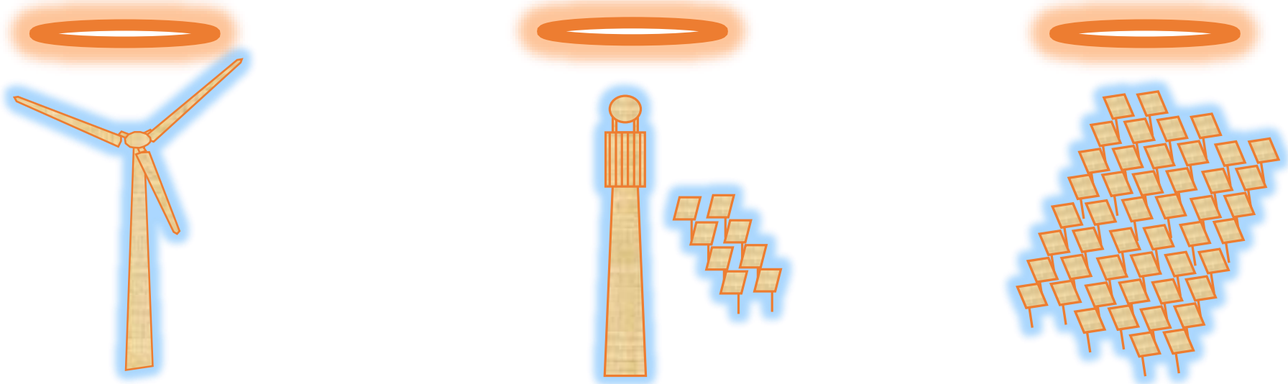
AALBORG CSP
- Changing Energy

High Temperature Thermal Energy Storage & Re-use of existing Energy assets

There is no all-mighty technology



Peter Badstue Jensen
Vice President - Partner

1 Oct, 2019

Potential CO2 saving from 3 Coal Fired Plants in Denmark

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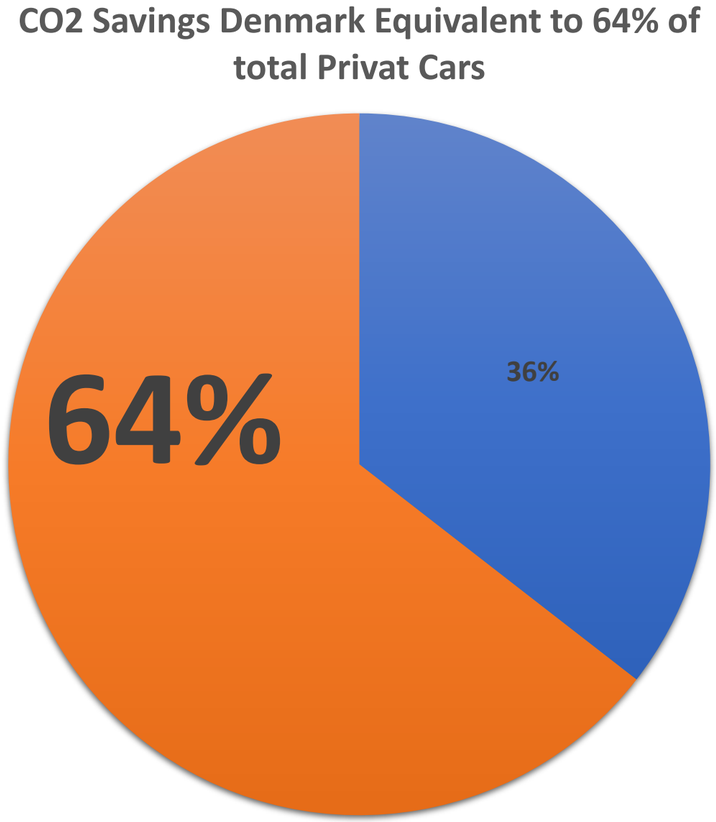
3 Coal fired plants Combined CO2 in 2017:

- 4.609.111 Ton.CO2/Year 2017.

Potential equivivalent CO2 if from cars:

• **Reduction number of cars:**	**1.936.601**
Total Cars in DK.2019	**3.002.889**

Or 6.000 Jumbojets CPH – New York t/r



Replacement of fossil fuel through integration

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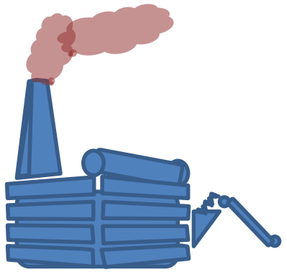
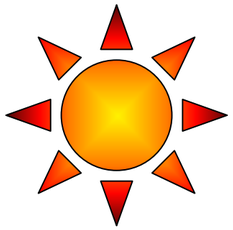
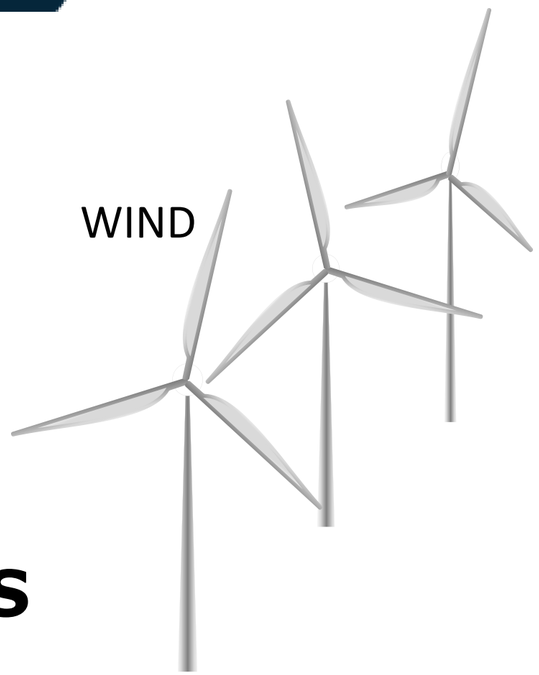
BIO FUEL



SOLAR



WIND



NEXT STEPS

INTEGRATED RENEWABLE ENERGY & LARGE HIGH TEMPERATURE ENERGY STORAGE SYSTEMS

THE RENEWABLE ENERGY PALETTE

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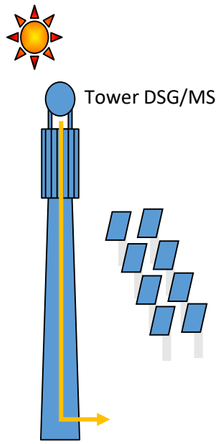
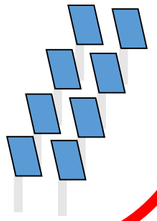
SOLAR FIELD



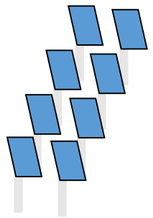
Tower DSG/MS

Parabolic Trough HTF/DST/MS

PV

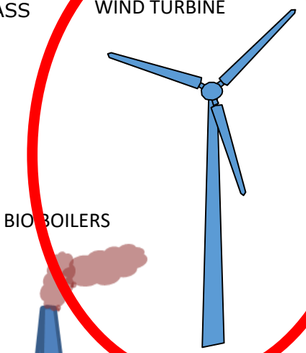


Flat thermal panels

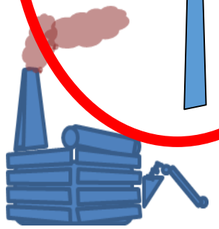


BIOMASS

WIND TURBINE

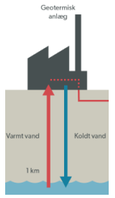


BIO BOILERS



Fresnel receiver
HTF/DST/MS

Geo-thermal



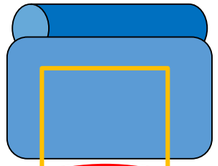
BATTERIES

Hot water storage

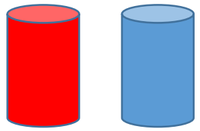
Daily/Weekly

Seasonally

Concrete/Hot Stone

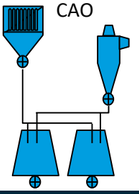


Molten Salt days/week.

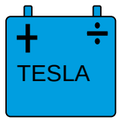


Chemical Energy

CAO

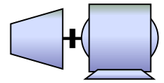


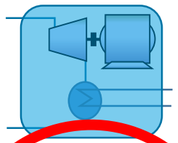
Li-ion



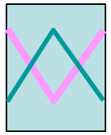
ELECTRICITY/CONVERSION

Steam turbine
Generator

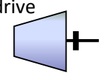




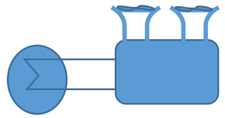
HT Electrolysis



Steam turbine
Mech. drive

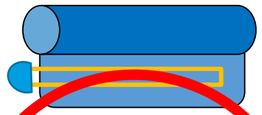


Steam condenser
& Cooling tower



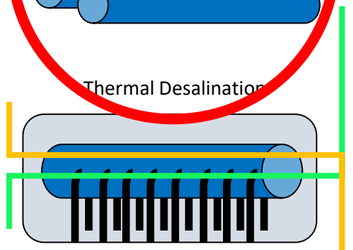
ENERGY USAGE/CO-GEN

Electrical boiler/Heat Pump

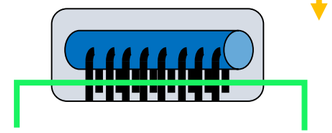


Steam Boiler

Thermal Desalination



Reverse Osmoses



Heatpump / Absorption Chiller

Process / District heat

Why MOLTEN SALT High Temperature Energy Storage

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- Changing Energy

High Temperature Energy Storage
Already in operation in :
CHINA, USA, Spain, Marocco

Is ‘BANKABLE’
International Banks can
provide financing.

Is relatively inexpensive
23-27 USD/MWht
Heater, Storage, Steam Generator

The Chinese High Temperature Energy Storage projects commenced

AALBORG CSP - Changing Energy

Projects commenced and planned to be completed before end 2020

3300 MWh Thermal storage

Sep. 19 Status
4 large scale projects completed

Project Name	Storage (Hours)
CGN Delingha 50MW HTF PT Project	9
Qinghai SUPCON Solar Delingha 50MW MS Tower Project	6
Beijing Shouhang IHW Resources Saving Technology 100MW MS Tower Project	11
Yumen Xinneng 50MW MS Tower Project	6
Shenzhen Jinfan Akesai 50MW MS PT Project	15
Inner Mongolia China Nulcear Royal Tech Wuzhongqi 100MW HTF PT Project	4
DCTC Dunhuang 50MW MS CLFR Project	13
Zhangbei Huaqiang Group Zhangjiakou 50MW DSG CLFR Project	14
Rayspower Group Yumen 50MW HTF PT Project	7
Northwest Electric Power Design Institute Hami 50MW MS Tower Project	8

Project Name Format: Investor/Developer Name + Capacity + Technology

Abbreviations:

MS—Molten Salt; PT—Parabolic Trough; CLFR—Compact Linear Fresnel Reflector; DSG—Direct Steam Generation; HTF—Heat Transfer Fluid

http://en.cnste.org/html/news/2017/1013/330.html

Typical CSP power plant with Molten Salt HIGH TEMPERATURE Energy Storage

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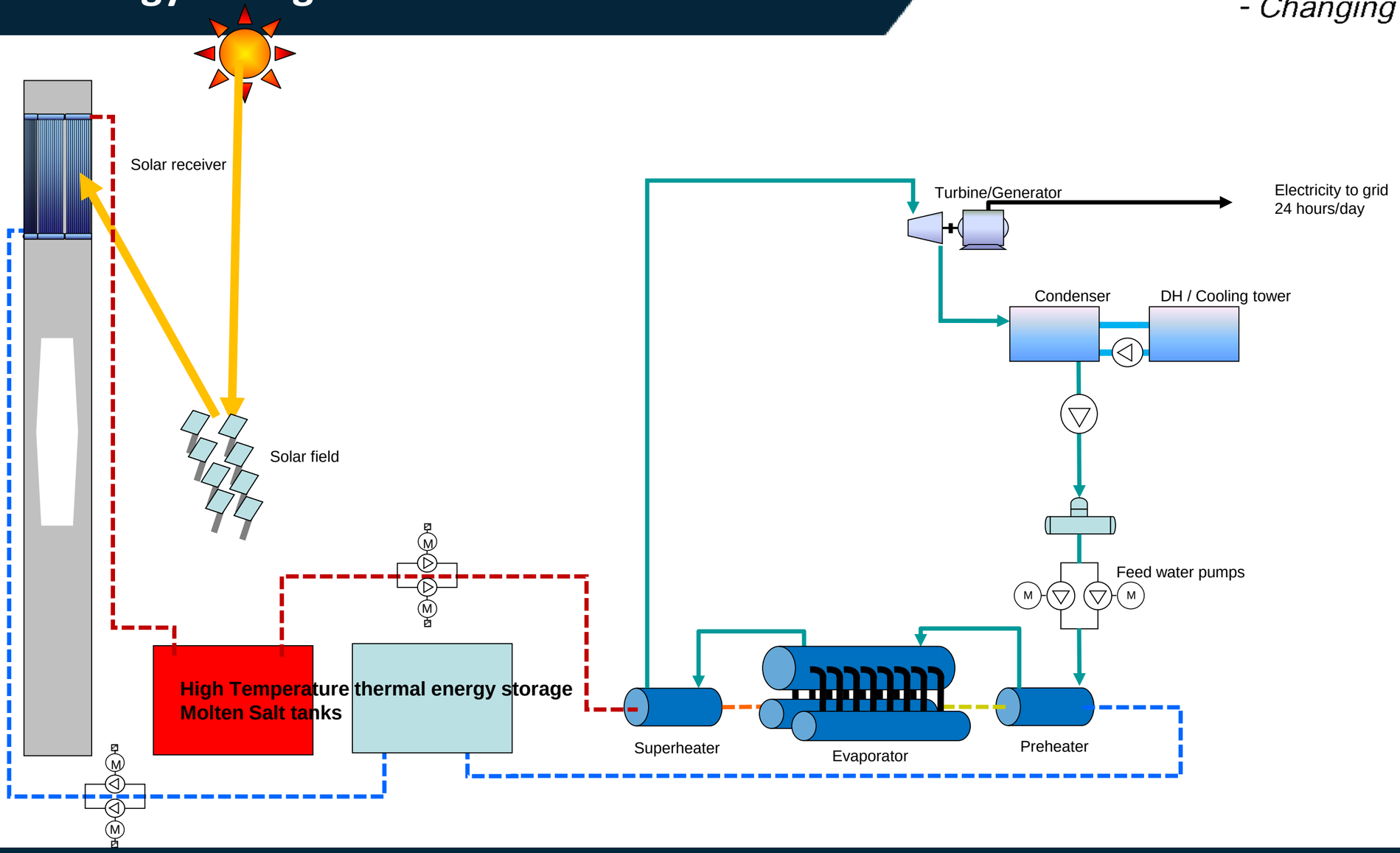

In Denmark we have wind power, but also Coal Power And the Spot marked

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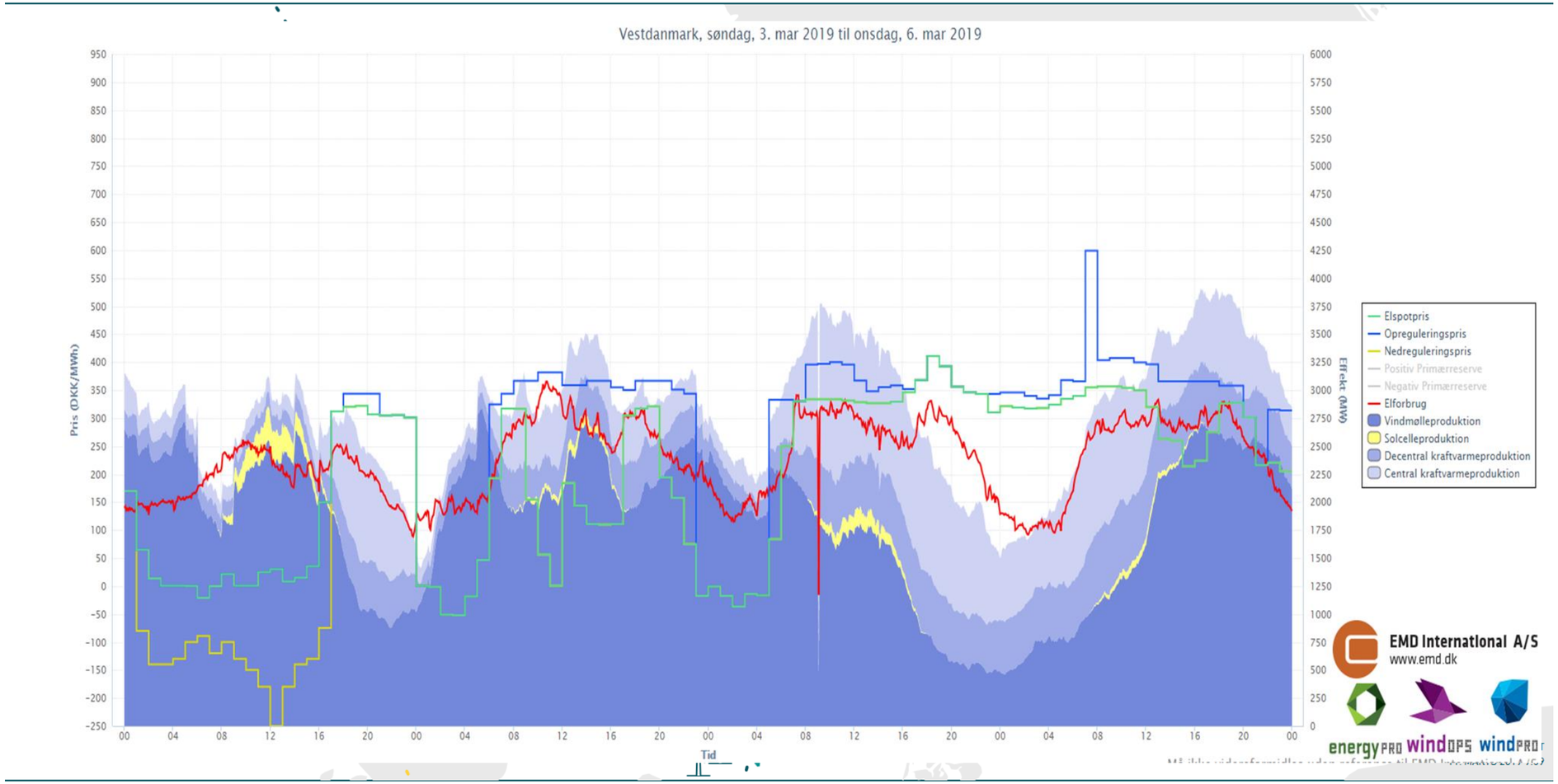

The Danish Electricity situation – ‘Blowing in the Wind’

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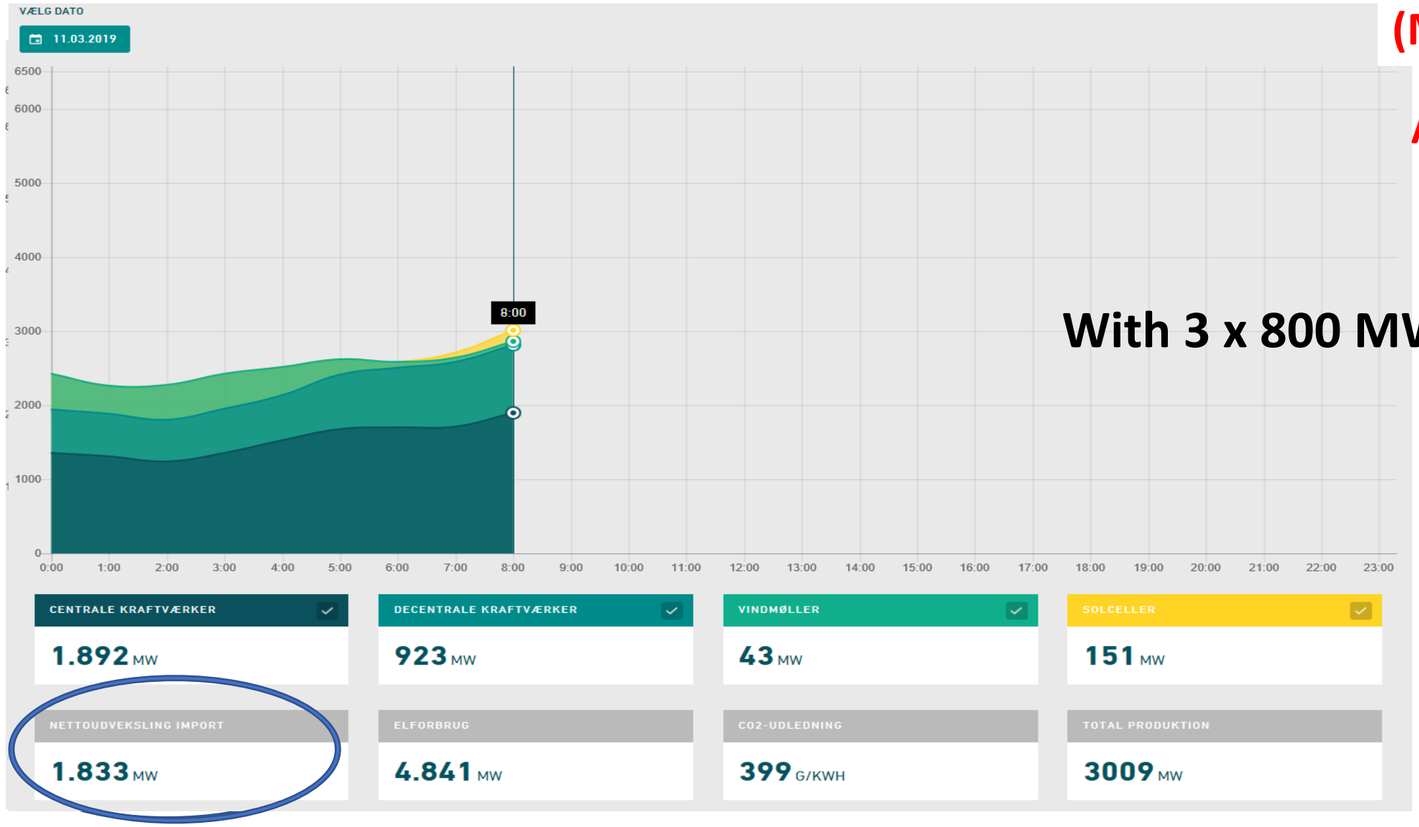
Eur/MWh – Nord pool DK1

11-03-2019	45,21	335 kr



Import – 1.833 MW
At 335 kr/MWh
(Money out ofthe box)

Aprox 1,600,000,000 Kr/y

With 3 x 800 MW Additional Wind farms

Potential new cost
3,200,000,000 Kr/y

EMD International A/S
www.emd.dk

Energy hubs with centralized High Temperature Energy Storage. Electricity, Heat and Methanol Production

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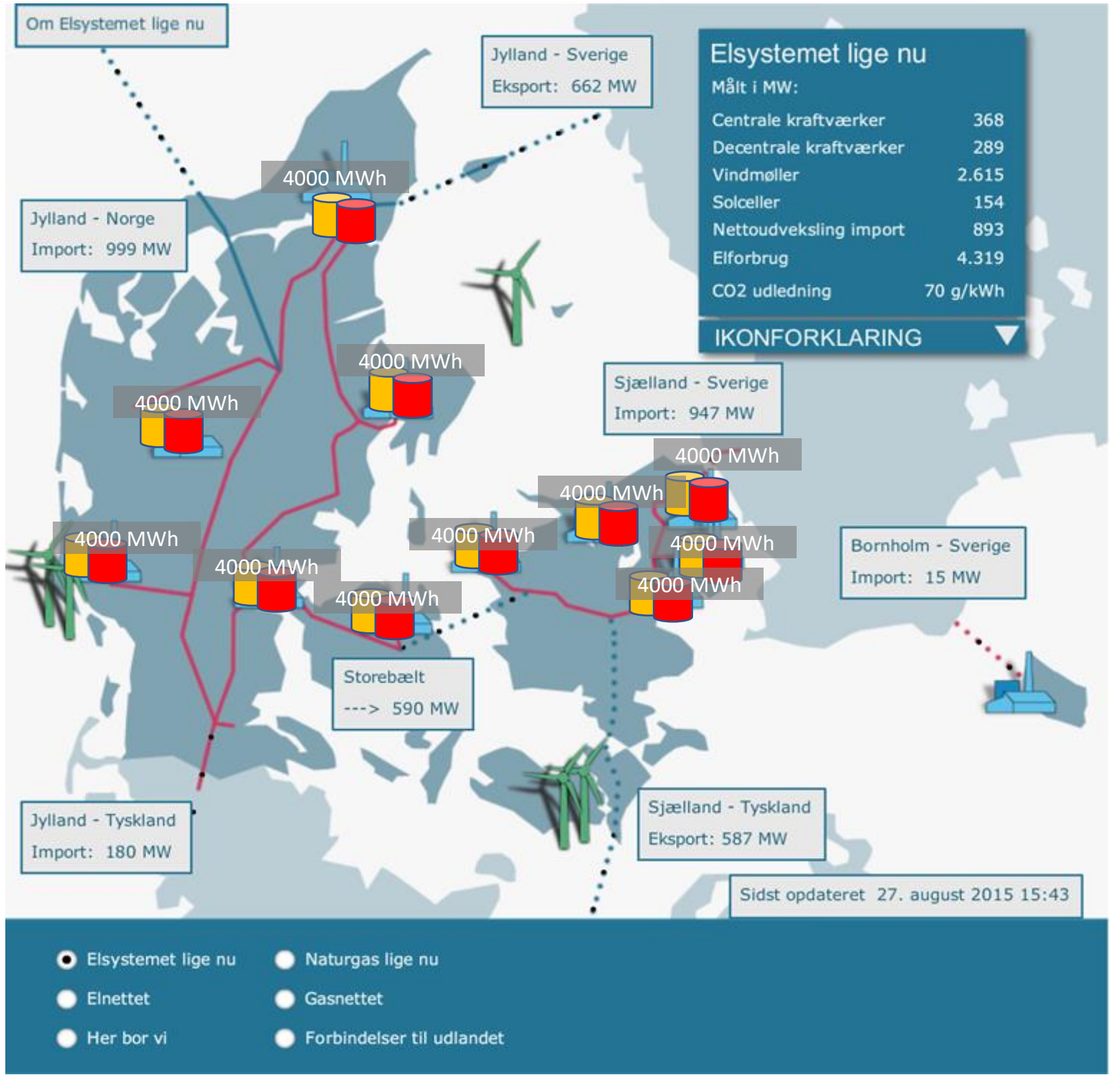
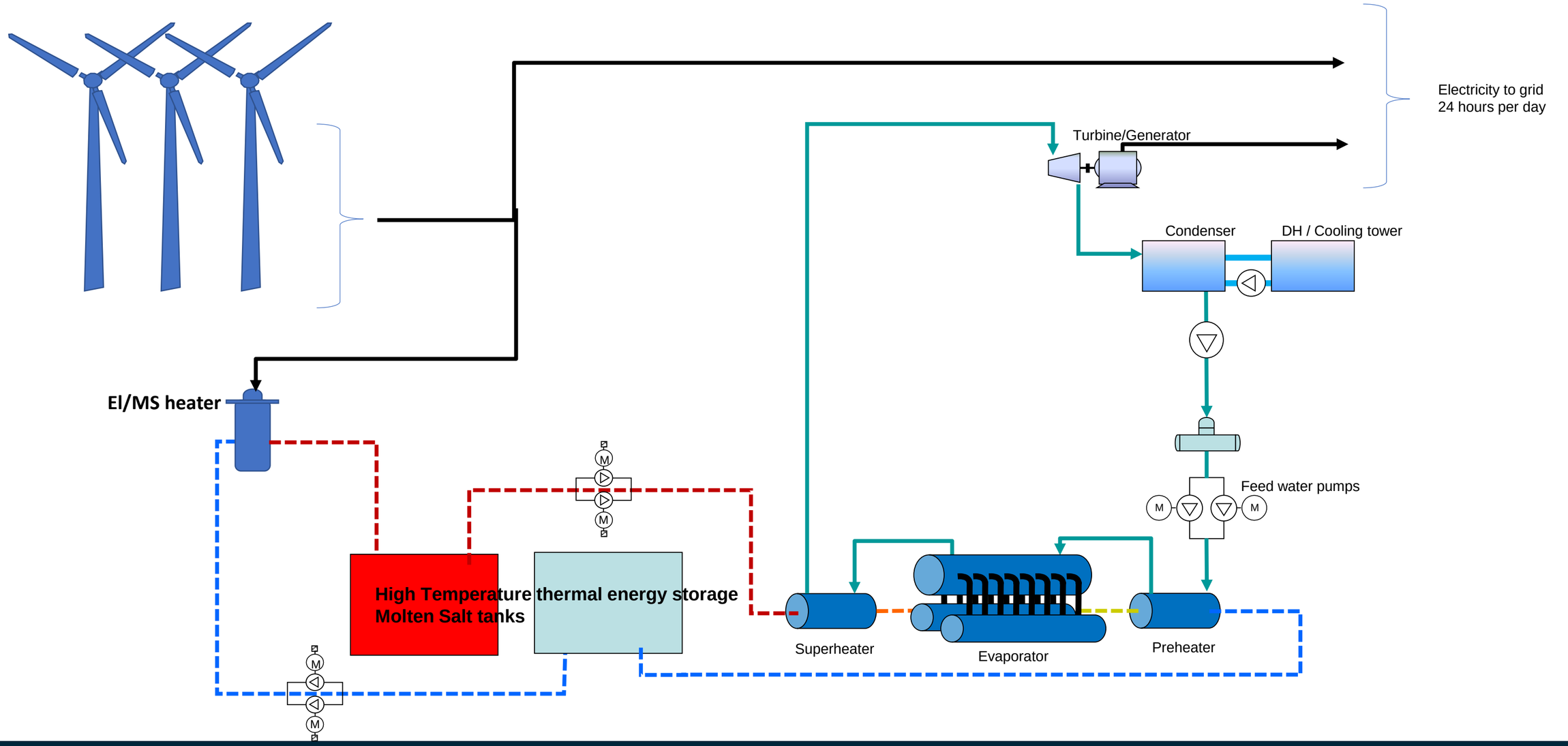
FUTURE GREEN DENMARK

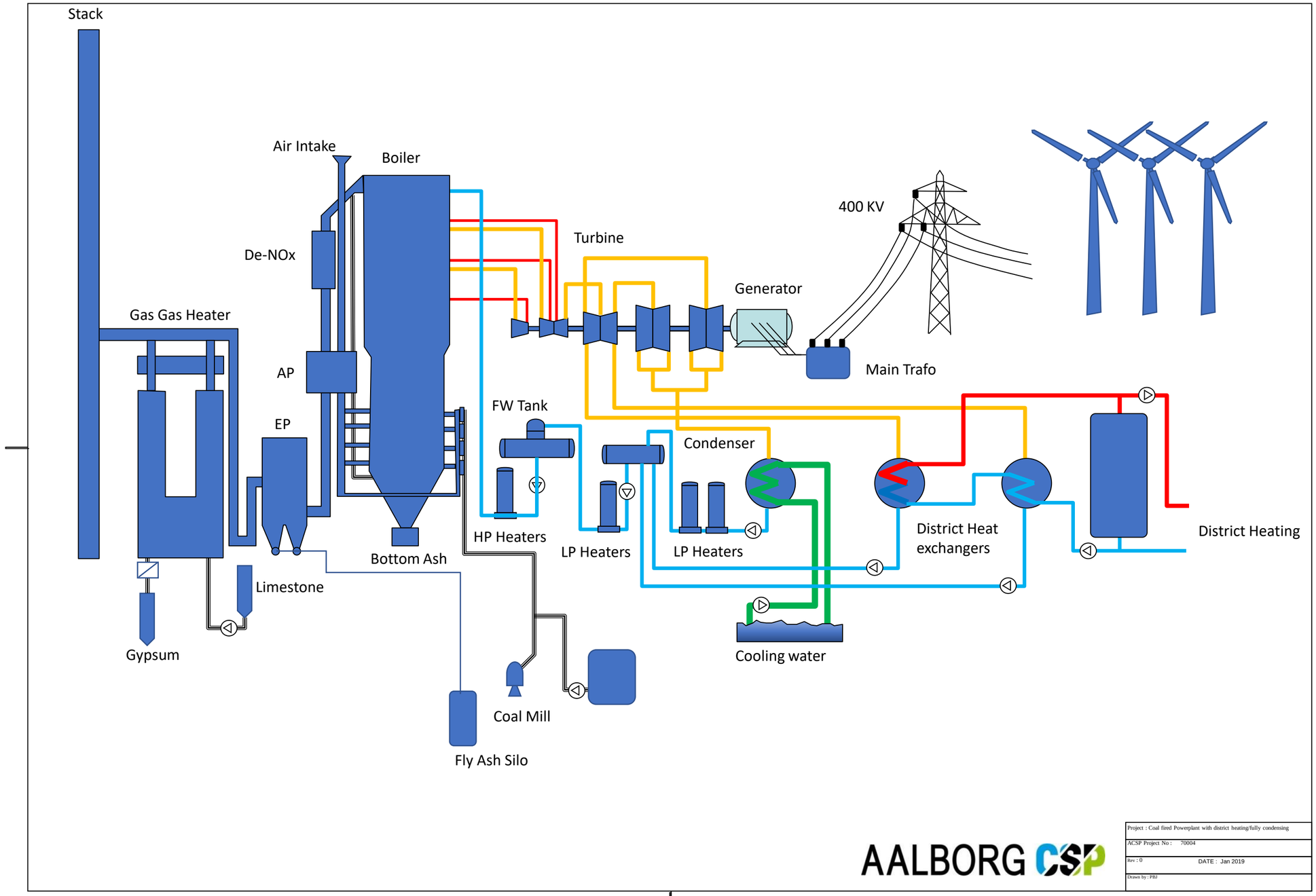


Typical CSP power plant with Molten Salt HIGH TEMPERATURE Energy Storage

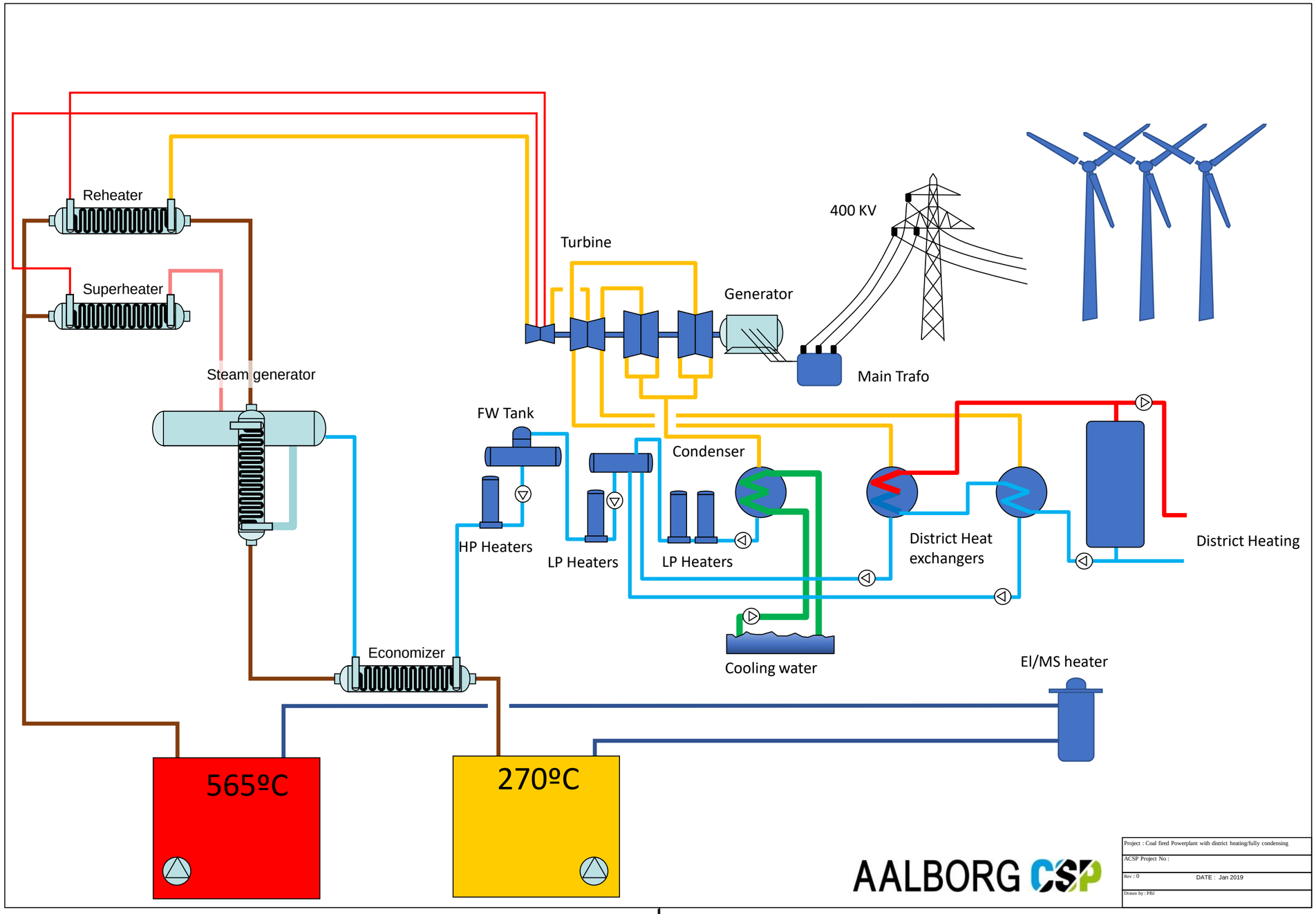
AALBORG CSP
- Changing Energy



Typical Coal fired power plant unit generating electricity and heat



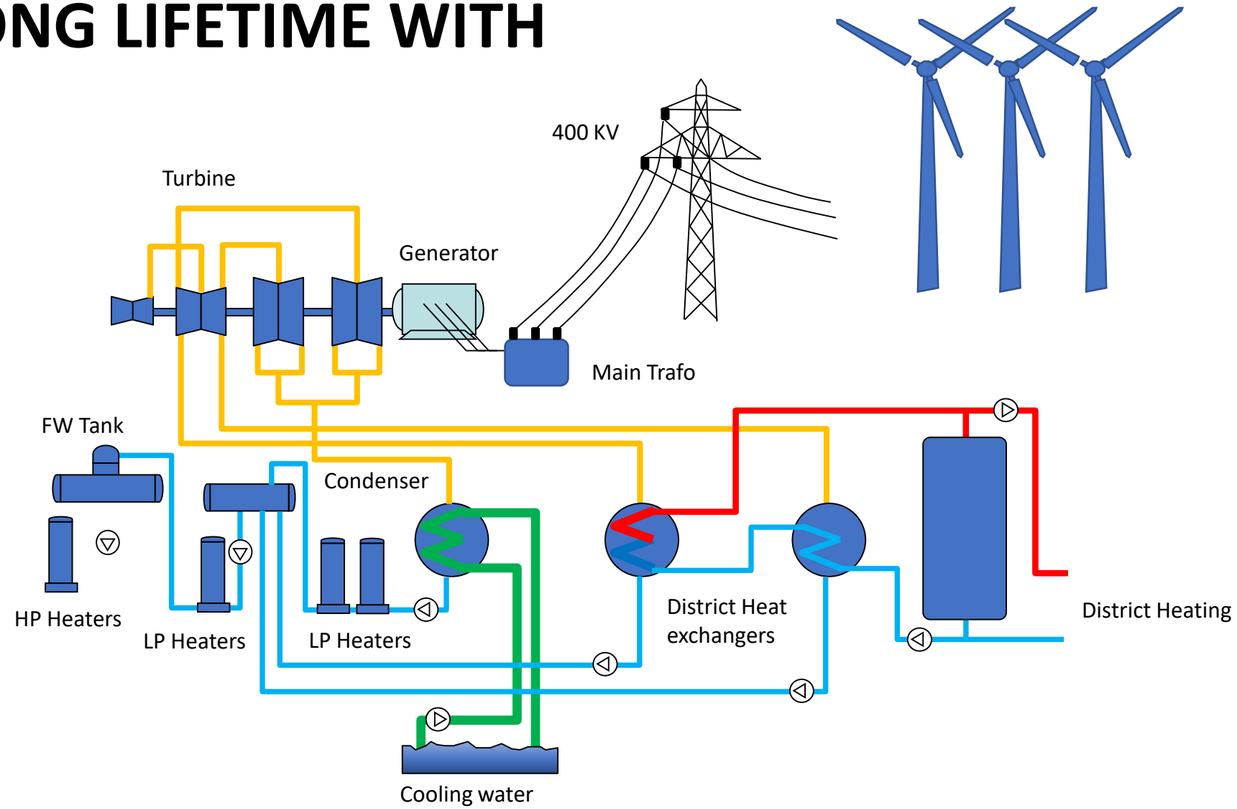
Coal fired power plant Retrofitted and downscaled to operate 100% Renewable



Typical reuseable assets from converted Coal fired power plant

THE REUSABLE ASSETS HAS LONG LIFETIME WITH CONTINUED MAINTENANCE
Lower temp = longer lifetime

A unique chance to make Green power at reduced Investment.



AALBORG CSP

Preliminary prediction of P/L from operation And Investment (100 MWe Heater / 1500 MWh Storage)

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	Reference	inkl el-afgifter	inkl el-afgifter elpatronlov	inkl kun Energinet nettarif
Revenues				
salg af el	44.086.068	149.373	1.106.811	10.128.814
salg af varme	56.652.000	72.000	540.000	9.630.000
Revenues Total	**100.738.068**	**221.373**	**1.646.811**	**19.758.814**
Operation expenditures				
køb af el	75.567.020	-192.593	-415.329	8.066.781
Afgifter og nettariffer	0	333.600	591.300	0
Nettariffer	0	0	922.500	6.420.000
Operation expenditures Total	**75.567.020**	**141.007**	**1.098.471**	**14.486.781**
Net Cash from Operation	**25.171.048**	**80.366**	**548.340**	**5.272.033**

Investment in High Temperature Energy Storage incl Boiler and heater
Using existing Turbine and DH infrastructure 23-27 USD/KWht.

Unique opportunity to reuse exixting ASSETS such as steamturbogenerators, Transformers, high voltage switch-gear and district heating systems

Made in collaboration with : EMD International A/S www.emd.dk

Investment

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Installation of one plant 4.000 MWht High temperature Energy Storage

Investment cost 100 mio or USD 650 mio DKK

Investment in 40.000 MWht (10 x 4.000 MWht)

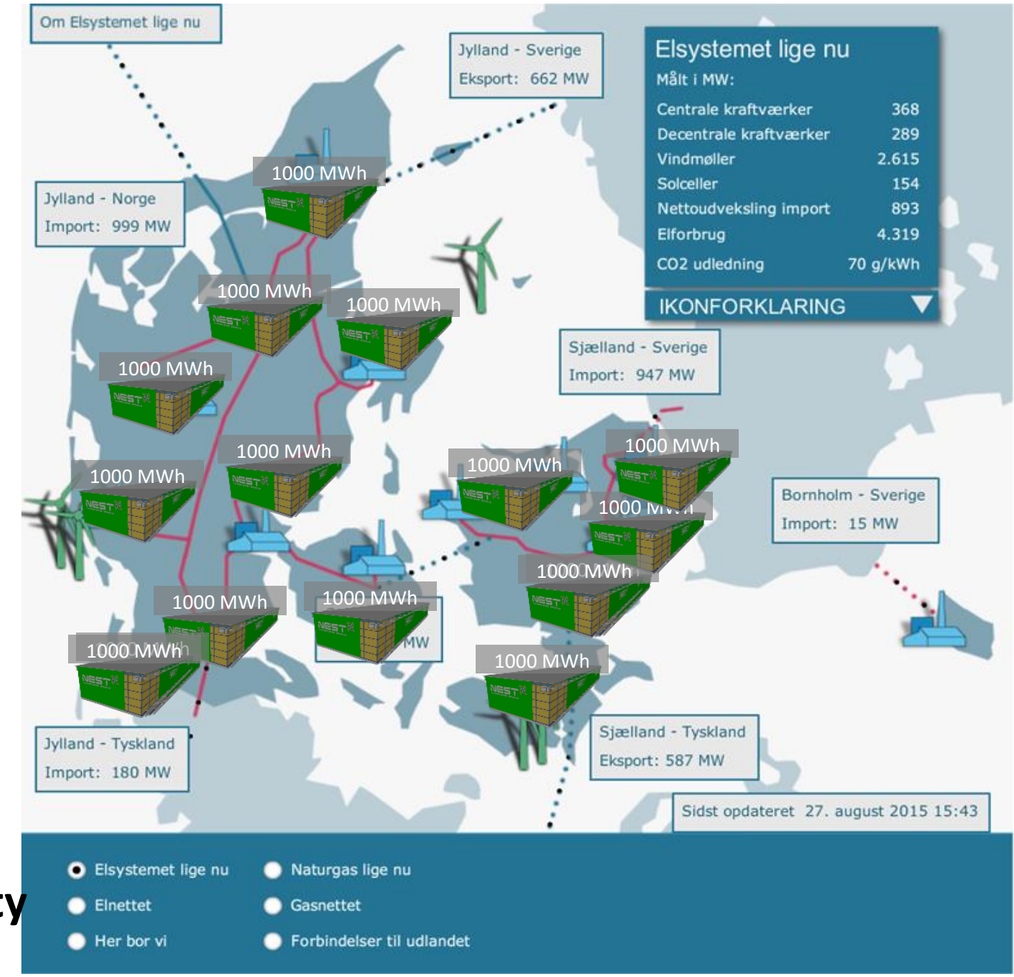
= 10 x 650 = 6,5 bill. DKK

Annually potential saving from IM/EX = 3,2 bill. DKK

-Capex financing through grants from Danish ”Klimakompenseringsfonde”
-Opex Business case through :

- **Buying and selling Electricity**
- **Selling heat**
- **Provision of Grid Balancing and stability services.**

El/Heat Ratio 40% = El. 1.600 MWh & Heat 3.400 MWh



It may not be possible only driven by the spotmarked, Storing energy capacity must have a value

Surplus Wind and Solar Electricity combined with **high temperature** and **low temperature** storage

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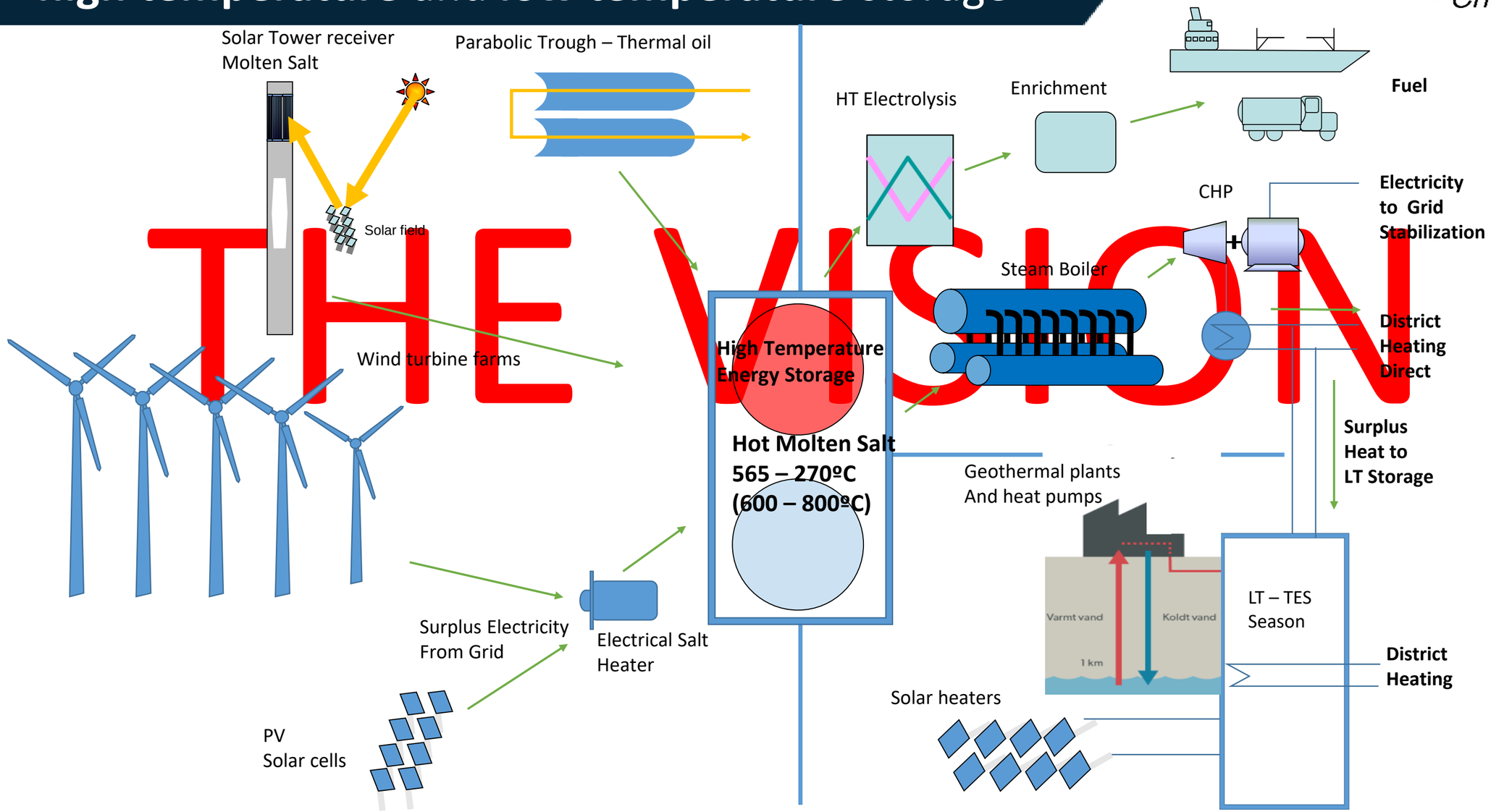

Complement use of Heatpumps and Geothermal energy

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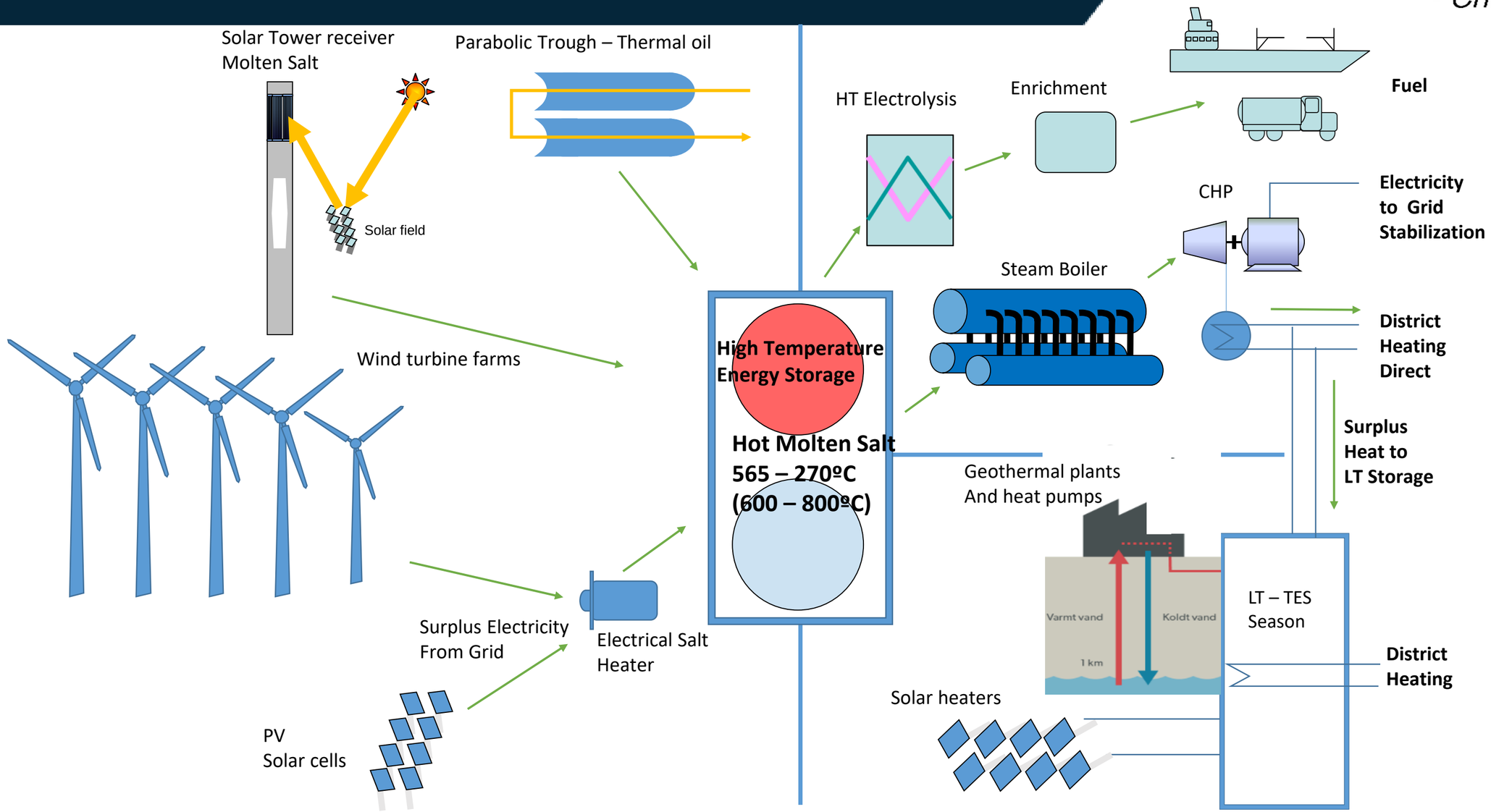
- Changing Energy



Can enhance Hydrogen production

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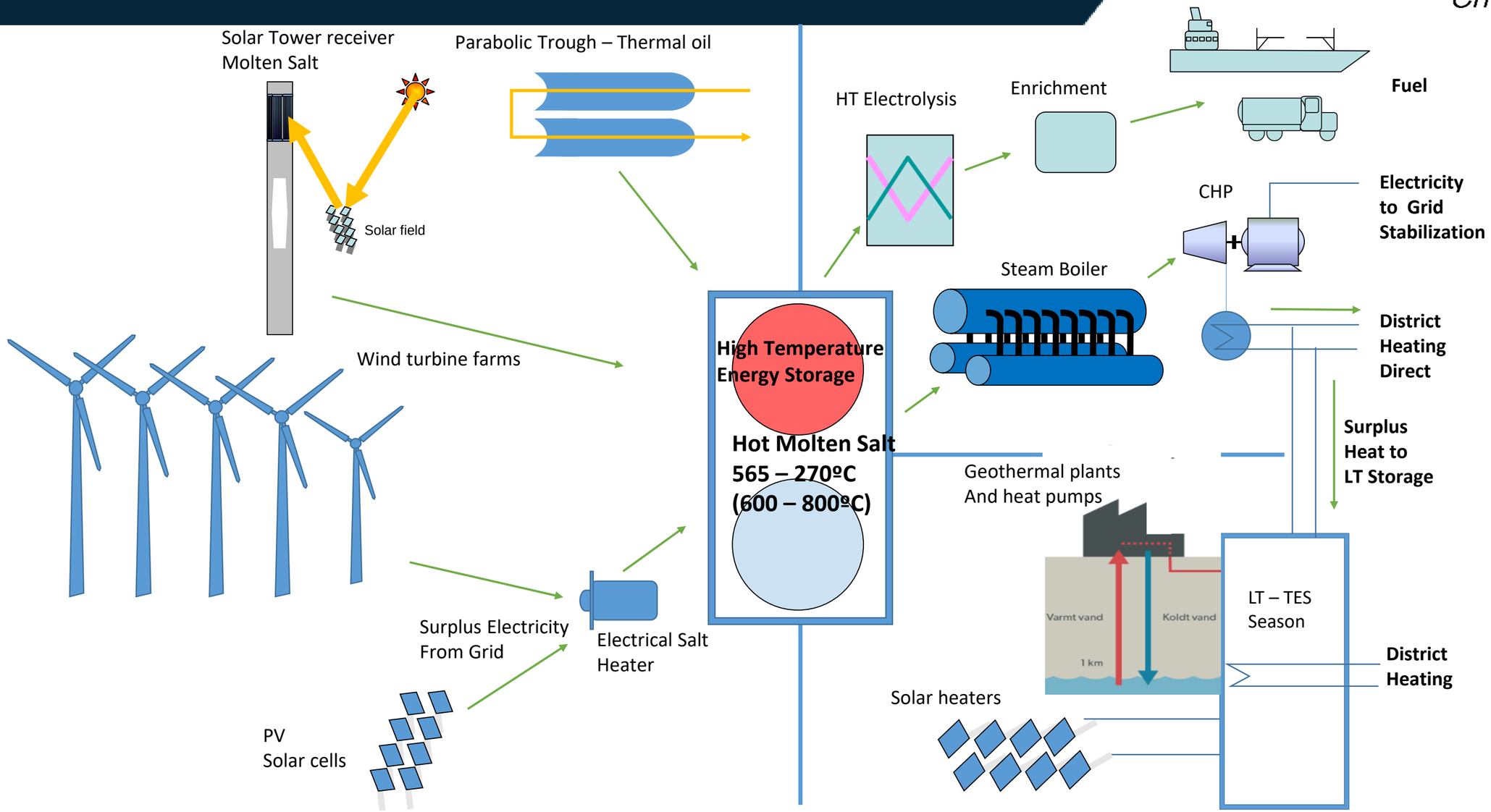

Achievable Political Goals

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National CO2 reduction with 70%

United Nations Sustainable Development Goals