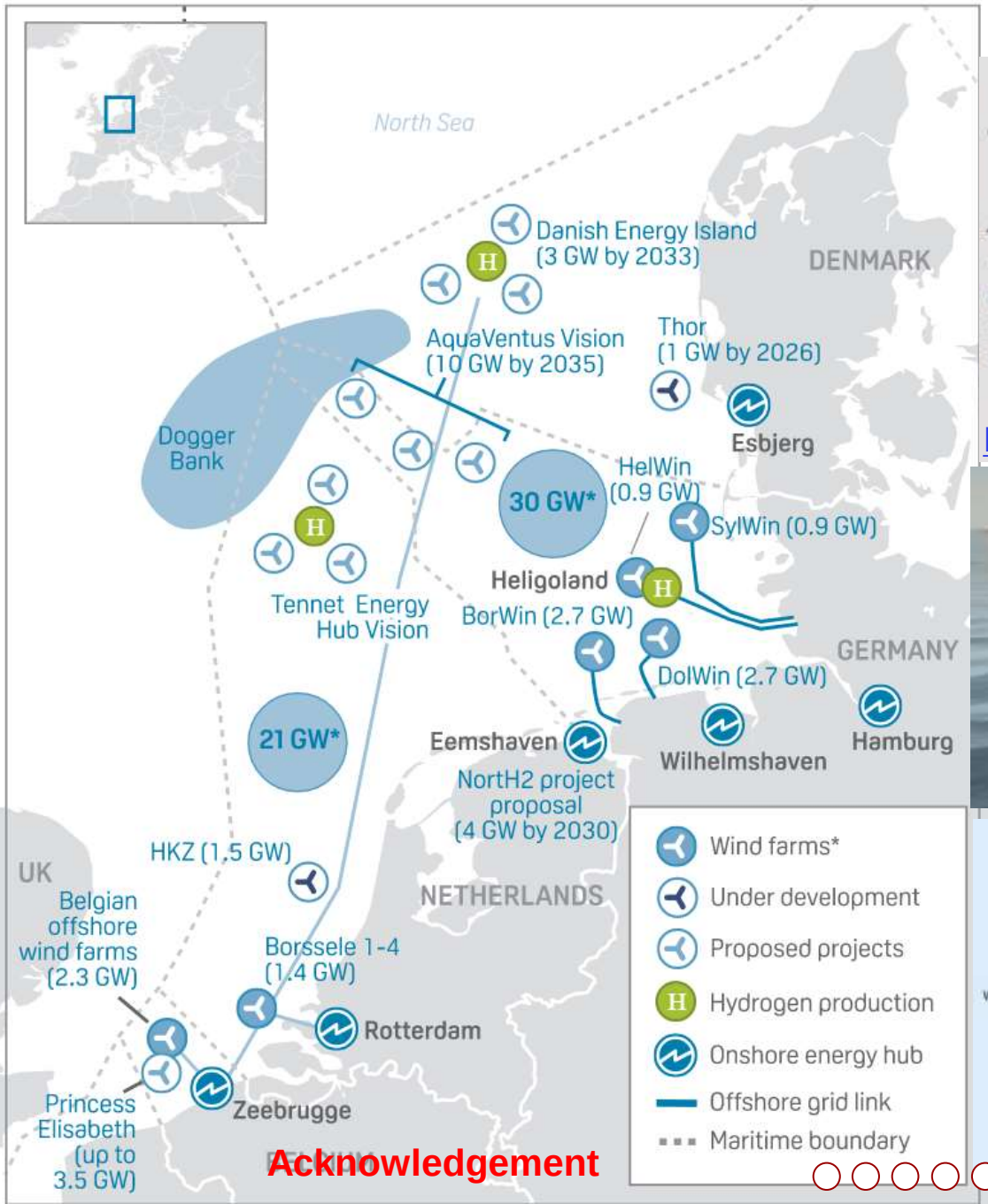



Bornholm Visualizer (powerlab.dk)




Denmark's $34BN Energy Islands Could Solve Europe's Power Problem - YouTube




- https://boss-project.com
- (http://insulae-h2020.eu/#)
- (TOPChargE IFD – Nerve Smart Systems)
- Secure Power for Grid Control, SPGC | Energiteknologi (energiforskning.dk)
- Homepage – QualyGridS
- EnergyLab Nordhavn – EnergyLab Nordhavn fremtidens energi system
- Forside – Nordhavn (byoghavn.dk)

**Acknowledgement**