# DOCKETED

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|---|---|
| **Docket Number:** | 20-MISC-01 |
| **Project Title:** | 2020 Miscellaneous Proceedings. |
| **TN #:** | 236005 |
| **Document Title:** | Comment of Magellan Stortech and Stiesdal Storage Technologies in Response to Long Duration Storage WorkshopStorage |
| **Description:** | N/A |
| **Filer:** | System |
| **Organization:** | Magellan Stortech and Stiesdal Storage Technologies |
| **Submitter Role:** | Public |
| **Submission Date:** | 12/17/2020 4:36:48 PM |
| **Docketed Date:** | 12/17/2020 |

*Comment Received From: Jeffrey Kehne*
*Submitted On: 12/17/2020*
*Docket Number: 20-MISC-01*

## Comment of Magellan Stortech and Stiesdal Storage Technologies in Response to Long Duration Storage WorkshopStorage

Magellan Stortech and Stiesdal Storage Technologies are pleased to have this opportunity to submit comments on the California Energy Commissionâ€™s December 3, 2020 Staff Workshop on Long Duration Energy Storage Scenarios. We appreciate the Commission's commitment to comprehensive analysis of the role that long duration energy storage can play in helping California meet its greenhouse gas reduction goals. We have attached an overview of the GridScale thermal battery system that Stiesdal Storage Technologies is working to commercialize. We look forward to working with the UC Merced and E3 teams to clarify the benefits that long-duration storage can provide.

*Additional submitted attachment is included below.*

# Stiesdal Storage Technologies
# GridScale Battery

Submission in Response to "Initial Public Workshop for Comments on Long Duration Energy Storage Scenarios,” 20-MISC-01 (submitted December 17, 2020)

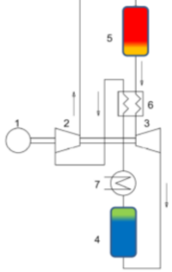
# Framework

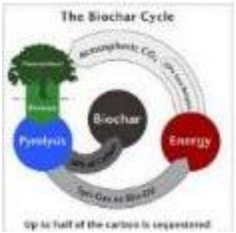
## Purpose

- The purpose of the Stiesdal A/S is **to contribute to climate change mitigation by developing and commercializing solutions to key challenges.**
- Relevant solutions need to
  - Have a **potential for high impact on climate change mitigation**
  - Be suitable for **industrialization**
  - Be suitable for the **skills and capabilities** of the Company

**Stiesdal A/S**

| | Stiesdal Offshore Technologies A/S | Stiesdal Storage Technologies A/S | Stiesdal Fuel Technologies A/S |
|---|---|---|---|
| Project | **Tetra** | **GridScale** | **SkyClean** |
| Target | Unlimited low-cost offshore wind energy | Unlimited share of renewables on grid | Carbon capture and sequestration |
| Means | Industrialized fixed & floating foundations | Storage system w. 10h – 10d capacity | Carbon-negative jet fuel |





# Stiesdal A/S Leadership

## Henrik Stiesdal

**Chief Executive Officer**

- Wind power pioneer, built first test turbine 1976, and first commercial turbine 1978; licensed wind turbine design to Vestas 1979, kick-starting modern Danish wind industry.
- Served as technical manager of Bonus Energy A/S from 1988, ran company together with CEO until Siemens acquisition 2004, then took position as CTO of Siemens Wind Power.
- Installed world's first offshore wind farm (1991) and world's first floating wind turbine (2009).
- Invented and implemented key technologies, including Siemens proprietary blade manufacturing, low-weight direct-drive turbines, variable-speed operation, energy storage, etc.

## Peder Nickelsen

**Chief Operating Officer**

- Has worked at Siemens Gamesa for more than 25 years and in various Senior Management positions for 20 years.
- Was responsible for the technical development and execution of first 3 generations of the Siemens Gamesa offshore turbines from 2MW to 6MW.
- Involved in more than 50% of all offshore turbine projects including customer relations.
- Was responsible for technical risk assessment management of the complete portfolio for Siemens Gamesa including corrective actions and costumer/supplier interfaces.
- Academic background in mechanical engineering from Aalborg University.

# Stiesdal GridScale Battery technology addresses the growing need for reliable, cost-effective bulk energy storage

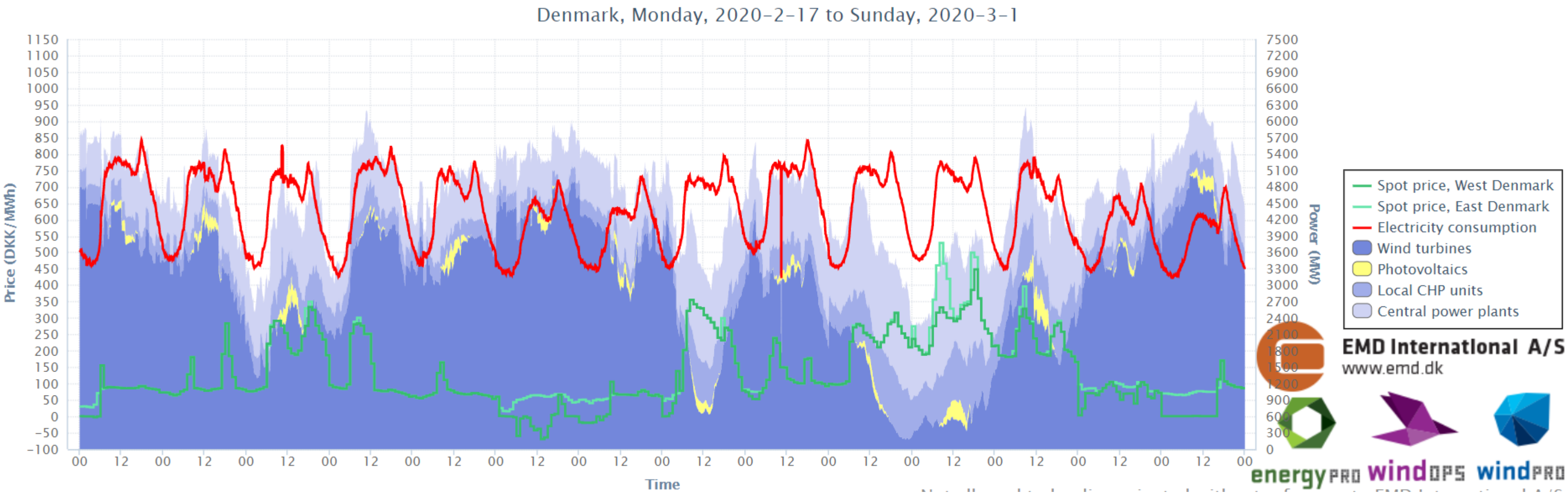
**A GridScale Battery is a cost-efficient, long-duration, and low carbon thermal energy storage system that can**

- Maintain system-wide resource adequacy as fossil-fired generation is retired by storing large amounts of electrical energy for hours, days or weeks at lower cost than any comparable technology
- Meet local reliability requirements without large-scale T&D investment by providing safe, geographically flexible storage at key locations
- Address resiliency needs by providing long-duration capabilities for microgrids designed to meet critical electricity needs during service interruptions

# Key motivation for storage – renewable power integration

## Production and load curves for Denmark illustrate the issue

- Even in a high-wind period such as the last two weeks of February, 2020, there are periods with essentially no renewables production

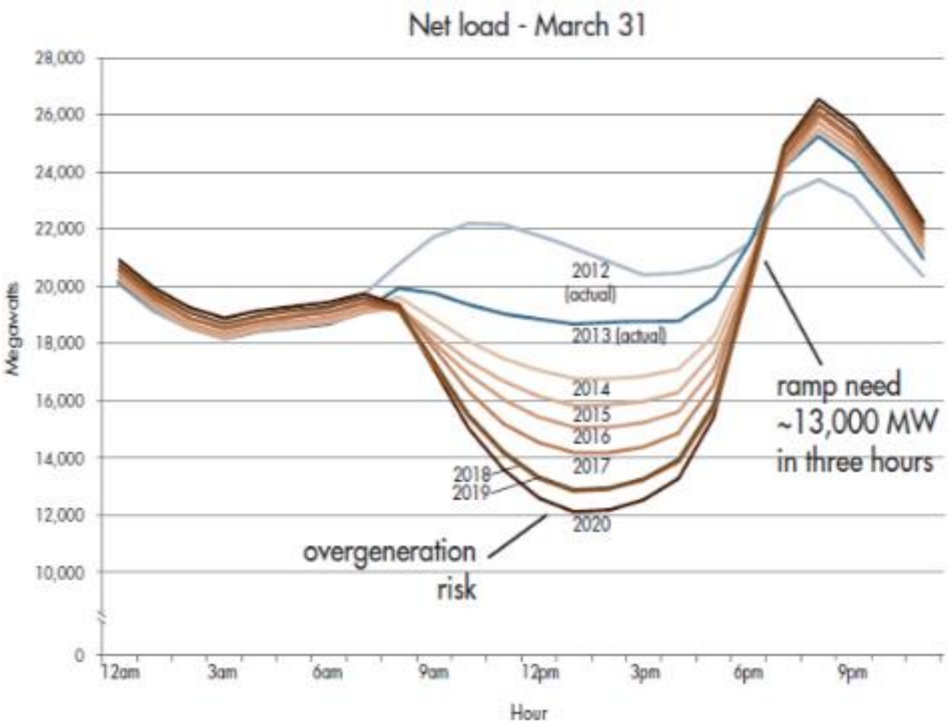



Source: EMD International

# Key motivation for storage – enabling increased PV production

## The Duck Curve

- Large-scale PV build out without storage leads to costly evening ramping needs
- Within a few years CAISO expects ramp rates to reach 13,000 MW over three hours, above current thermal peaker capacity
- High-capacity storage systems with fast ramp rates offer a low-carbon solution



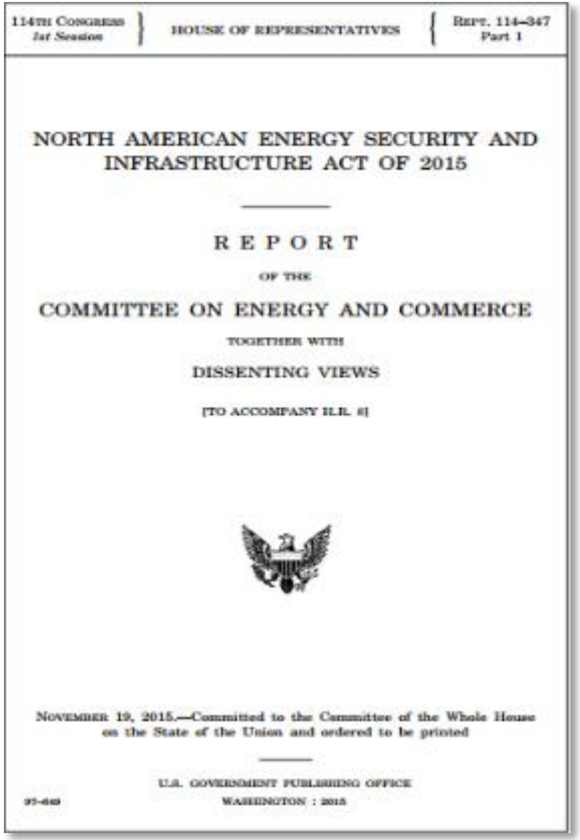

Source: CAISO

# Key motivation for storage – strengthening energy security

**The grid is increasingly vulnerable to disruption by malicious actors and natural disasters**

- Storage plants can be located in urban areas, providing on-the-spot backup to improve grid resilience against service interruption

Source: US Congress



114TH CONGRESS 1st Session | HOUSE OF REPRESENTATIVES | REPT. 114–347 Part 1

NORTH AMERICAN ENERGY SECURITY AND INFRASTRUCTURE ACT OF 2015

REPORT

OF THE

COMMITTEE ON ENERGY AND COMMERCE

TOGETHER WITH

DISSENTING VIEWS

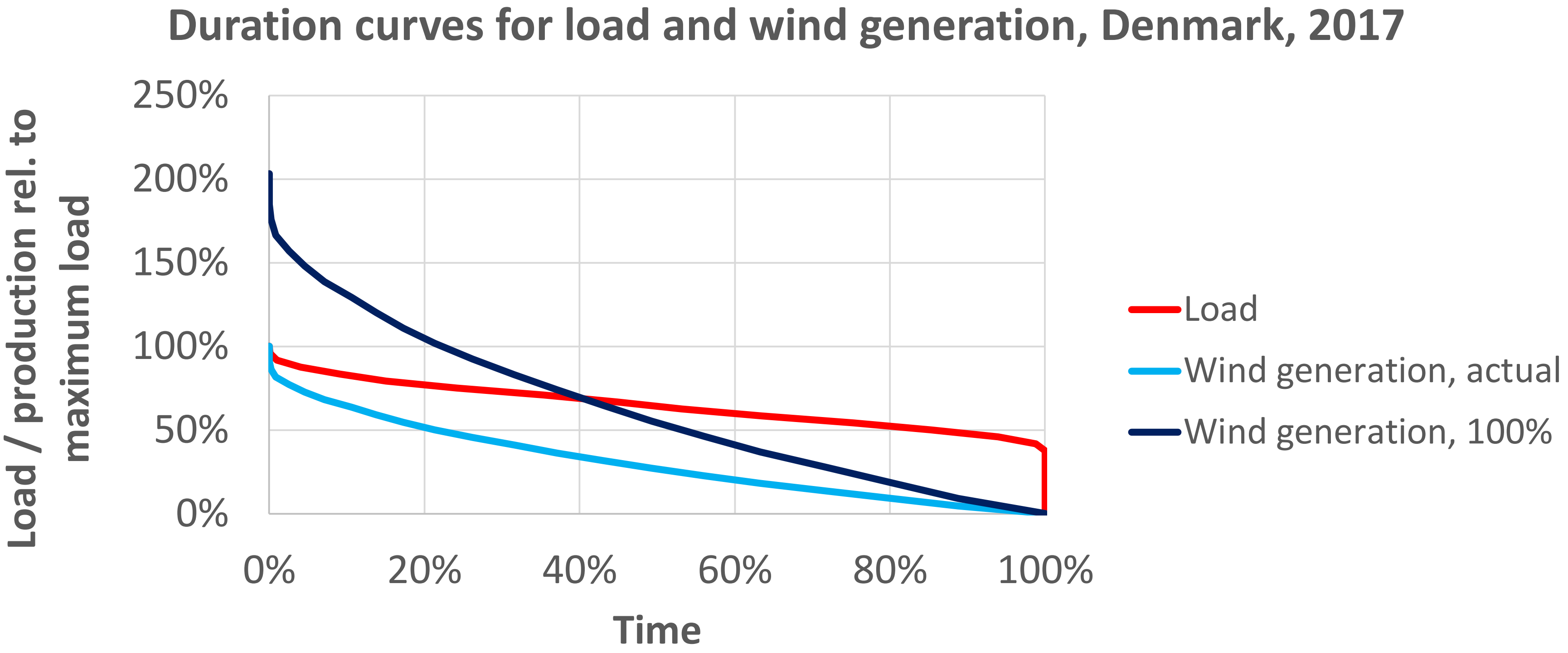
[TO ACCOMPANY H.R. 8]

NOVEMBER 19, 2015.—Committed to the Committee of the Whole House on the State of the Union and ordered to be printed

U.S. GOVERNMENT PUBLISHING OFFICE

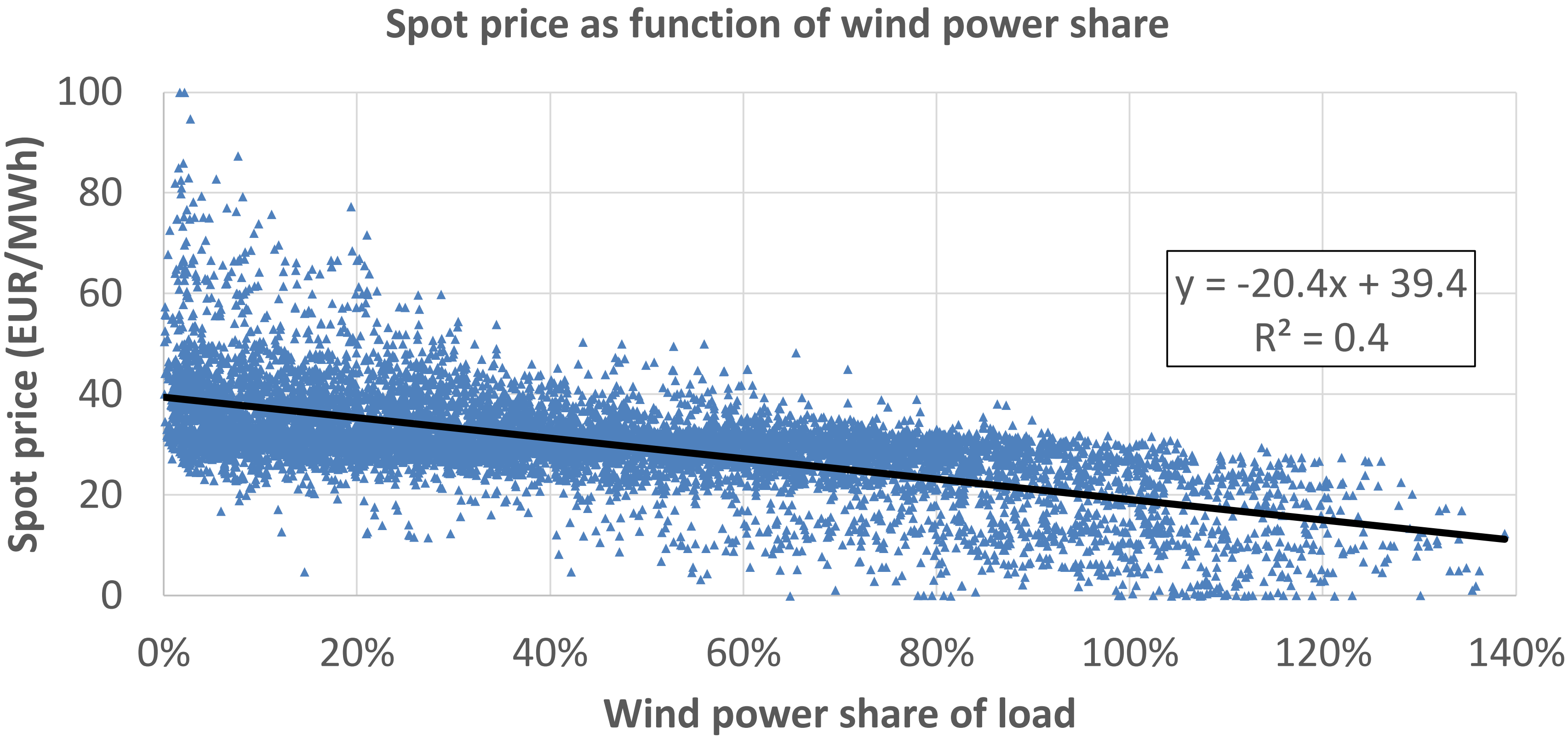
97-649 WASHINGTON : 2015

# In Denmark, wind power is not a particularly good fit to load



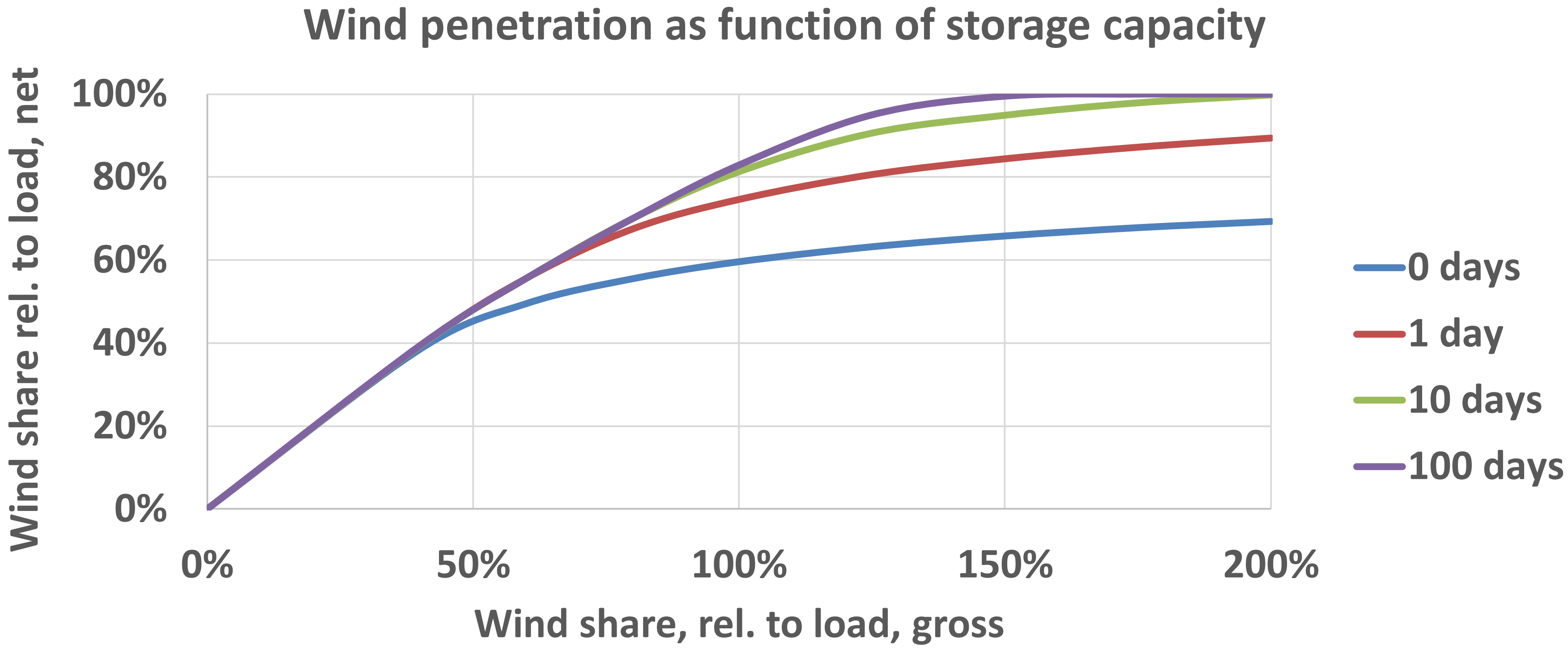

Source: Energinet.dk

# Market mechanisms reduce the value of wind production

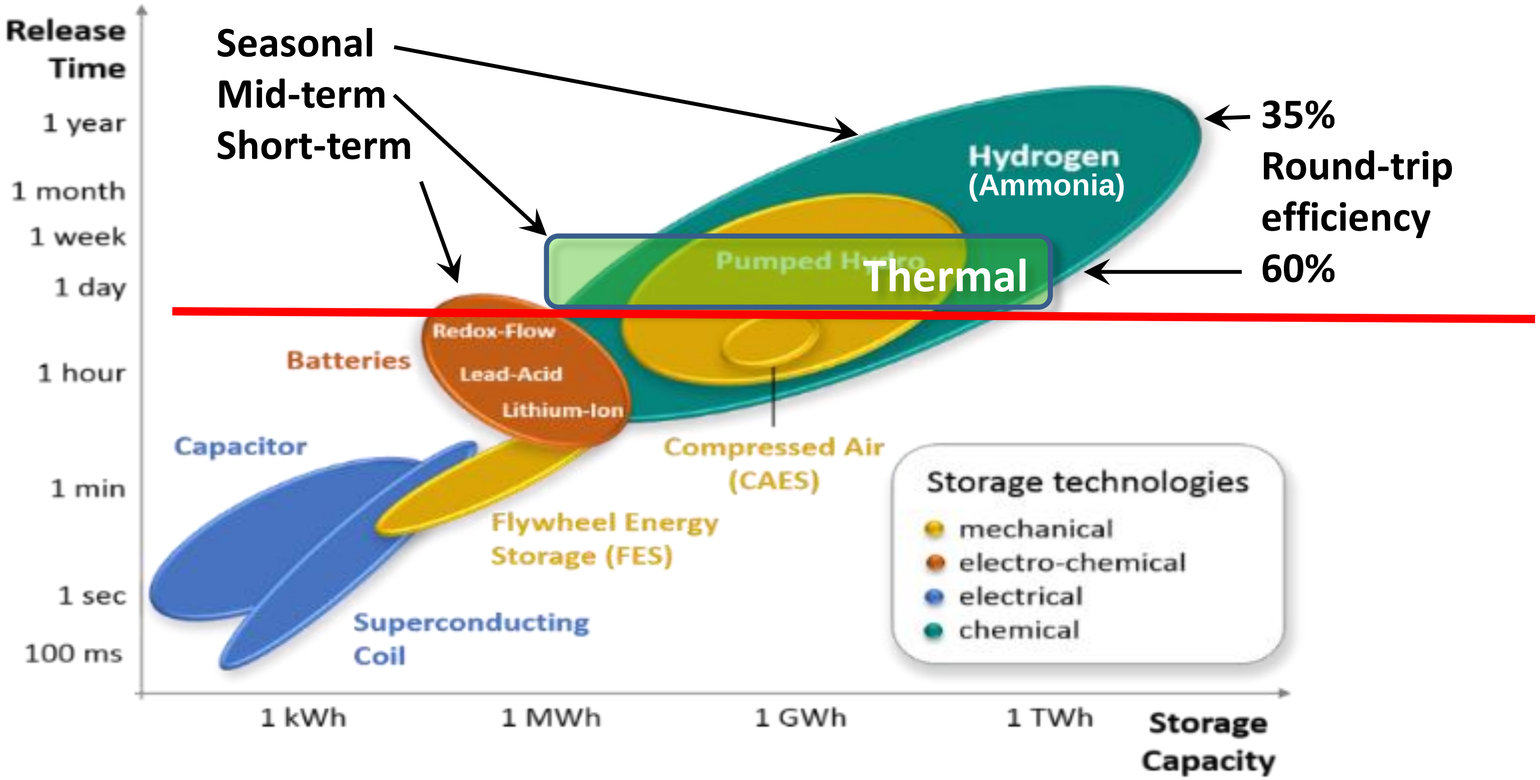



Source: Energinet.dk

# So – how much storage do we need?



# The key storage technologies




Source: IIDST

# The heat pump principle of the GridScale Battery

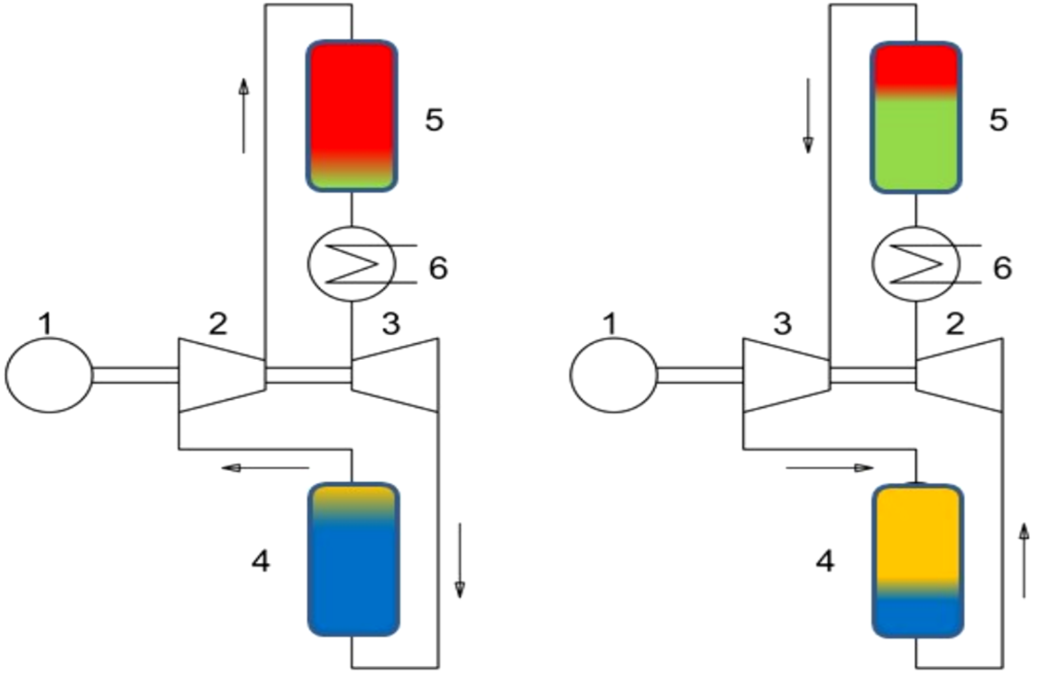
1 Motor
2 Compressor
3 Turbine
4 Cold storage tank
5 Hot storage tank
6 Cooler

600 deg.C

385 deg.C

75 deg.C

-30 deg.C

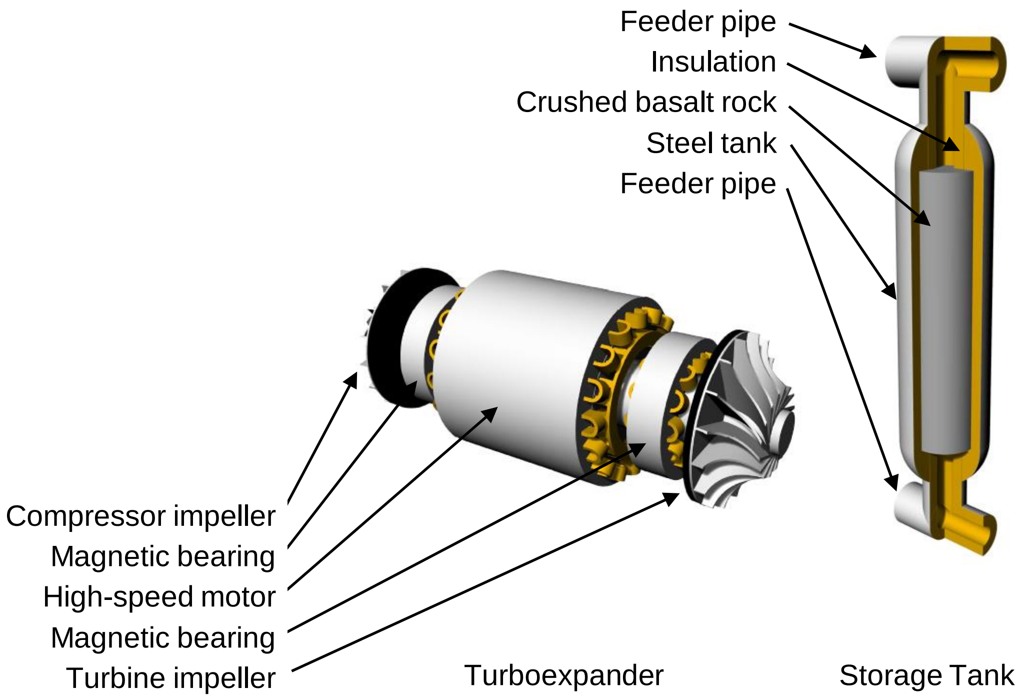



Charge Discharge

# The industrialized concept of the GridScale Battery

## Design for industrialization and mass production is a key feature

- The turboexpander design uses standardized industrial components, combined into a high-efficiency unit
- Thermal energy is stored in insulated steel tanks filled with crushed basalt rock
- Internal insulation system facilitates the use of conventional steel in reservoir tanks



# The industrialized concept of the GridScale Battery

## Modularity for easy scaling

- A storage unit comprises well-defined modules suited for industrialized manufacturing
    - A turboexpander unit with pre-pressure compressor, controls etc.
    - A filter unit with air filters and manifolds
    - Two rows of standardized storage reservoirs
- Storage duration is adjusted with number of storage tanks
- Power rating is adjusted with number of parallel units

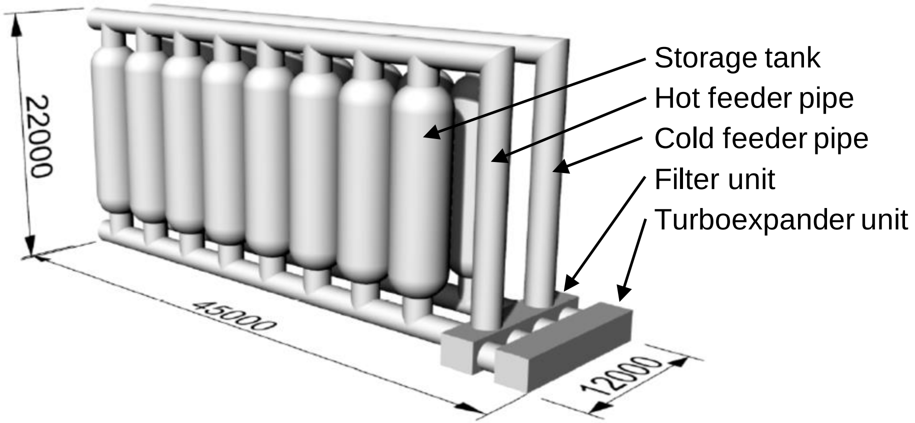



Figure shows 2.5 MW, 60 MWhe GridScale Battery

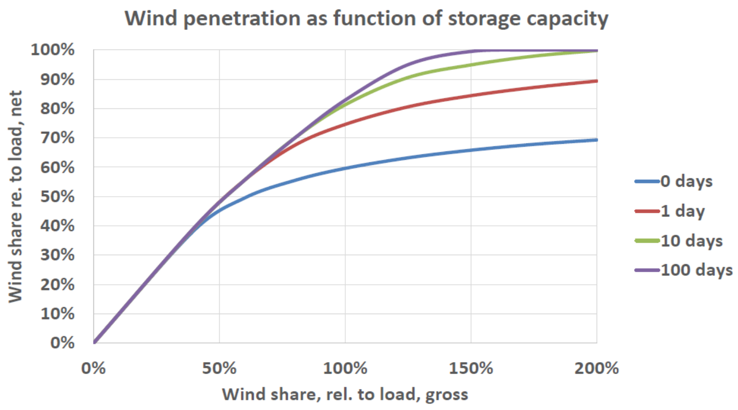
# Cost and benefits

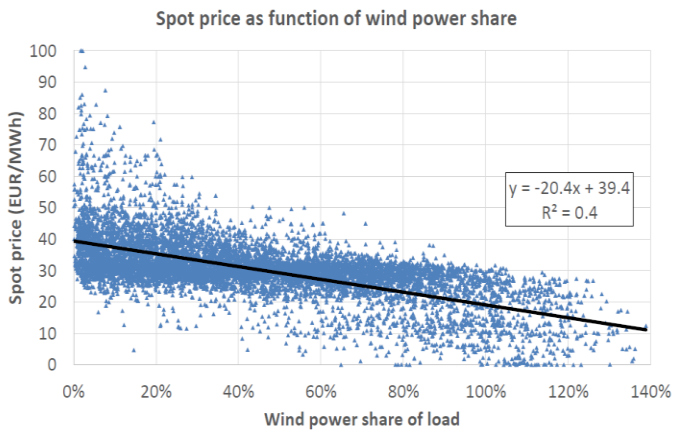
## Case: 500 MW offshore wind farm, 50% capacity factor

| | | |
|---|---|---|
| • LCOE without storage: | 65 EUR/MWh | **100%** |
| • LCOE with 24 h thermal storage: | 82 EUR/MWh | **125%** |
| • LCOE with 24 h Li-ion storage: | 155 EUR/MWh | **235%** |

## Benefits

- Higher penetration + higher value



# Recent experiments – the GridScale Battery Packed Bed

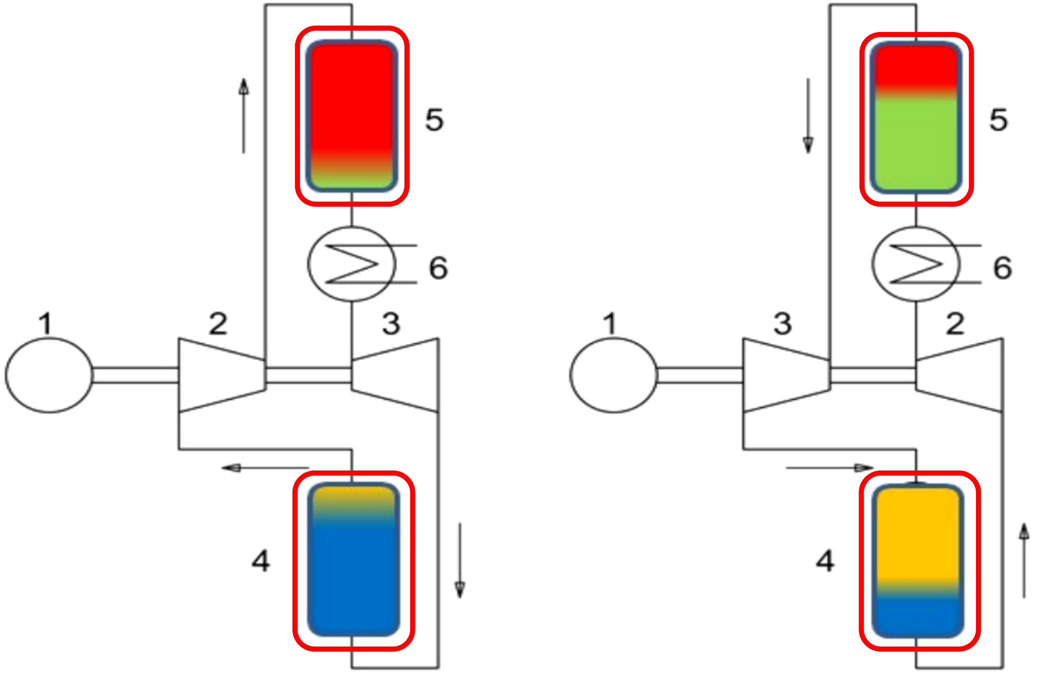
1 Motor
2 Compressor
3 Turbine
4 Cold storage tank
5 Hot storage tank
6 Cooler

600 deg.C

385 deg.C

75 deg.C

-30 deg.C




Charge Discharge

# SST is systematically addressing key system optimization issues

**Optimization of the packed bed raises a range of issues**

**The scale model supplied answers relating to**

- Thermal gradient
- Pressure drop

**The prototype is answering questions relating to**

- Settling
- Ratcheting
- Lifetime
- Insulation

# Experiments carried out with different stone sizes

**The stone size affects both thermal gradient and pressure drop**

- The quality of the thermal gradient decreases with increasing stone size
- The pressure drop is surprisingly small and decreases with increasing stone size
- The challenge is to identify a stone size that provides a good thermal gradient with a low pressure drop

**Experiments have confirmed that the rock beds can be configured to perform as desired**

# Thermal Battery compared with known storage technologies

| Topic | Li-ion | Pump $H_2O$ | CAES | Hydrogen | Thermal |
|---|---|---|---|---|---|
| Technology readiness charge-discharge | Mature | Mature | Mature | Development stage | Mature |
| Technology readiness storage unit | Mature | Mature | Mature | Mature | Development stage |
| Round-trip efficiency | 90% | 85% | 40-60% | 30-50% | 35-60+% |
| Round-trip energy cost | High | Low | Low | Medium | Low |
| Energy density | High | Low | Low | High | High |
| Footprint | Small | Large | Small | Small | Small |
| Scalability, power | 0.01-25 MW | 50-1000 MW | 5-100 MW | 1-1000 MW | 1-1000+ MW |
| Scalability, energy | 0.01-25 MWh | 100-10.000 MWh | 10-1000 MWh | 1-100.000 MWh | 1-100.000 MWh |
| Location requirement | None | Special topography | Special geology | Special geology | None |
| Raw material use | High | None | None | Moderate (electrolyzer) | None |

# GridScale demonstration project

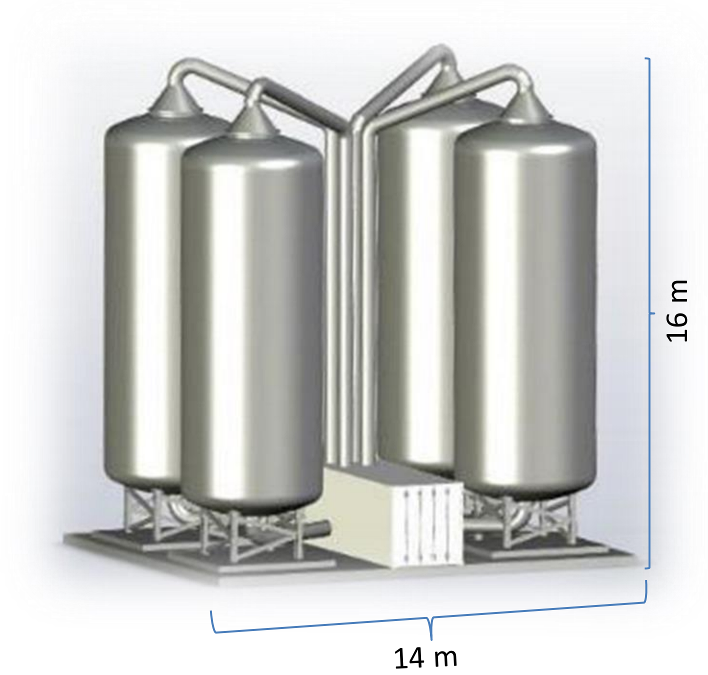
## Demonstration project

- First GridScale demonstration project will be a fully functional storage plant located in Denmark
- Rated Power for charging will be 4 MW*
- Rated Power for discharging will be 2.1 MW*
- Stored energy will allow for 5 hours of charging or discharging**
- Commissioning at customer location Q3 2022
- Functional testing of complete system to take place at factory location before transport to customer location

*Depending on achieved temperatures and base pressure of system

**Easily scaled by varying the number of storage tanks

**GridScale demonstration plant layout**



# From first demonstration to commercialization

Stiesdal and Magellan Stortech are exploring options for deployment of a larger U.S. demonstration project

- power output rating – 20 MW
- storage capacity – 200 MWh
- development begins in 2021, operation begins in 2022-23

Following deployment of the Danish and U.S. demos, Stiesdal and Magellan Stortech will work to finance and develop a series of first-generation commercial-scale U.S. projects

The flexibility of the GridScale system’s modular design allows for commercial-scale deployments with different ratios of (a) storage capacity to output, and (b) charge to discharge time.  For example

- **A GridScale system coupled with a solar farm could be configured to charge for 8 hours and discharge for 16 hours in order to enhance the system value of the solar power.**

**Thank you for your consideration**

**Questions?**

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