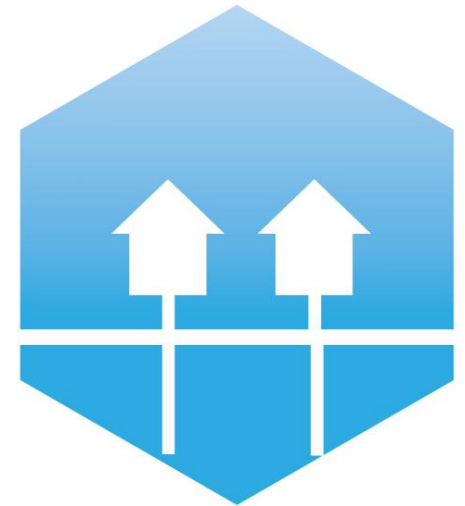
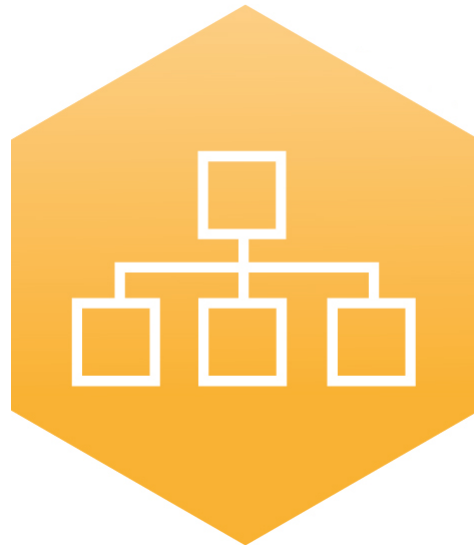


4<sup>th</sup> International Conference on Smart Energy Systems and 4th Generation District Heating  
Aalborg, 13-14 November 2018

# AALBORG **CSP**

*- Changing Energy*



**AALBORG UNIVERSITY**  
DENMARK

4th International Conference on Smart Energy  
Systems and 4th Generation District Heating 2018  
#SES4DH2018

# 4DH

**4th Generation District Heating  
Technologies and Systems**

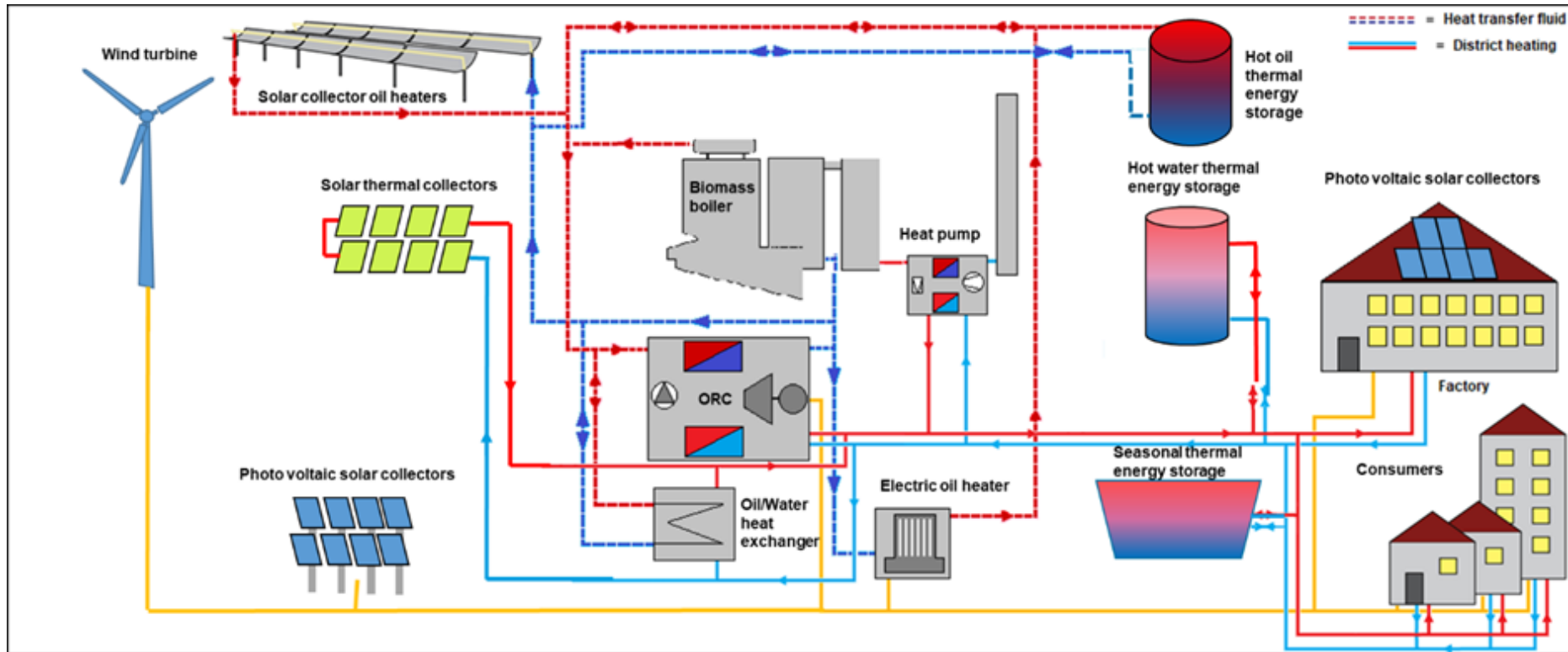
# 4G Integrated Energy Solutions

**BASED ON THE INTEGRATION OF  
CONCENTRATED SOLAR POWER -  
ALL WELL PROVEN TECHNOLOGIES**



**4DH**

4th Generation District Heating  
Technologies and Systems



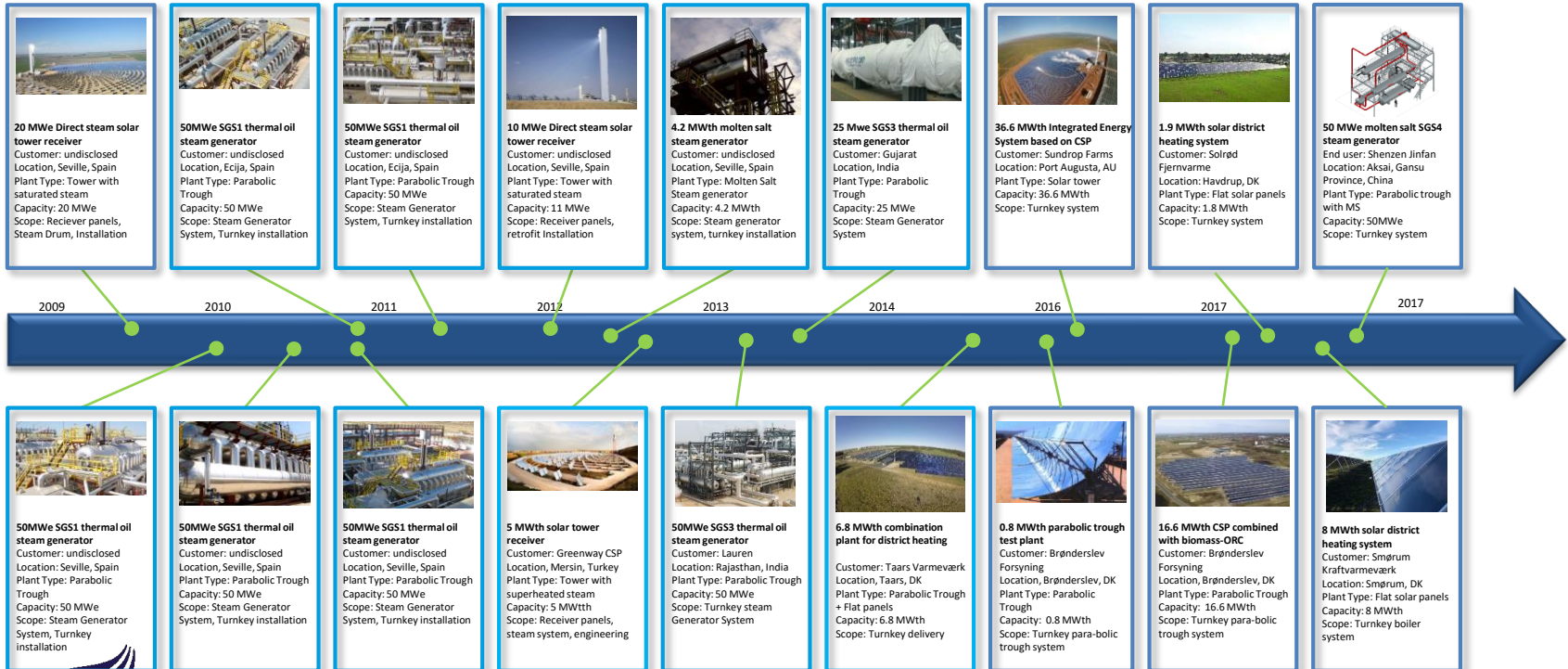
# From Aalborg Boilers to High tech Concentrated Solar Power Boilers



# From Aalborg Boilers to High tech Concentrated Solar Power Boilers



## SELECTED REFERENCES





# CSP FOR COMBINED HEAT AND POWER - Brønderslev, DK



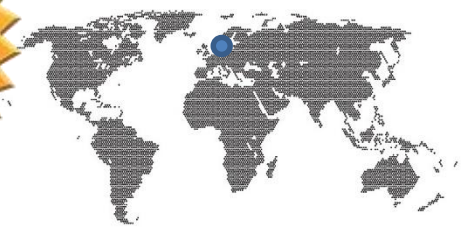
Globally unique green energy facility in Brønderslev wins prestigious Danish district heating award



*Aalborg CSP designed and delivered a CSP system to be integrated with a biomass-organic rankine cycle (ORC) plant for combined heat and power generation – the first one in the world to combine these two technologies in a large-scale setting.*

**Location:** Brønderslev, North of Denmark  
**Client:** Brøndersev Forsyning  
**Status:** operational  
**Capacity:** 16.6 MWth  
**CSP aperture area:** 26,929 m<sup>2</sup>

Final energy output:  Heat  Electricity



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# CST APPLICATION – PORT AUGUSTA, AU



20,000 MWh/ year



250,000 m<sup>3</sup>/ year

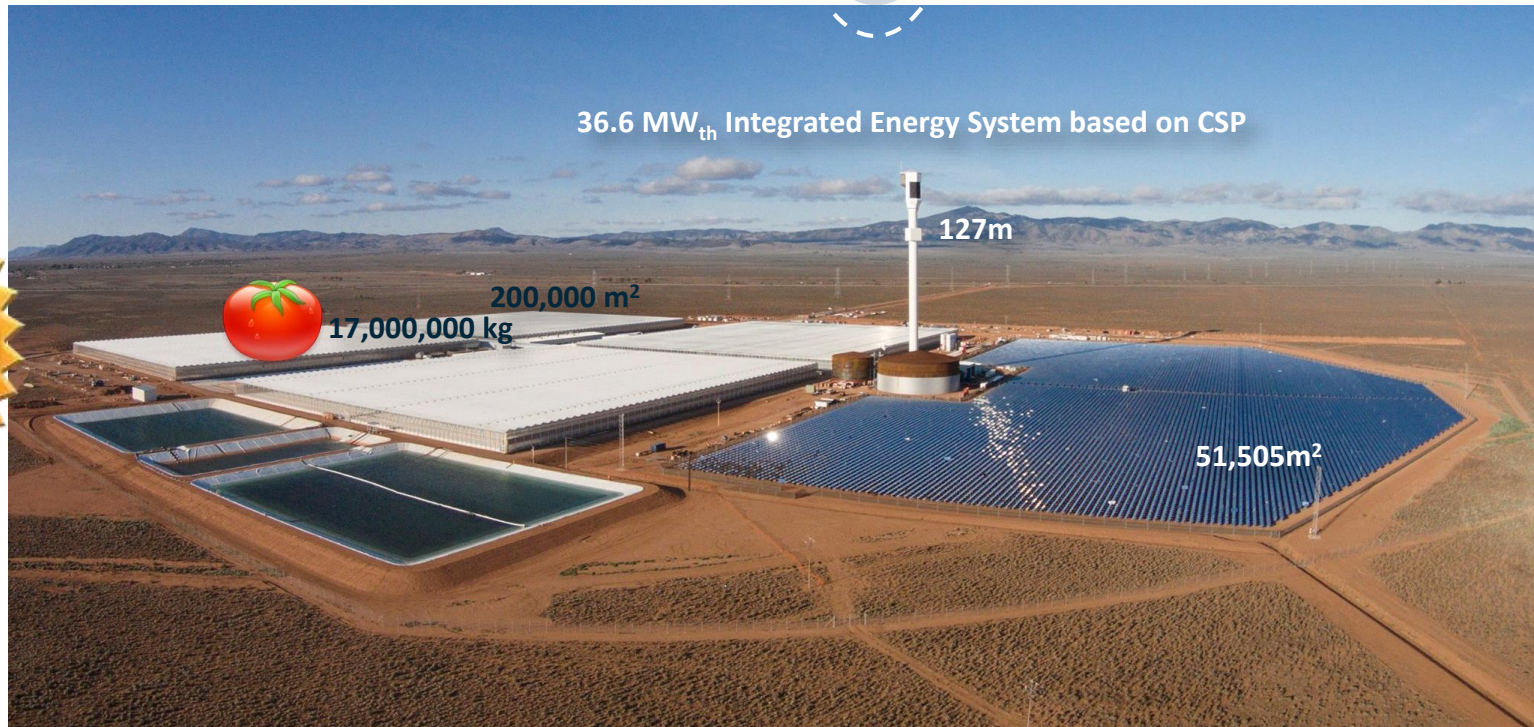


1,700 MWh/ year



## 4DH

4th Generation District Heating  
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**1<sup>st</sup>**  
of its kind  
in the  
world



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# AALBORG CSP

- *Changing Energy*



CSP power plant



Integrated EnergySystems



Renewable Energy Provider



Thermal Energy Storage (TES & TCS)



R&D Activities

ALL-Trough™

SGS3™

SGS4™

**KYOTO**

 EnergyNest

 SaltX  
Technology

 HELIAC



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# Solar Irradiation

Insolation from the sun on a clear day

**1366 W/M<sup>2</sup>**  
Outside atmosphere

**1000 W/M<sup>2</sup>**  
On surface



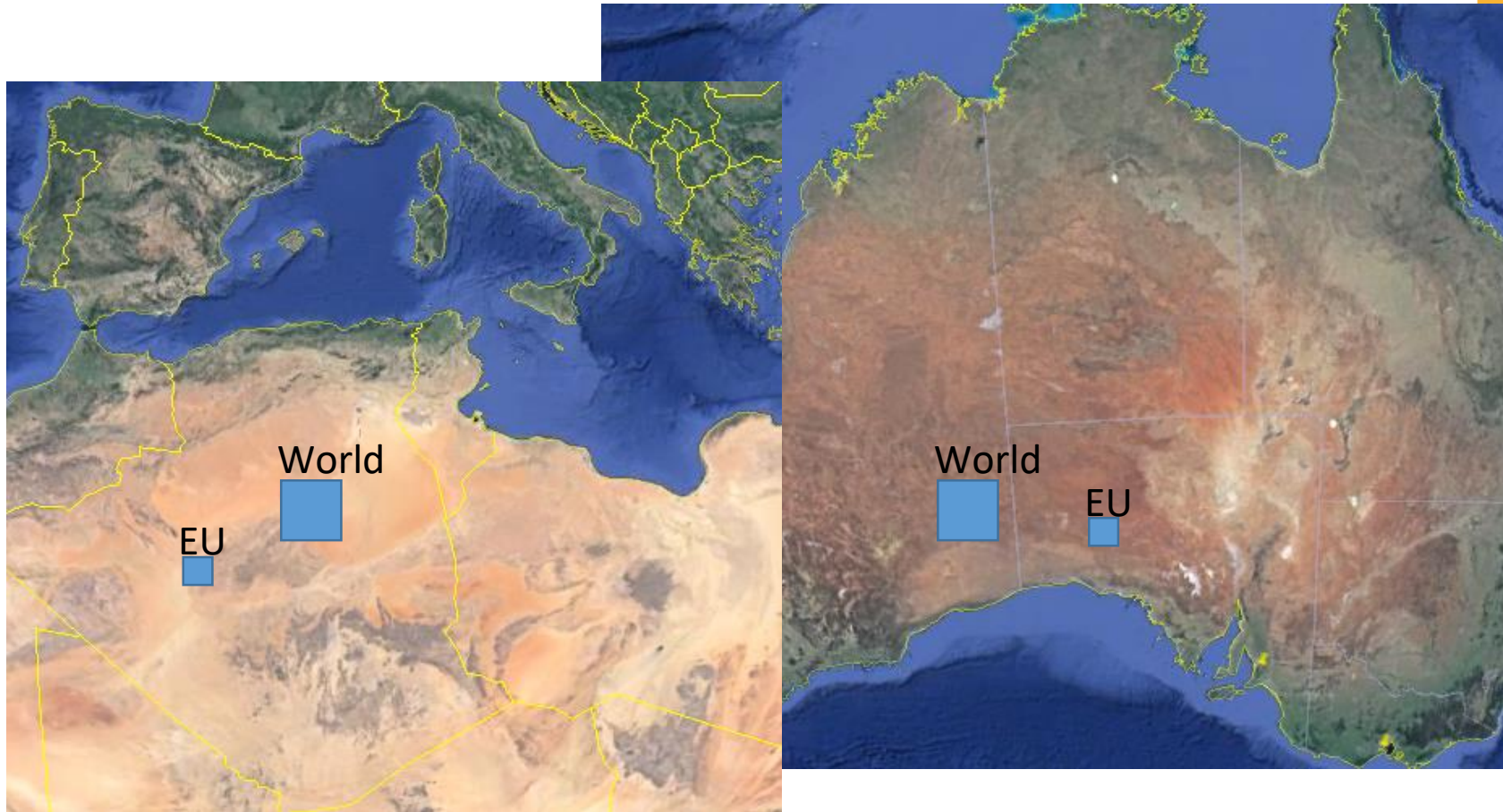


# Solar amount

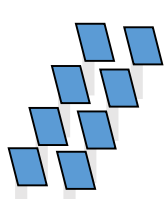


**4DH**

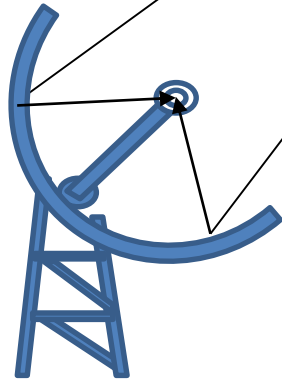
4th Generation District Heating  
Technologies and Systems



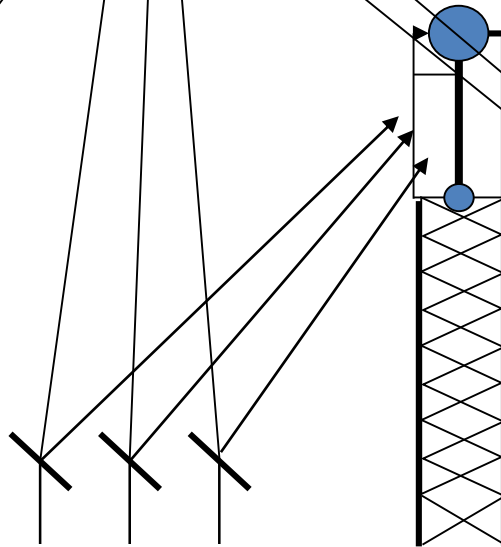
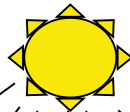
# Common CSP types



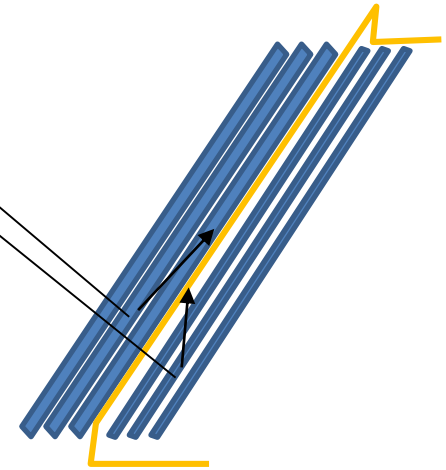
(Flat Plate Solar Collector)



Parabolic Trough

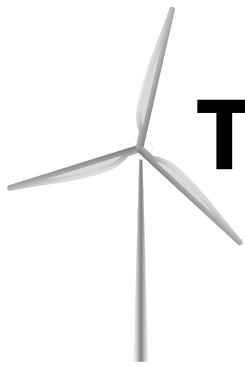


Solar Tower

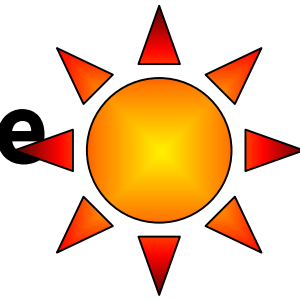


Linear Fresnell





# Thermal Energy Storage



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- 95°C **Water tanks – Thermocline – District Heating - Industrial**
- 430°C **Concrete Heat Storage - Thermal oil/Steam – DH Plant**
- 550°C **Chemical Heat Storage – CAO/Steam – CHP plant**
- 565°C **Molten Salt Storage – MS/Steam – Power & CHP Plant**
- > 600°C **Other Heat storage systems – Aluminum – Sulphur etc.**

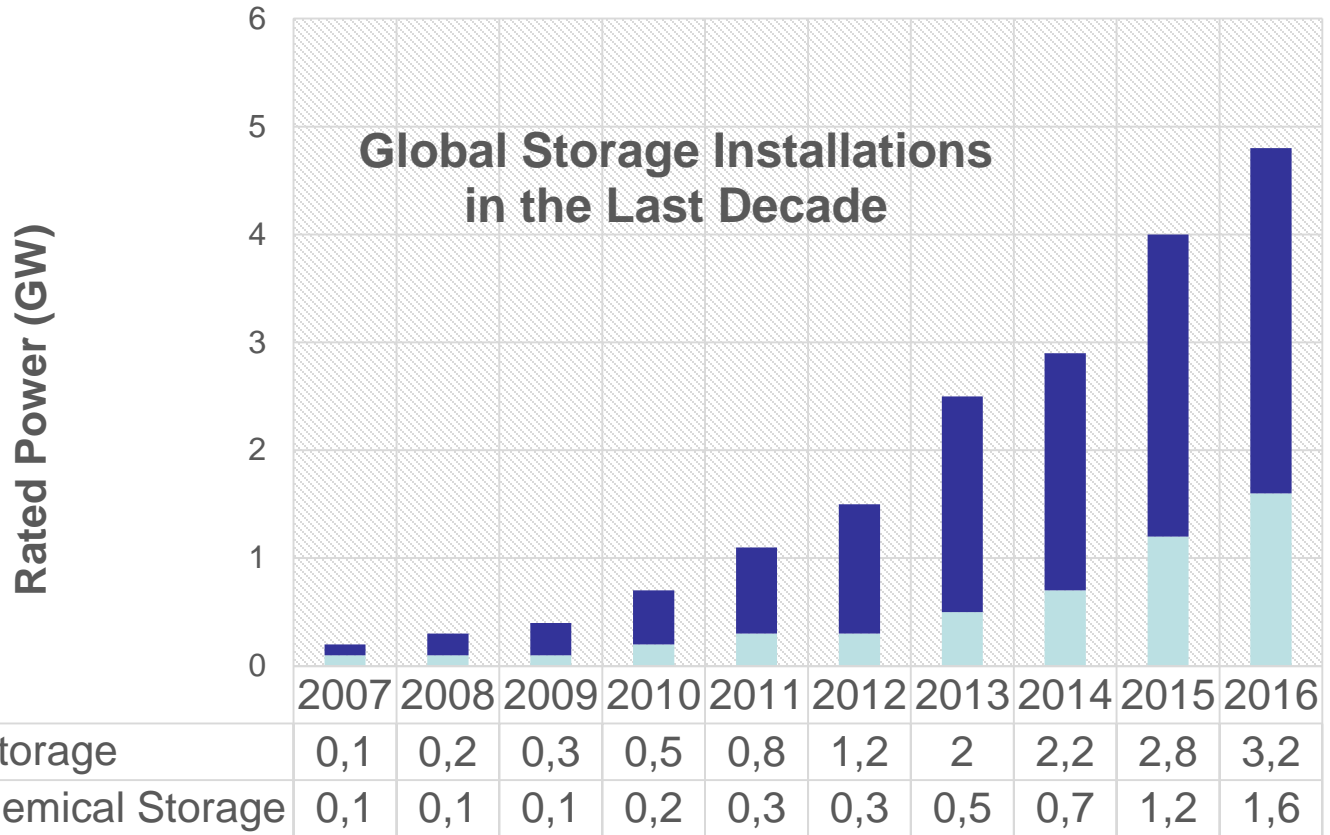




# The Global installed TES

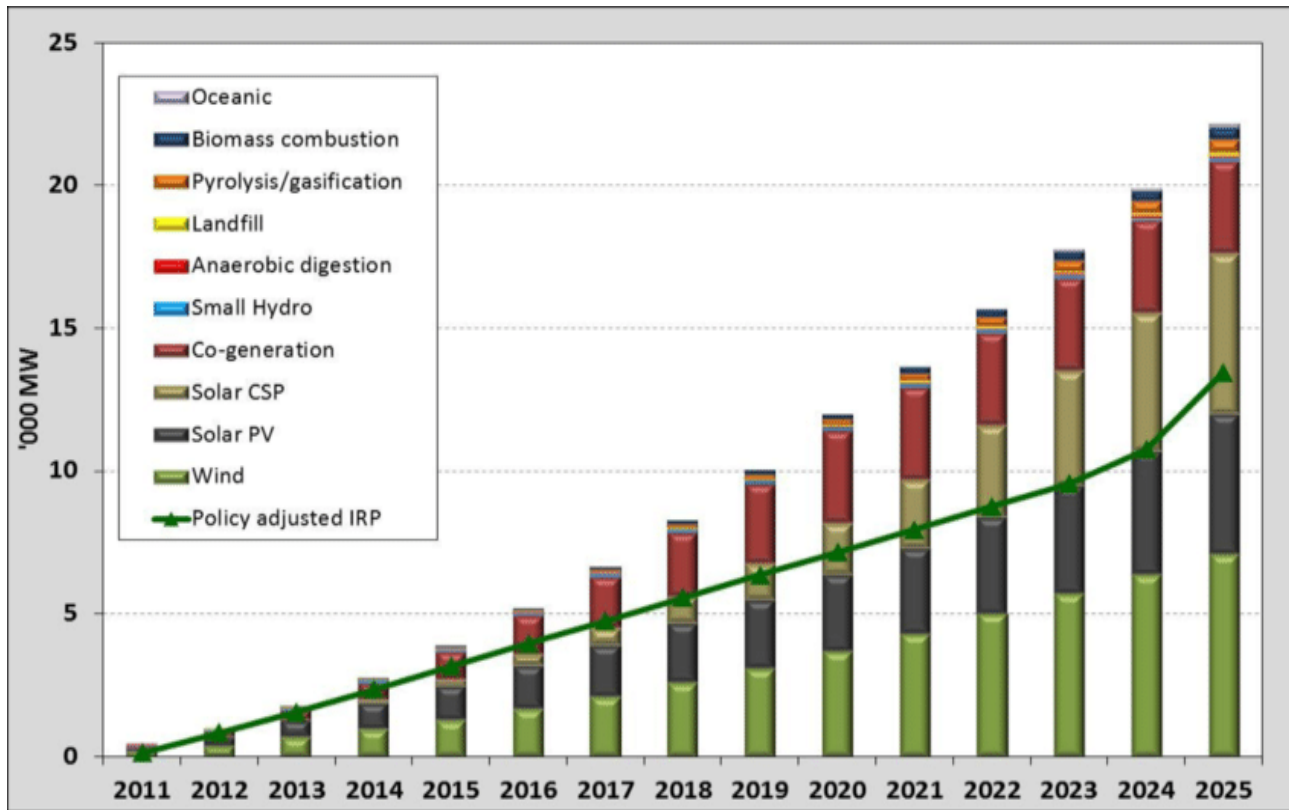


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Technology Type	Projects / Plants	Rated Power (MW)
Electro-Chemical	992	3296
Thermal Storage	207	3692

# The RE Market Expectations



Source: , Thierry Giordano, ResearchGate, Electricity generation Capacity2011-2025

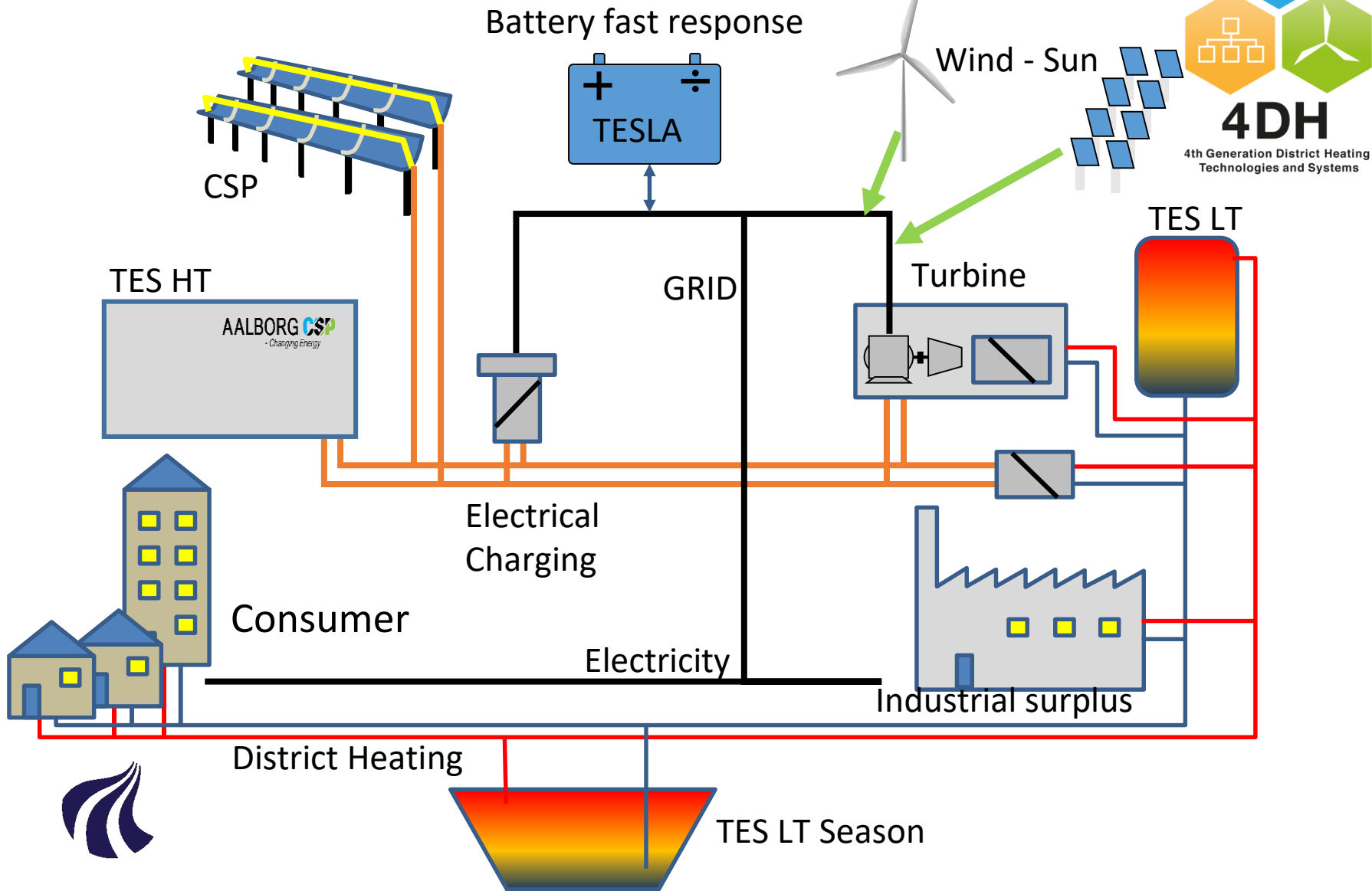
- A factor 3 increase in installed capacity from now until 2025
- The most potential RE source
- CSP is predicted to in 2022 to surpass the installed PV capacity
- Solar combined is expected to be at the same level as wind power in 2025



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# Solar and Wind Hybrid Energy





# Today's direction in Denmark = Wind to energy

Via cables to Norway / UK / France/Polen/Germany



## Wind Energy



## Electricity



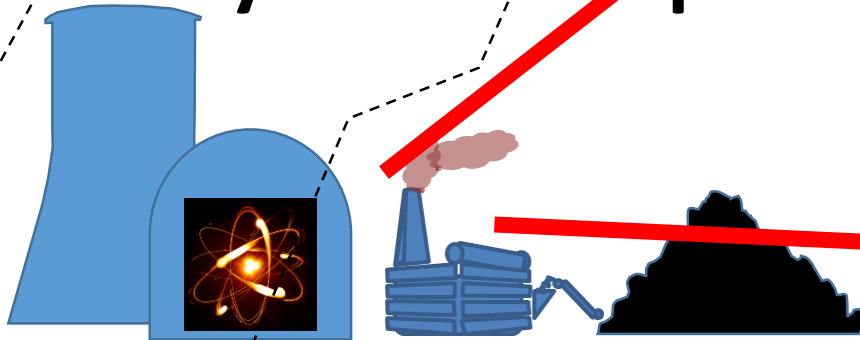
## Co-generation



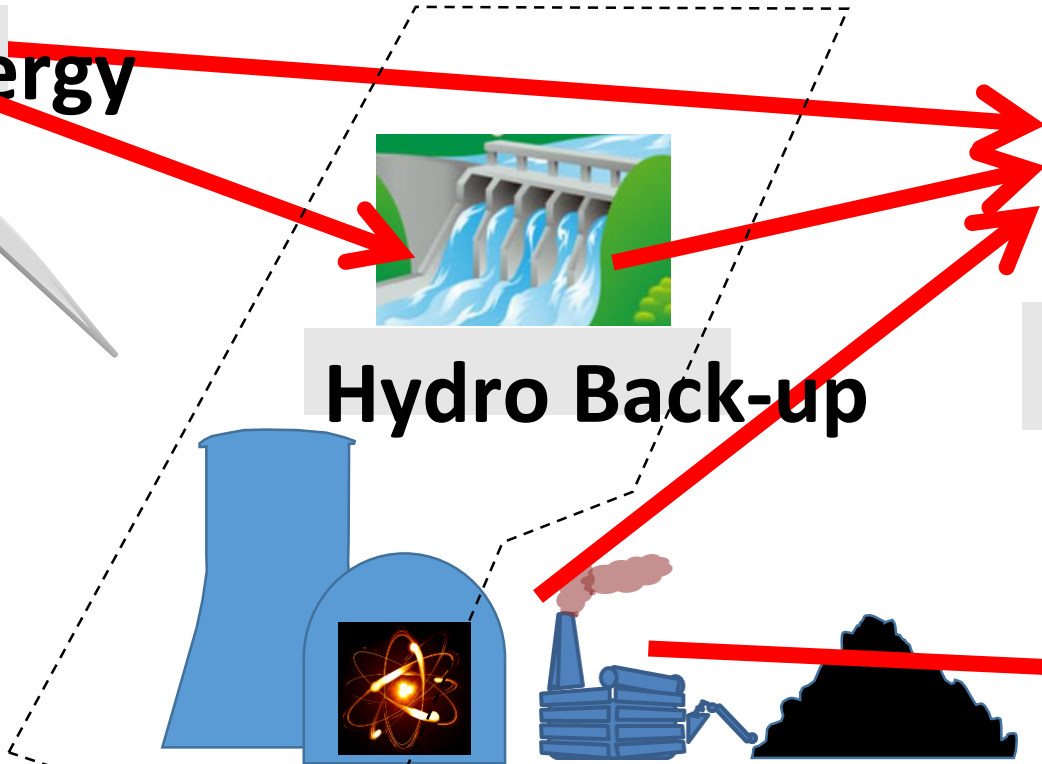
## Heating



## Hydro Back-up



## Coal/Nuclear Back-up

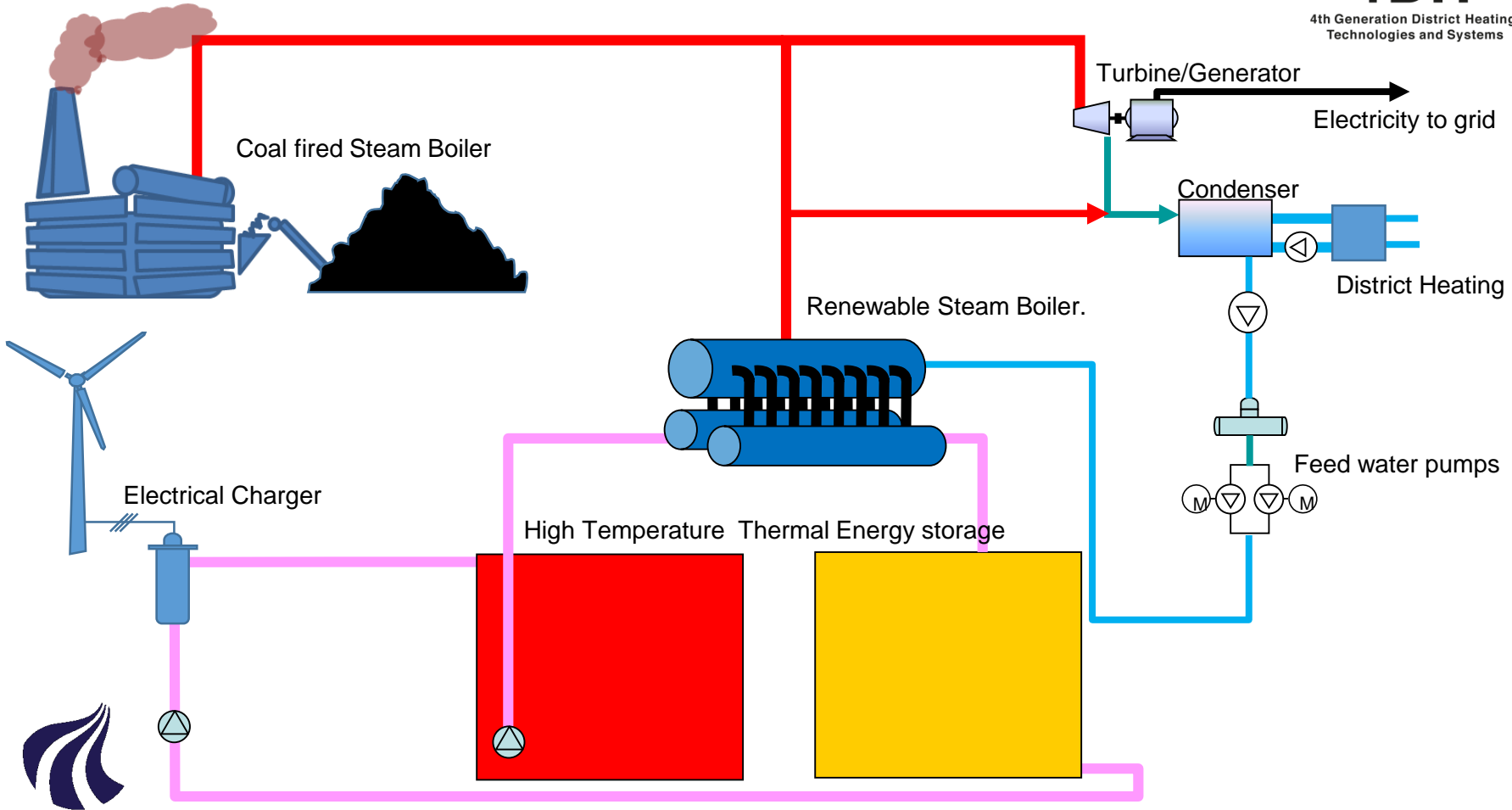


# Wind to Molten Salt power plant = El to El + District heating



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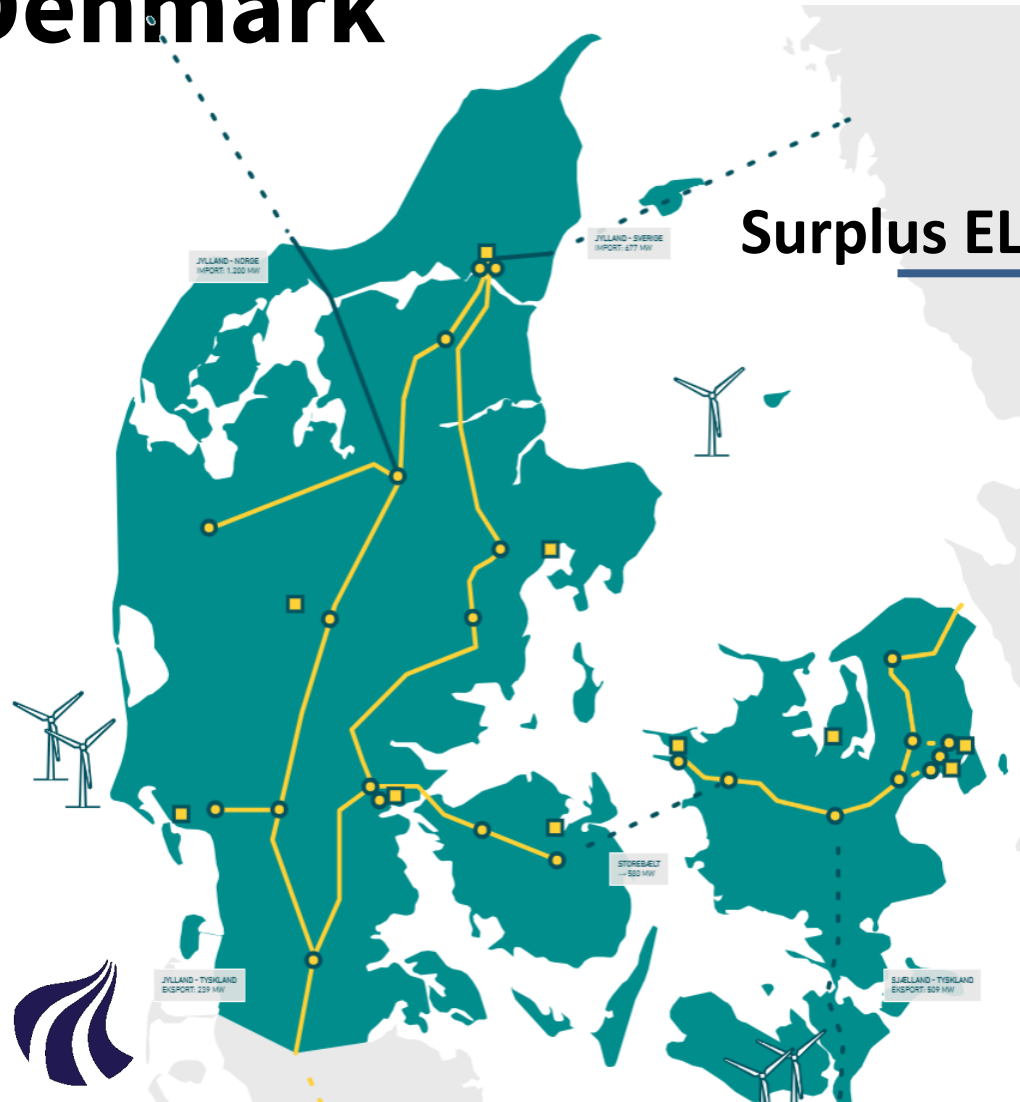


# Annual Power Consumption Denmark



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Surplus EL

CSP Solar Thermal

100%



30% EL

69% Heat

0,5 – 1 % convection loss

EL

Consumption peak = 5 GW<sub>e</sub>

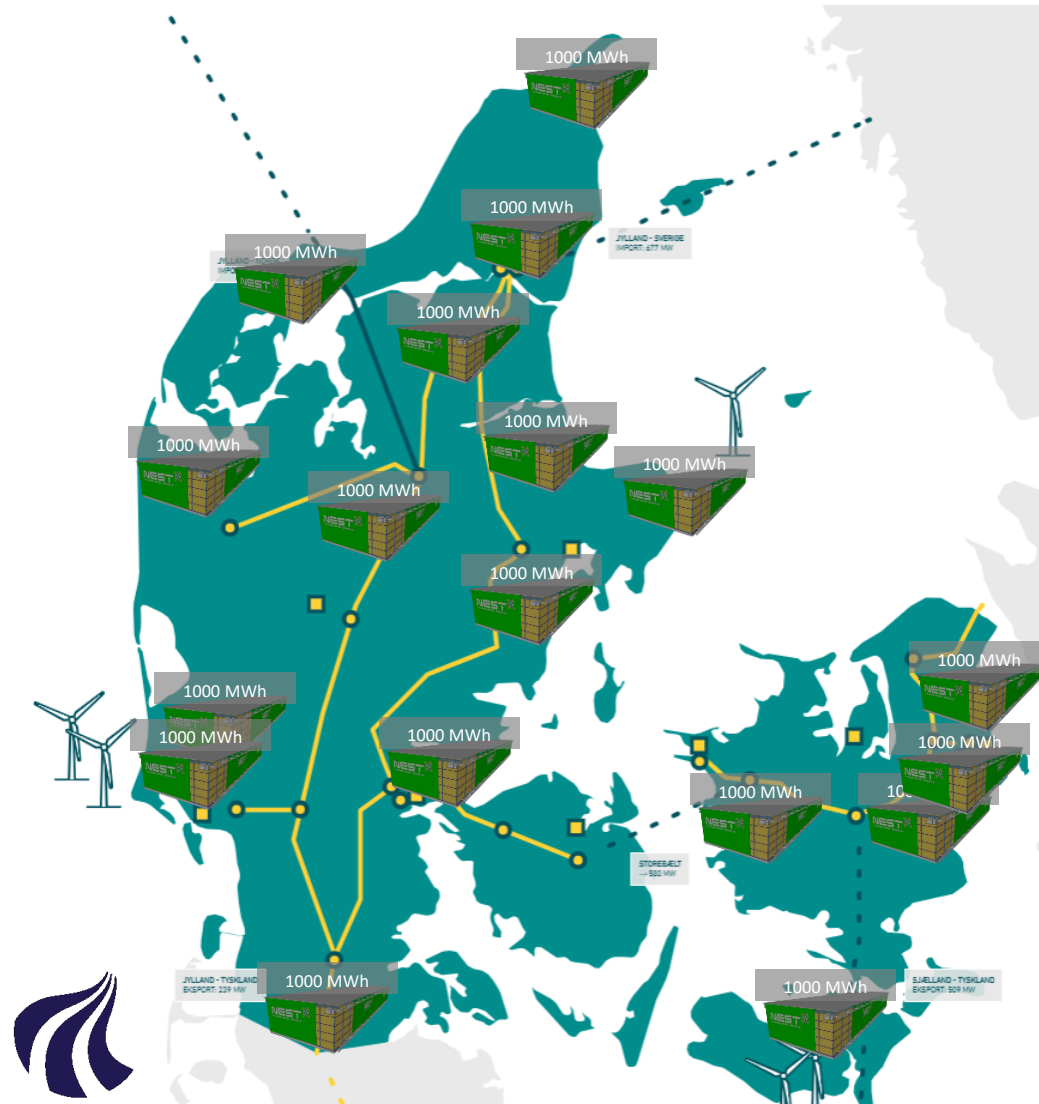
Yearly consumption = 34 TWh<sub>e</sub>

Heating Yearly

= 37 TWh<sub>t</sub>



# Denmark towards renewable



Storage to Cover Consumption  
peak  $5 \text{ GWh}_e = \text{around } 17 \text{ GWh}_{th}$

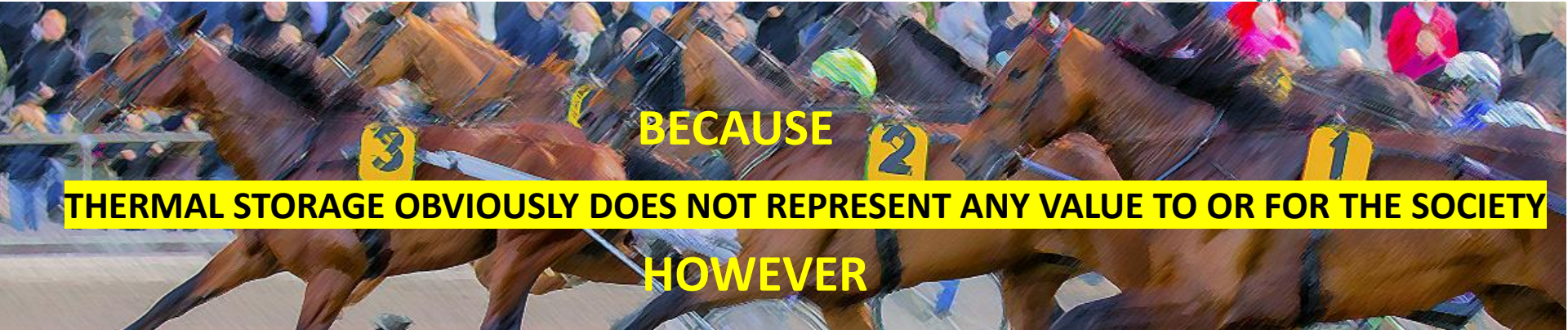
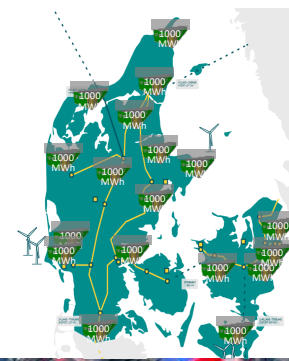
Using Molten Salt as TES a unit of  
 $1 \text{ GWh}_{th}$  can be built at the cost  
of DKK 180 Mio.

17 Units of  $1 \text{ GWh}_{th}$  gives a total  
investment DKK 3 Mia

Can be charge and discharge at  
all time acting as grid equalizer



# Why does this transition not happen in Denmark??



**BECAUSE**

**THERMAL STORAGE OBVIOUSLY DOES NOT REPRESENT ANY VALUE TO OR FOR THE SOCIETY**

**HOWEVER**

- Hence no un-subsidized RE will have a chance to grow before it reaches grid parity on it's own.
- The CO2 Kvota system has failed the CO2 kvota prices are neglectable (is 40-45 DKK/T should have been 200 DKK/T). Hope that the reboot will succeed
- The politicians are right now adopting a law that makes it legal to install electrical driven heat pumps (Split Aircondition units) with governmental subsidies, in private houses eventhough there already is a district heating network available.
- No more obligations to connect to District Heating.



Had the Wind Mills faced same conditions

**NO WIND MILLS WOULD EVER HAVE BEEN INSTALLED IN DENMARK**

# Denmark

## What is the benefit of High Temperature Thermal Energy Storage ???



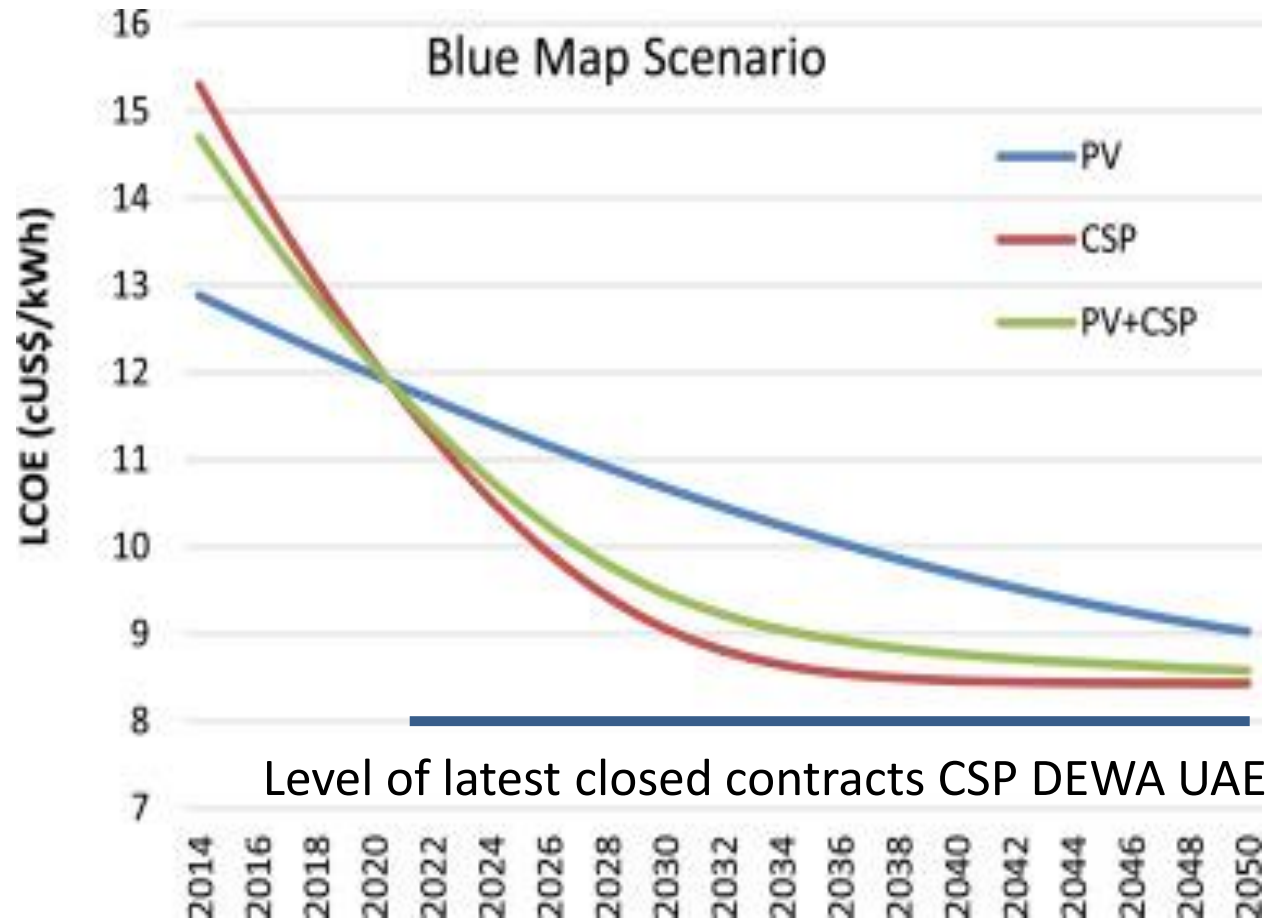
- ✓ The TES systems can be integrated using the existing infrastructure
  - At Power Plant utilizing existing Steam turbines, feed water systems etc.
  - At decentralized CHP plants utilizing existing District Heating systems
  
- ✓ **Give the possibility of import/export of large amounts of Electricity**



- ✓ Most of the Thermal plant components can be made and maintained by local workforce. (Most Split Air-con units (Heat Pumps) are made in China or Asia.)



# Expected Development of solar electricity prices 2014



Source: ScienceDirect, Energy, Volume 94 Jan,1,2016







YES WE CAN

All technologies are available

Thank you for your attention



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