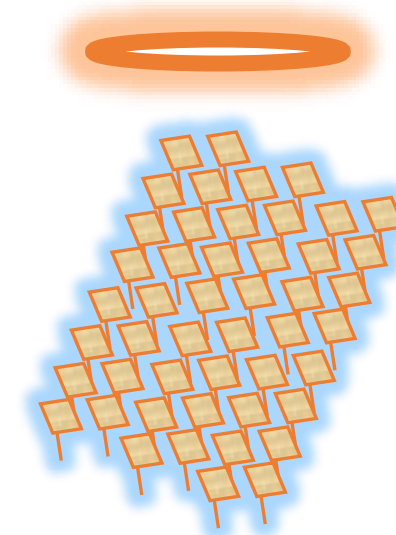
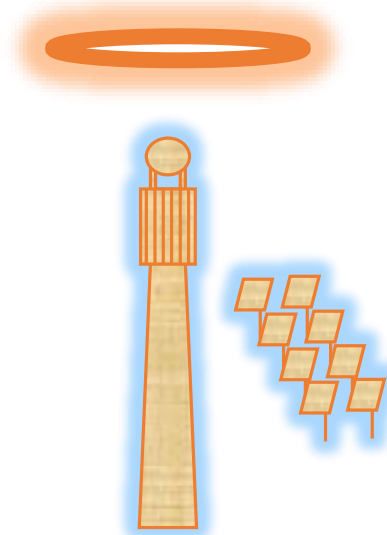
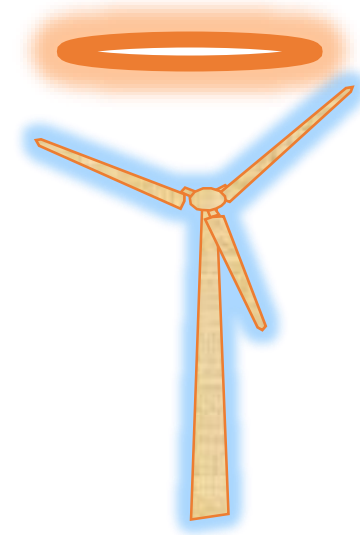


High Temperature Thermal Energy Storage & Re-use of existing Energy assets

There is no all-mighty technology



3 Coal fired plants Combined CO2 in 2017:

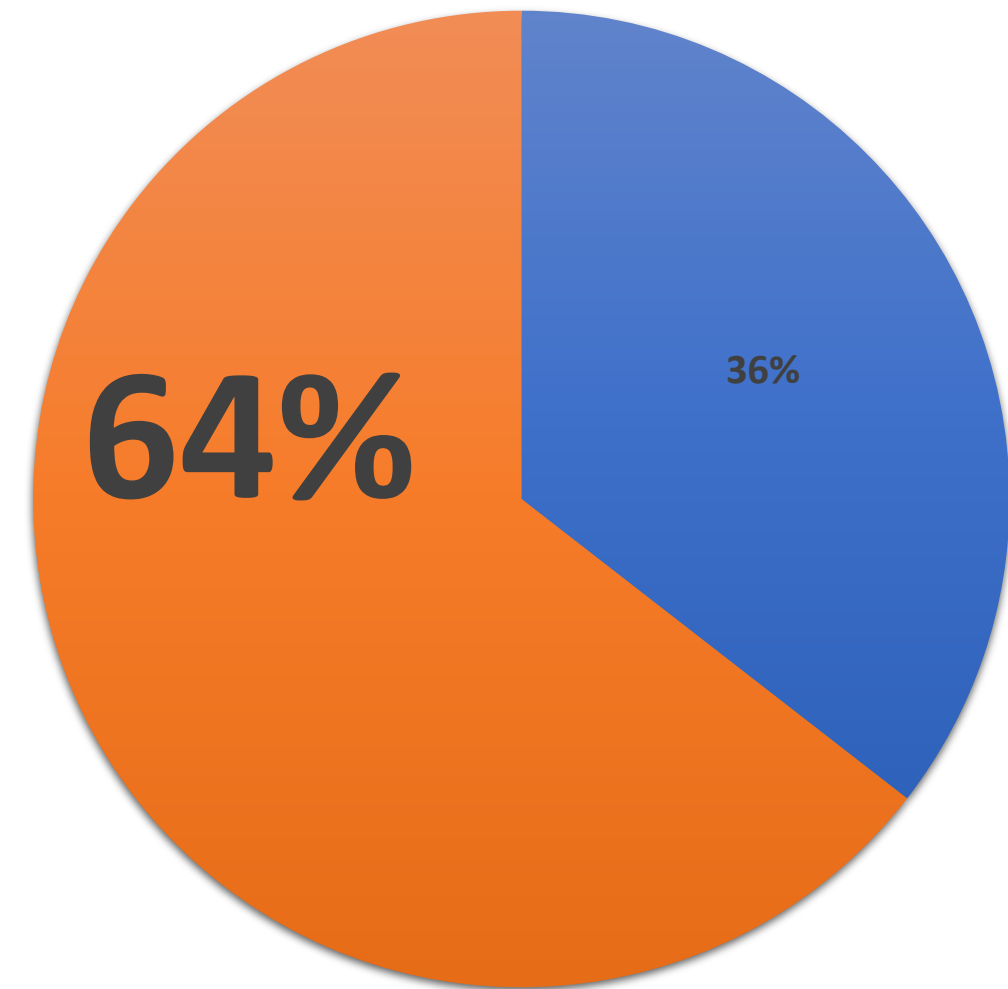
- 4.609.111 Ton.CO2/Year 2017.

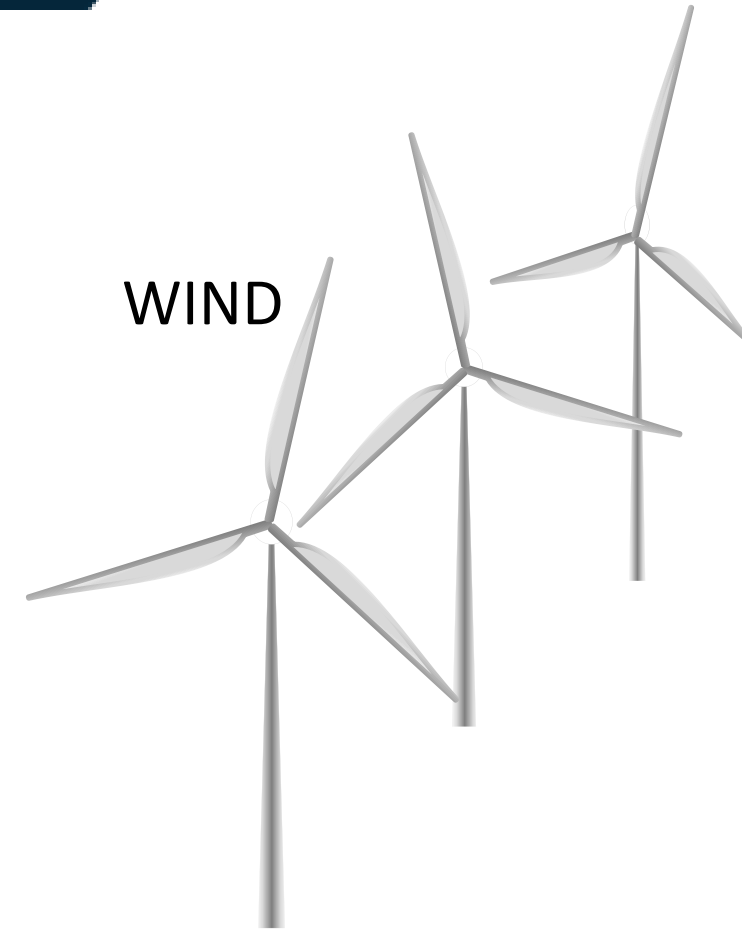
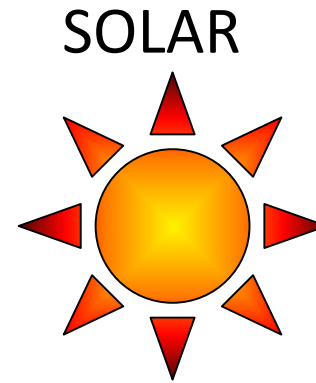
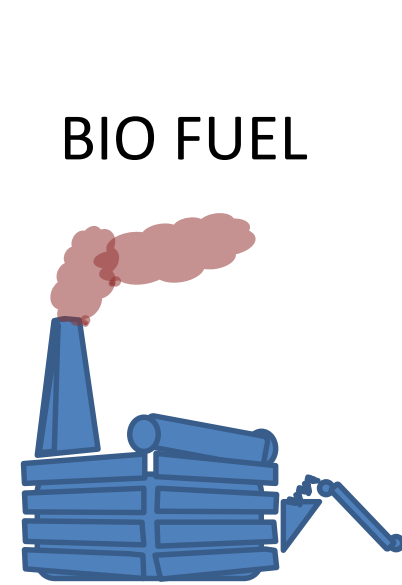
Potential equivalent CO2 if from cars:

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

Or 6.000 Jumbojets CPH – New York t/r

CO2 Savings Denmark Equivalent to 64% of total Privat Cars

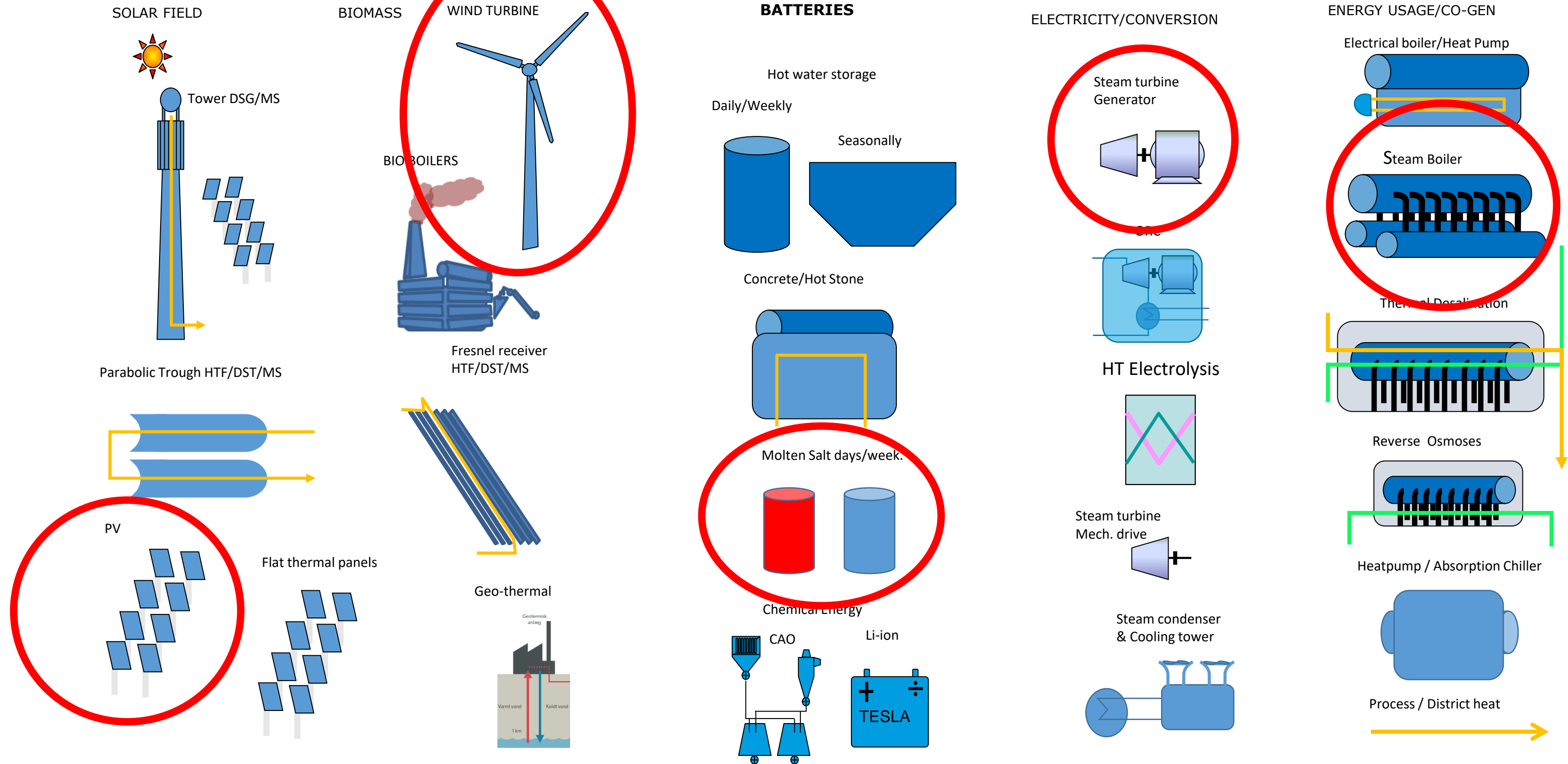




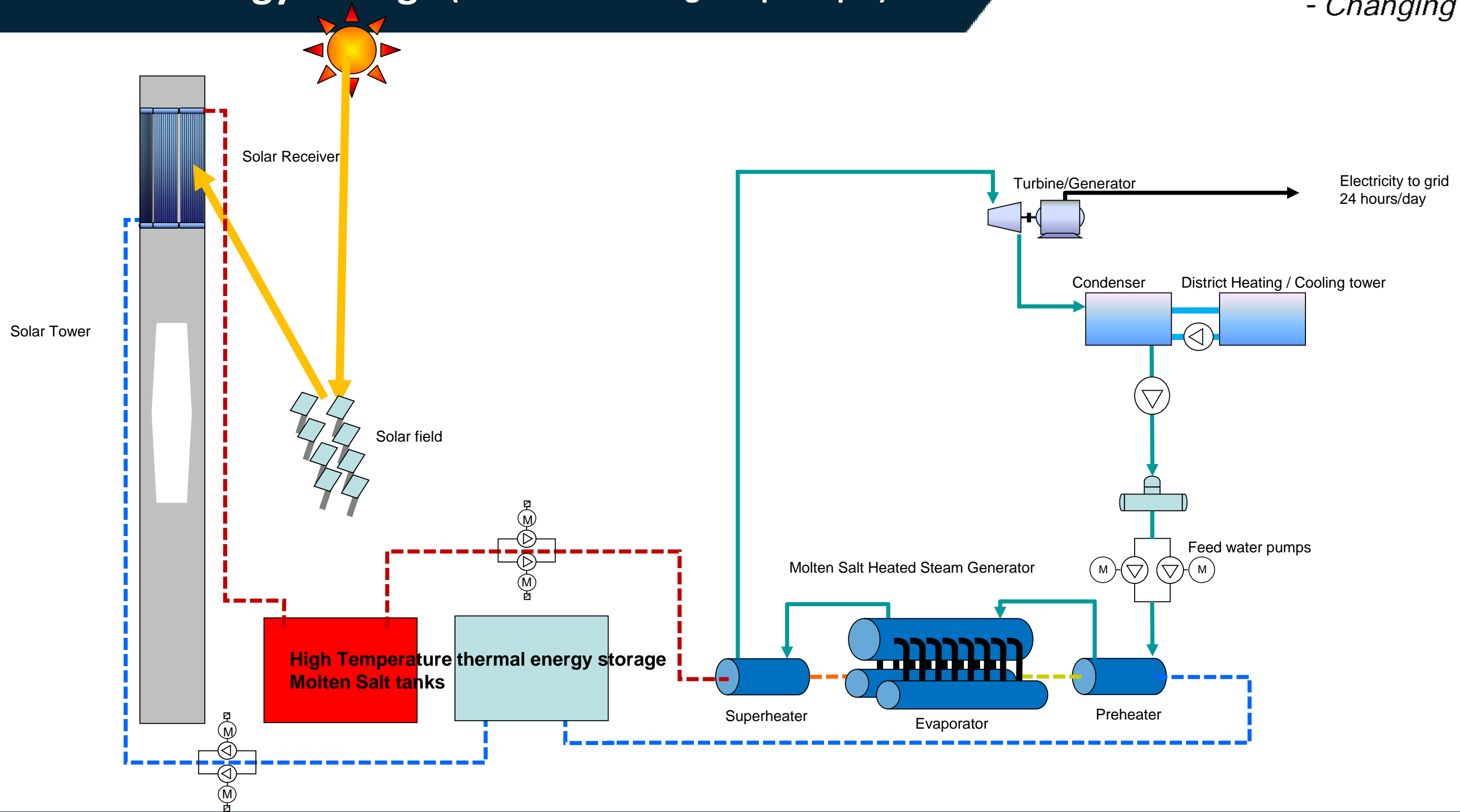
NEXT STEPS

**SECTOR INTEGRATED RENEWABLE ENERGY
&
LARGE HIGH TEMPERATURE ENERGY
STORAGE SYSTEMS**

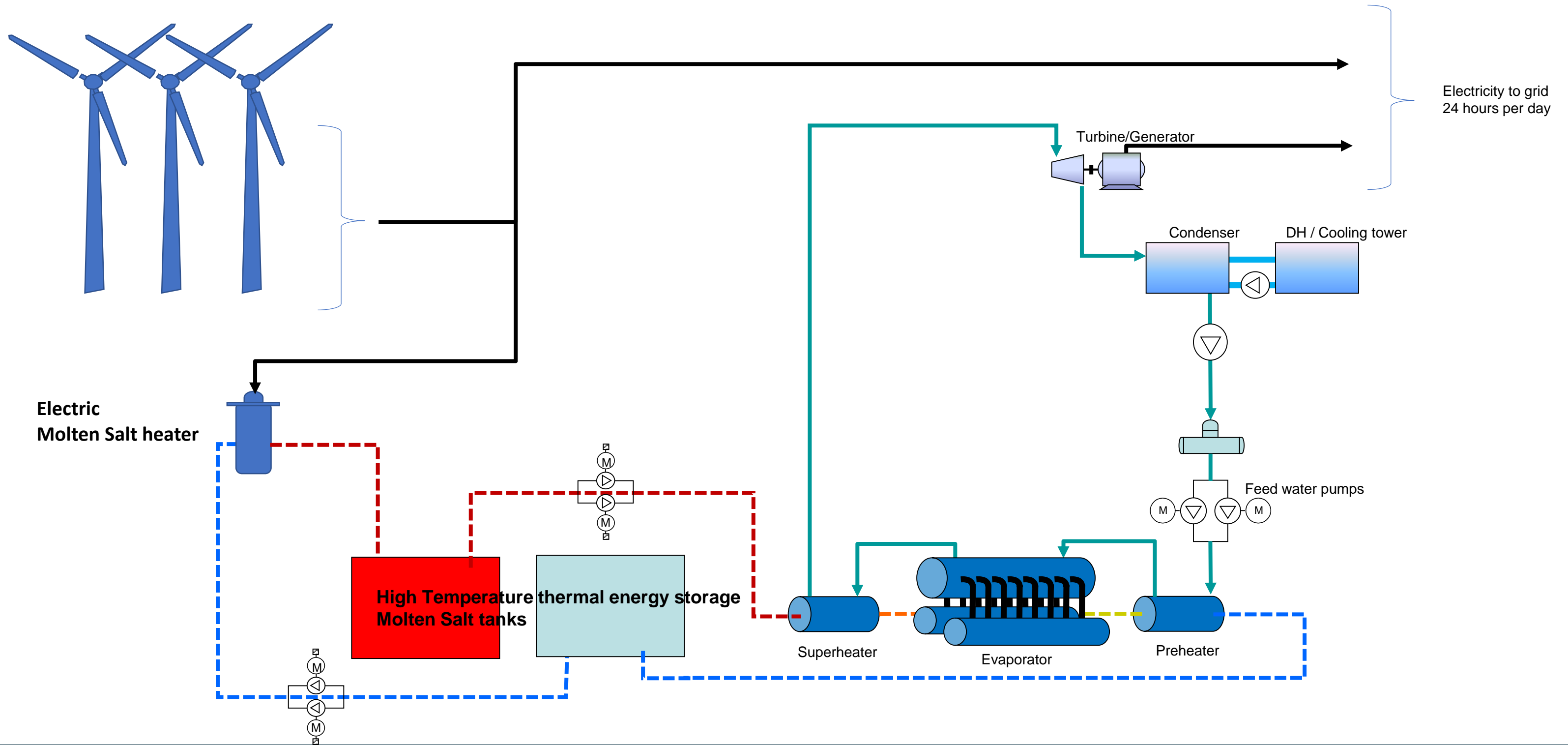
The 'renewable energy-palette' of possible building blocks of technologies more or less available.



Typical CSP power plant with Molten Salt HIGH TEMPERATURE Energy Storage (for understanding the principal)



Principal future Wind/Electrified power plant with Molten Salt HIGH TEMPERATURE Energy Storage



The Chinese High Temperature Energy Storage projects commenced

Projects commenced and planned to be completed before end 2020

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 Nuclear 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

3300 MWh Thermal storage

Sep. 19 Status
4 large scale projects
completed

High Temperature Energy Storage

Already in operation in :

CHINA, USA, Spain, Marocco

Technology is already 'BANKABLE'.

International Banks can provide financing.

In DK electrification of existing power plants
can be relatively inexpensive

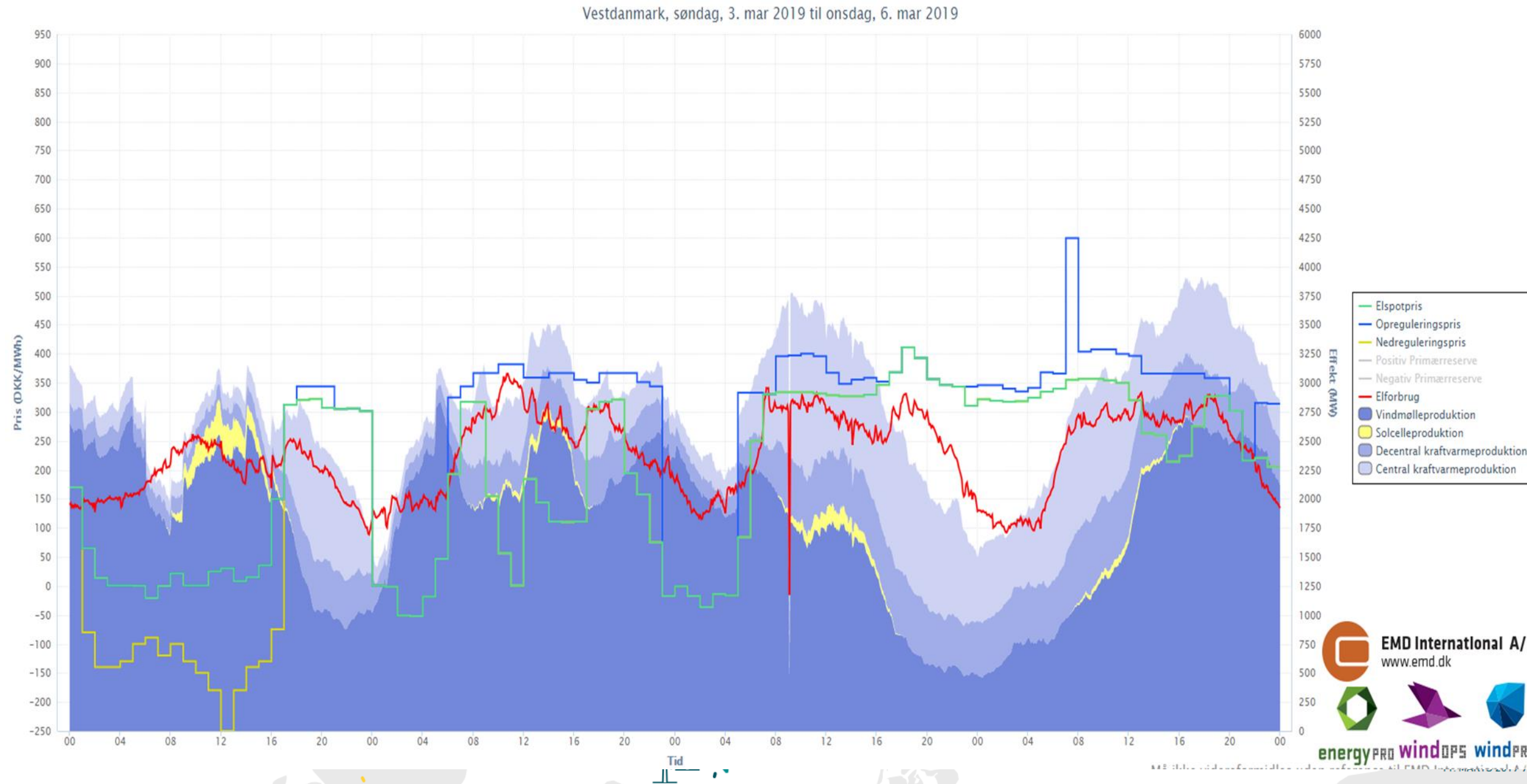
23-27 USD/MWht cover Heater, Storage &
Steam Generator + cost of retrofit to Turbine

Cost of demolishing Coal & Ash plant and
cleaning of plot must be done anyway.

MOLTEN SALT CSP TOWER



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

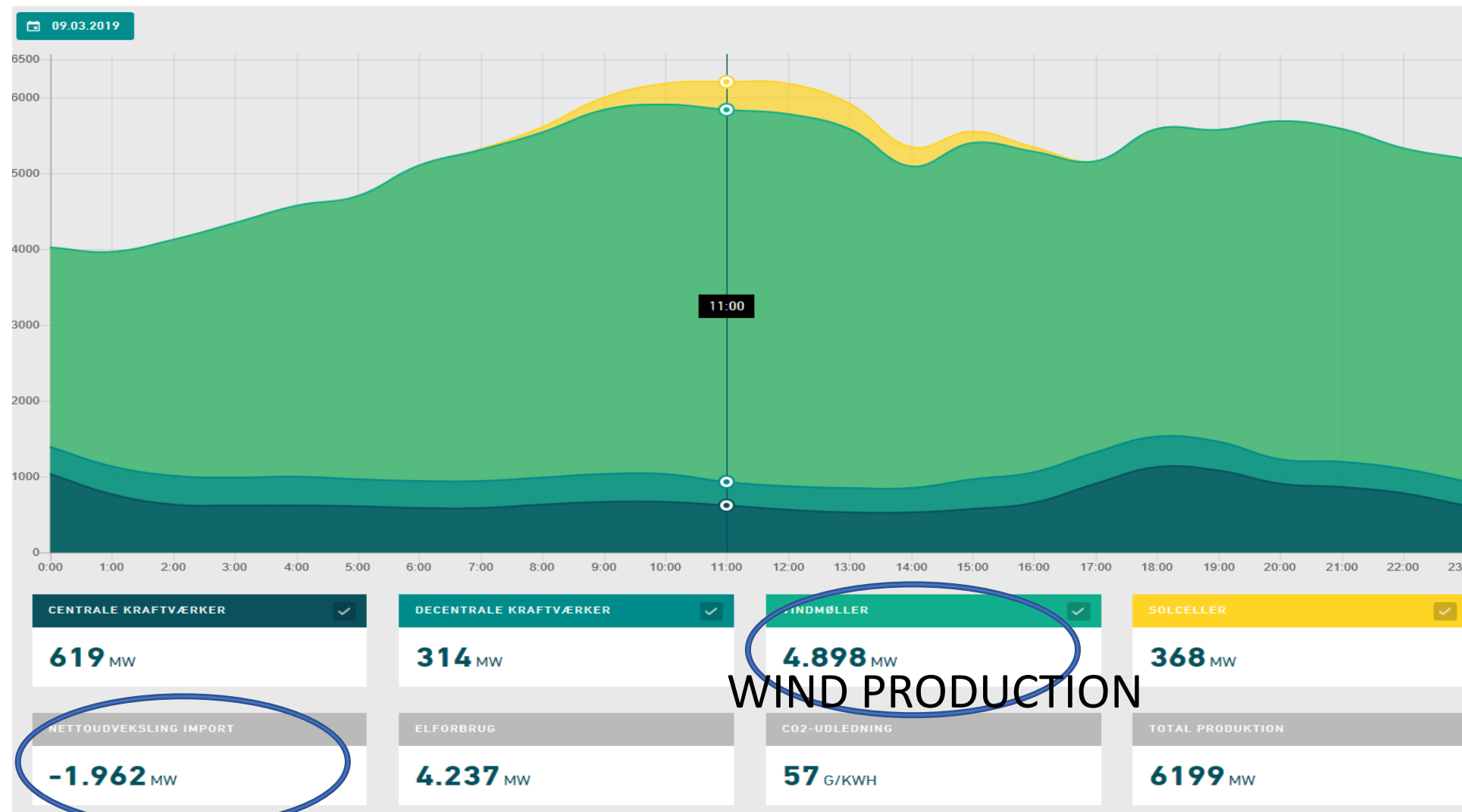


The Danish Electricity situation – ‘Blowing in the Wind’

Eur/MWh – Nord pool DK1

09-03-2019 7.98 59 kr

Export – 1.962 MW
At 59 kr/MWh
(Money in the box)

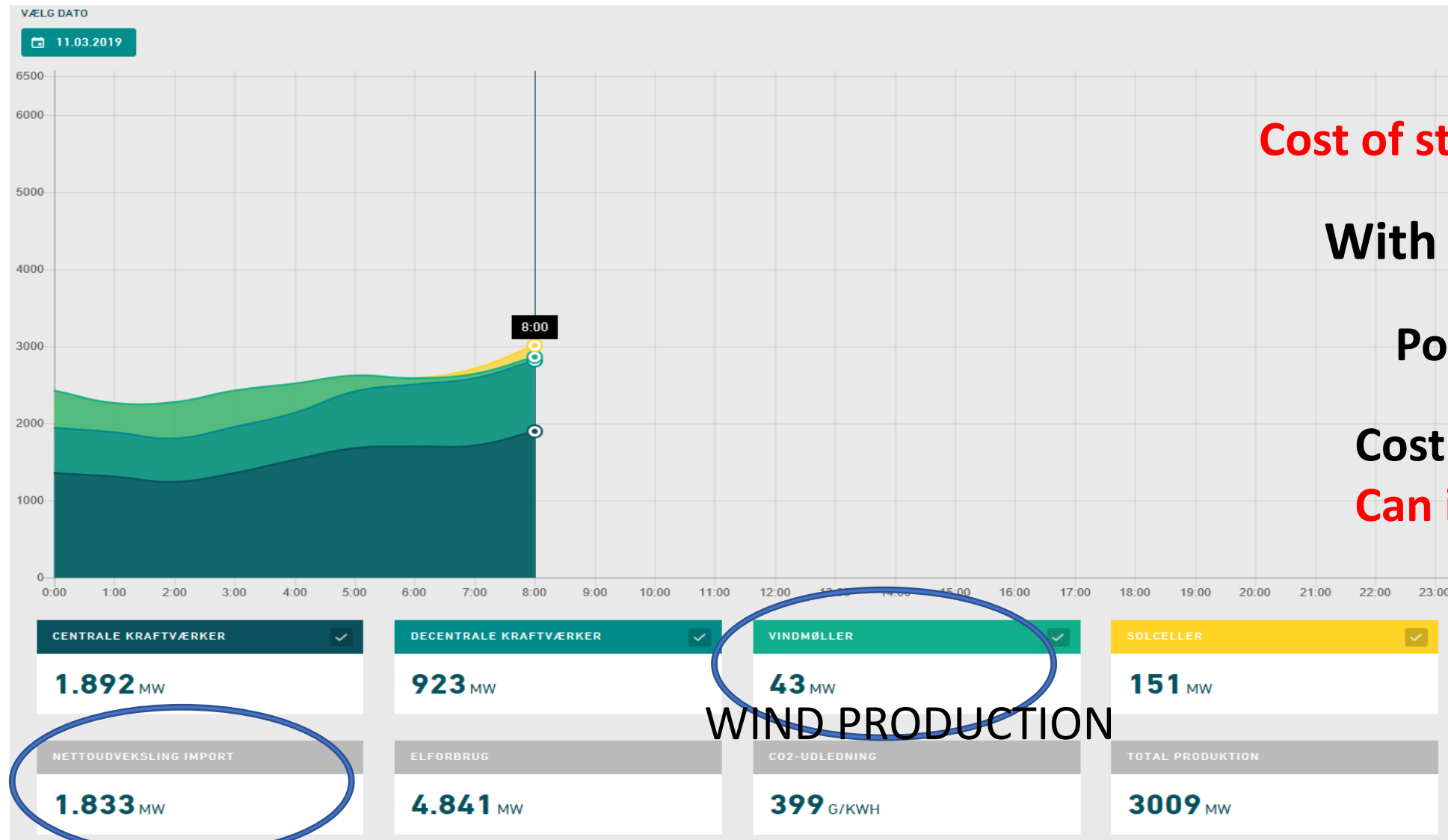


The Danish Electricity situation – ‘Blowing in the Wind’

Eur/MWh – Nord pool DK1



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



Cost of storage - Aprox 1,600,000,000 Kr/y (2017)

With 3 x 800 MW Additional Wind farms

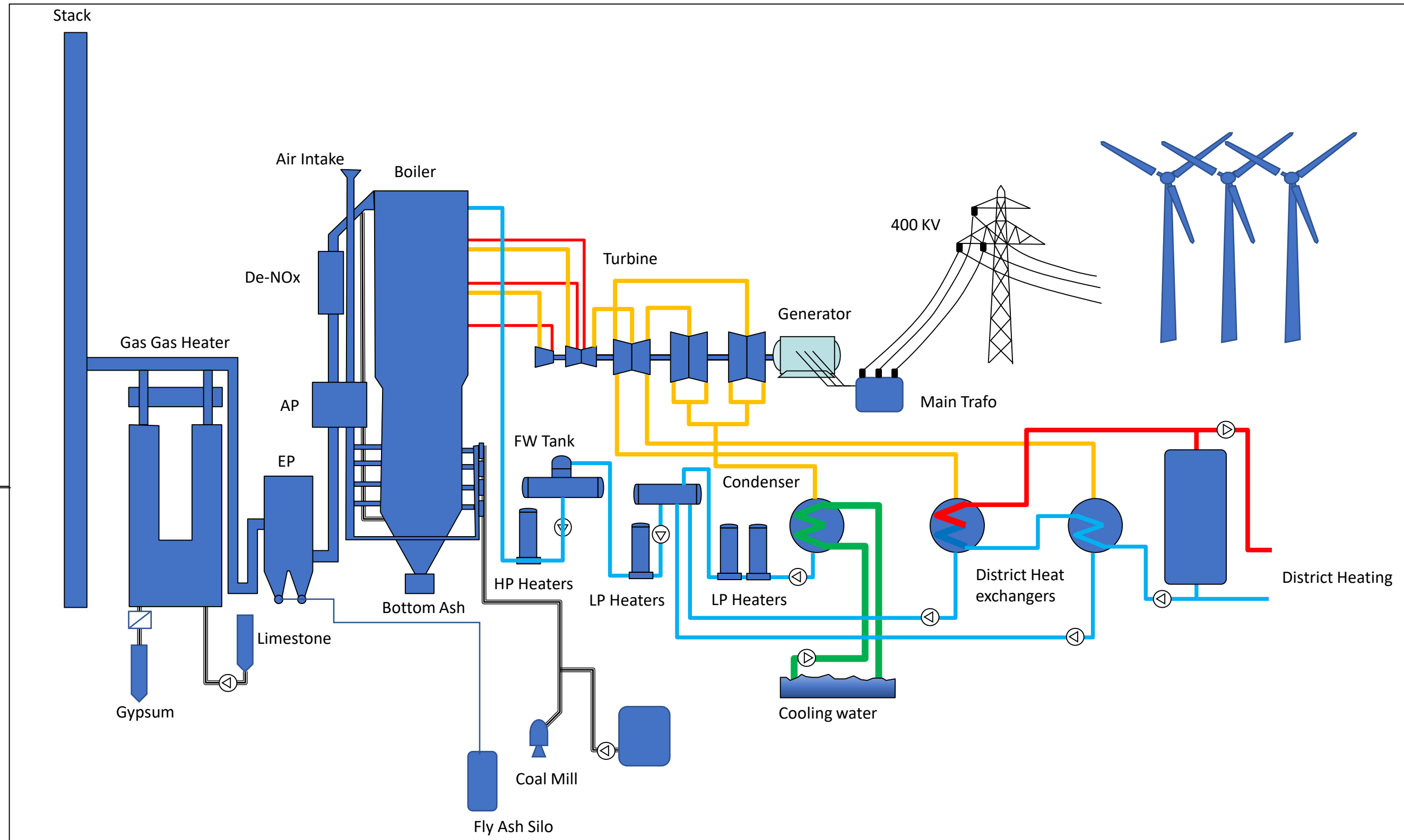
Potential new cost 3,200,000,000 Kr/y

Cost of storage – Who pays ??

Can it be used to pay back the investment ??



Typical Coal fired power plant unit generating electricity and heat



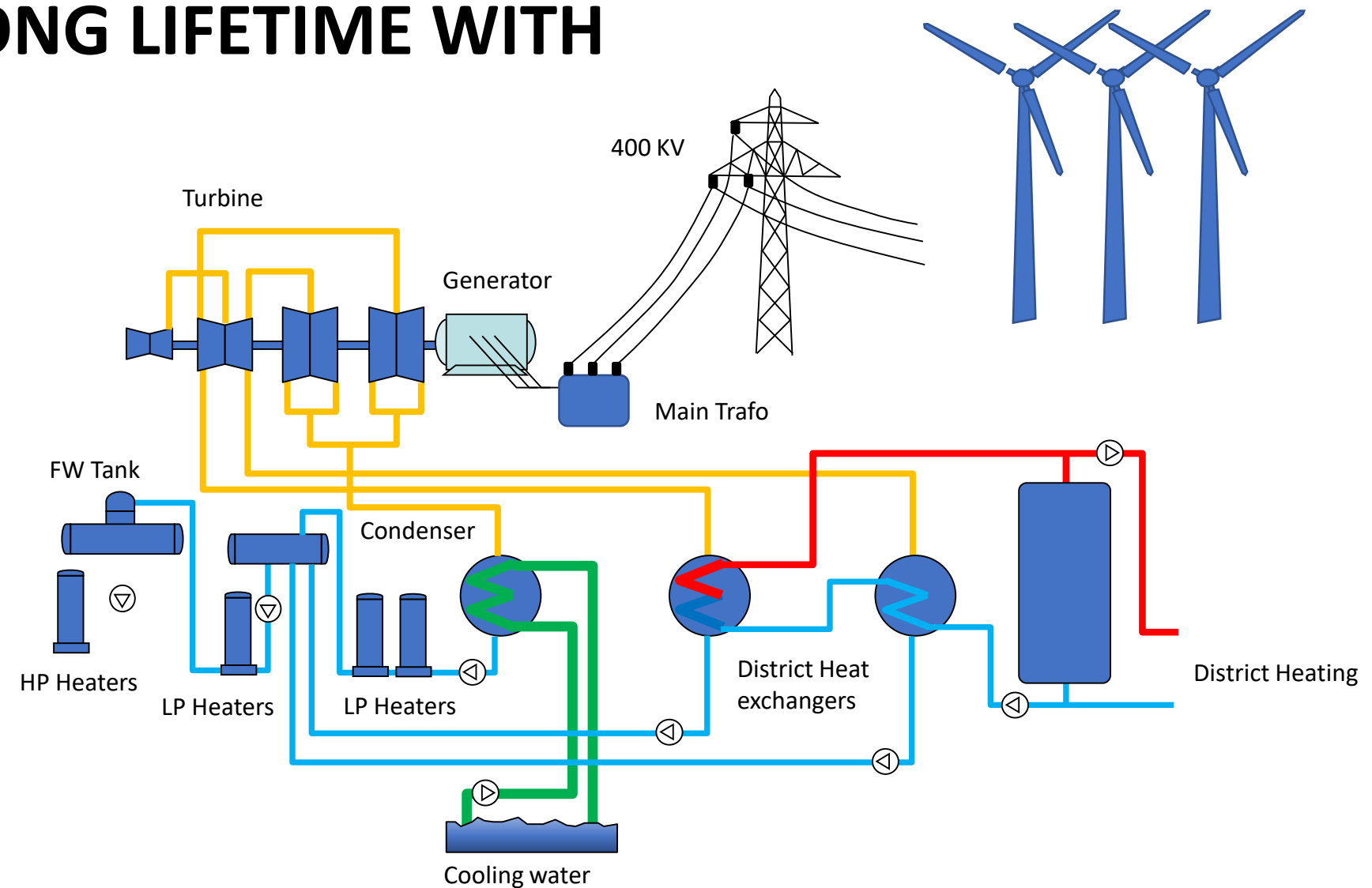
AALBORG CSP

Project : Coal fired Powerplant with district heating/fully condensing	
ACSPP Project No :	70004
Rev : 0	DATE : Jan 2019
Drawn by : FBI	

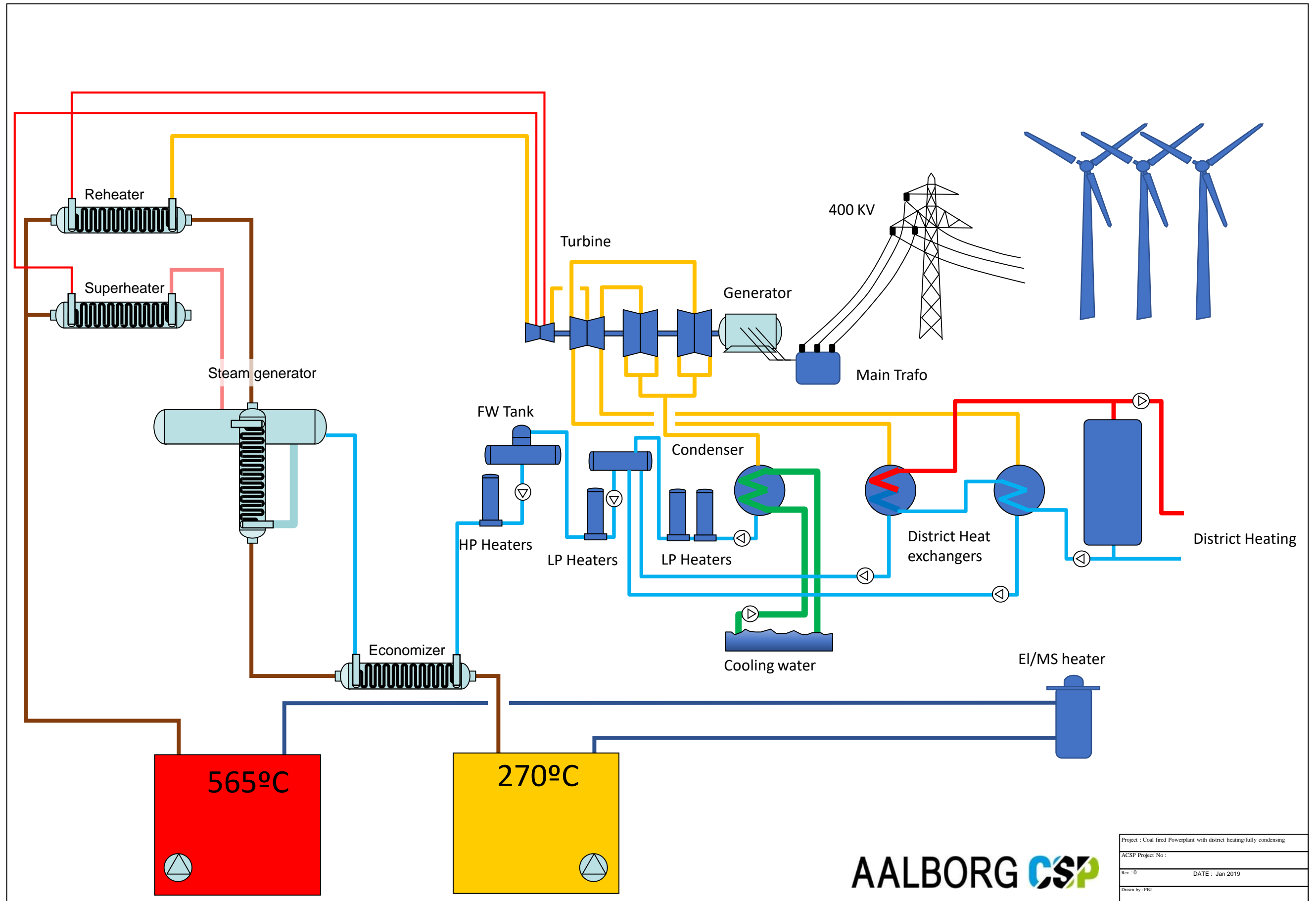
Typical reuseable assets from converted Coal fired power plant

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

**A unique chance to make
Green power at reduced
Investment.**



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



AALBORG CSP

Project : Coal fired Powerplant with district heating/fully condensing	
ACS Project No :	
Rev : 0	DATE : Jan 2019
Drawn by : FBI	

Preliminary prediction of P/L (100 MWe Heater / 1500 MWh Storage)
 NOT CONSIDERING GRID REGULATION SERVICES
 Investment 250 mio Kr (excl retrofit)



	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 Storage and Tanks Steam-Generator/Boiler and electric Salt-heater Using existing Turbine and DH infrastructure 23-27 USD/KWht.

Unique opportunity to reuse existing ASSETS such as steamturbine-generators, Transformers, high voltage switch-gear, Water treatment plant and district heating systems

Investment

Installation of one plant 4.000 MWh High temperature Energy Storage

Investment cost 100 mio or 650 mio DKK

Investment in 40.000 MWh (10 x 4.000 MWh)

= 10 x 650 = 6,5 bill. DKK

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

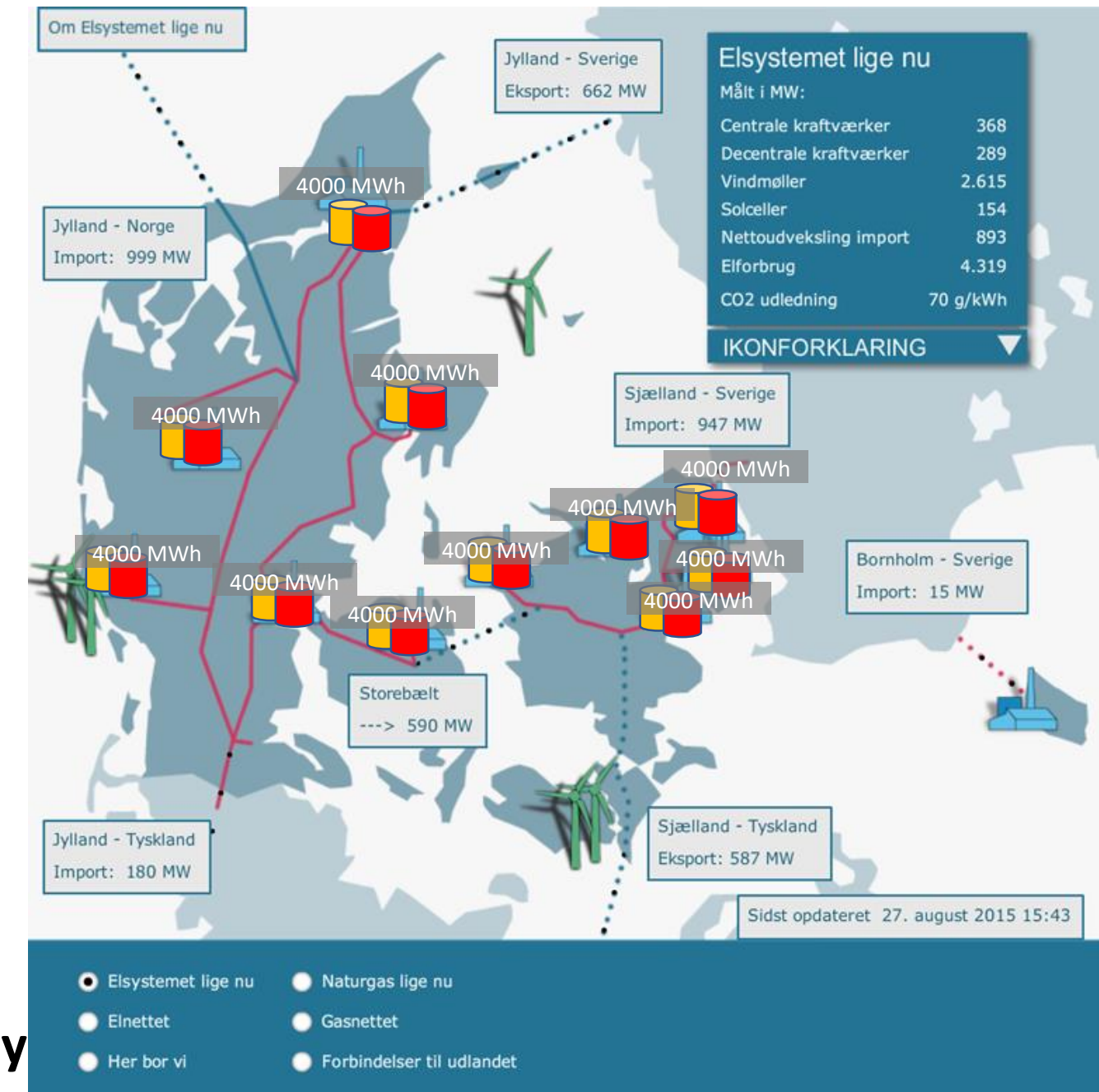
-Capex financing through grants from Danish "Klimakompenseringsfonde"

-Opex Business case through :

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

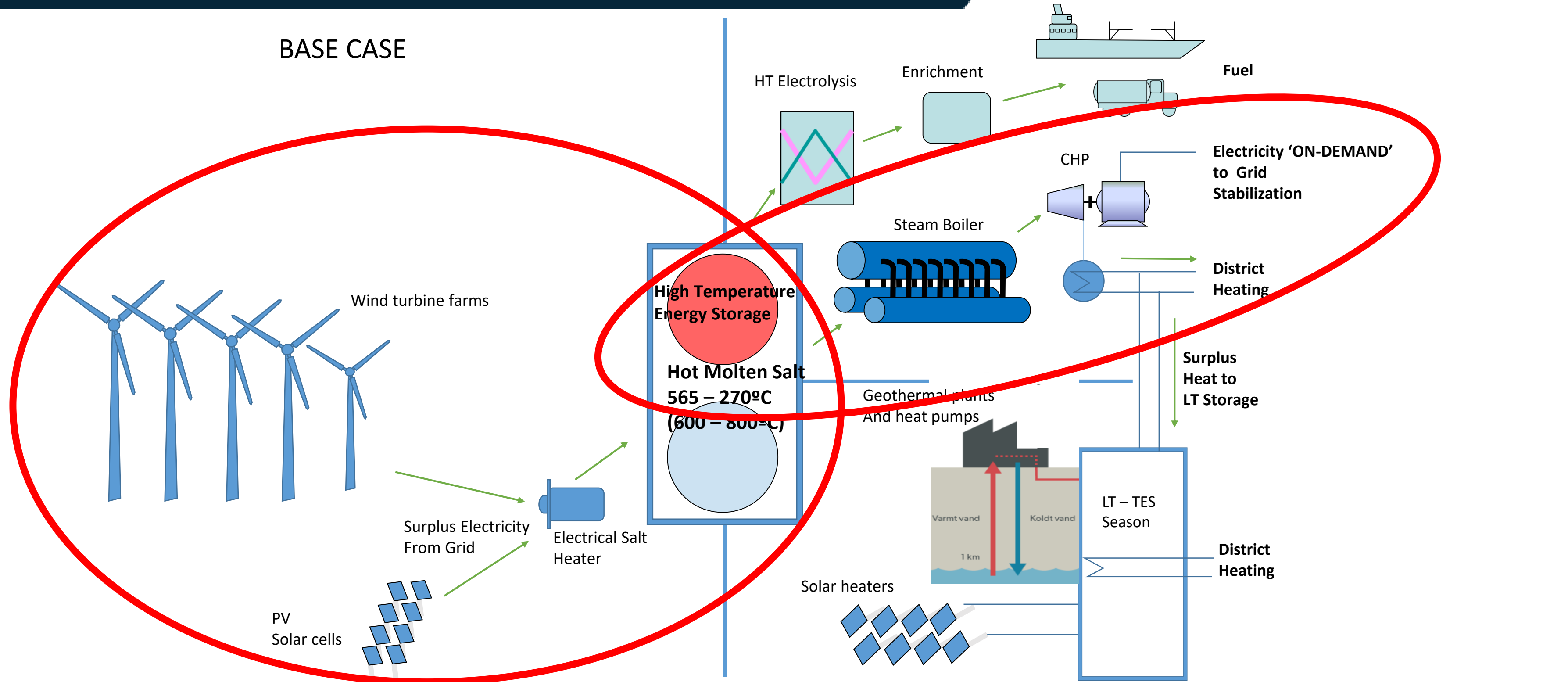
El/Heat Ratio 35/40% = EL 1.400/1.600 MWh & Heat 3.600/3.400 MWh

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

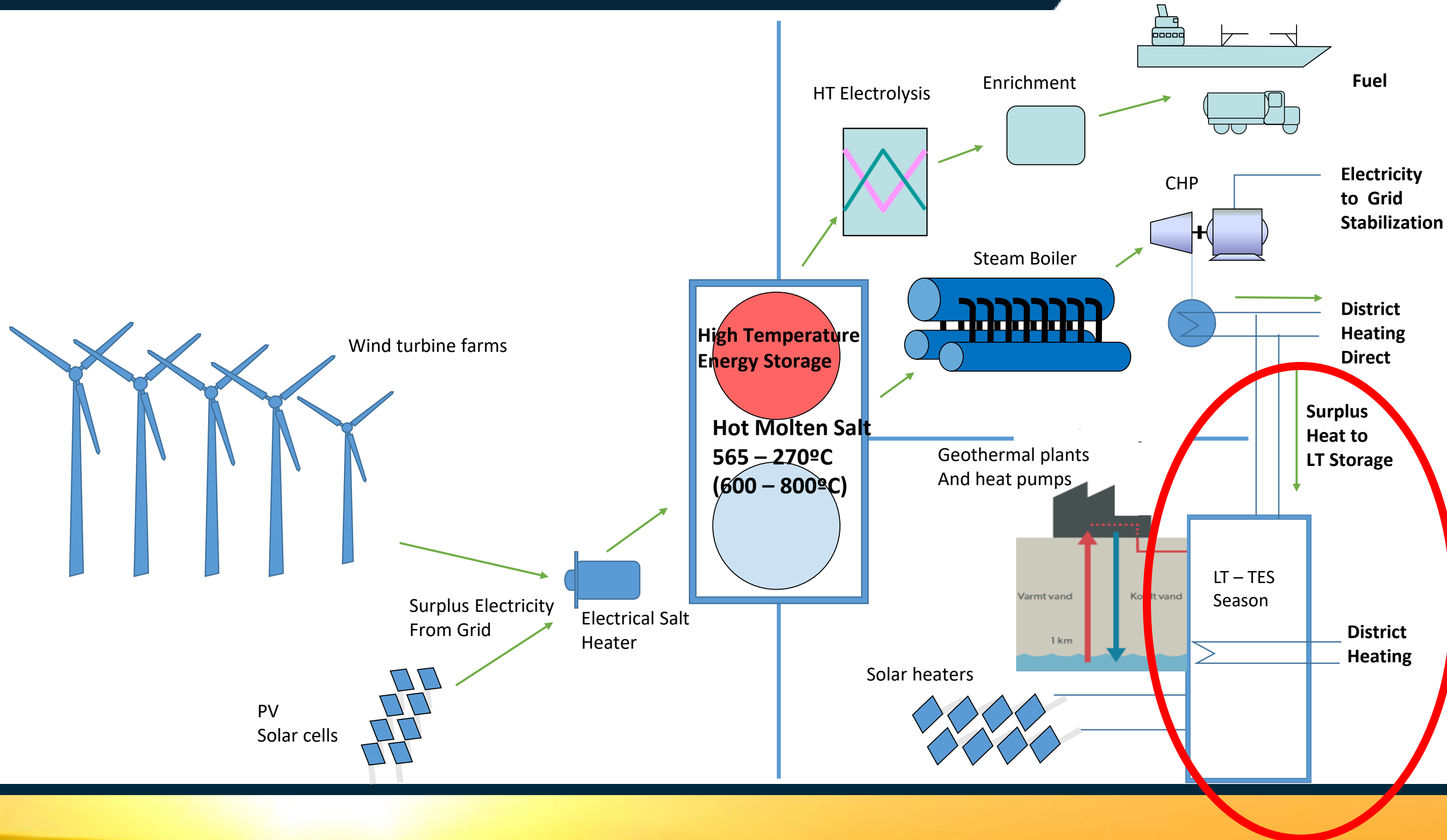


Surplus Wind and Solar Electricity charging to High Temperature Energy Storage – Discharge on demand

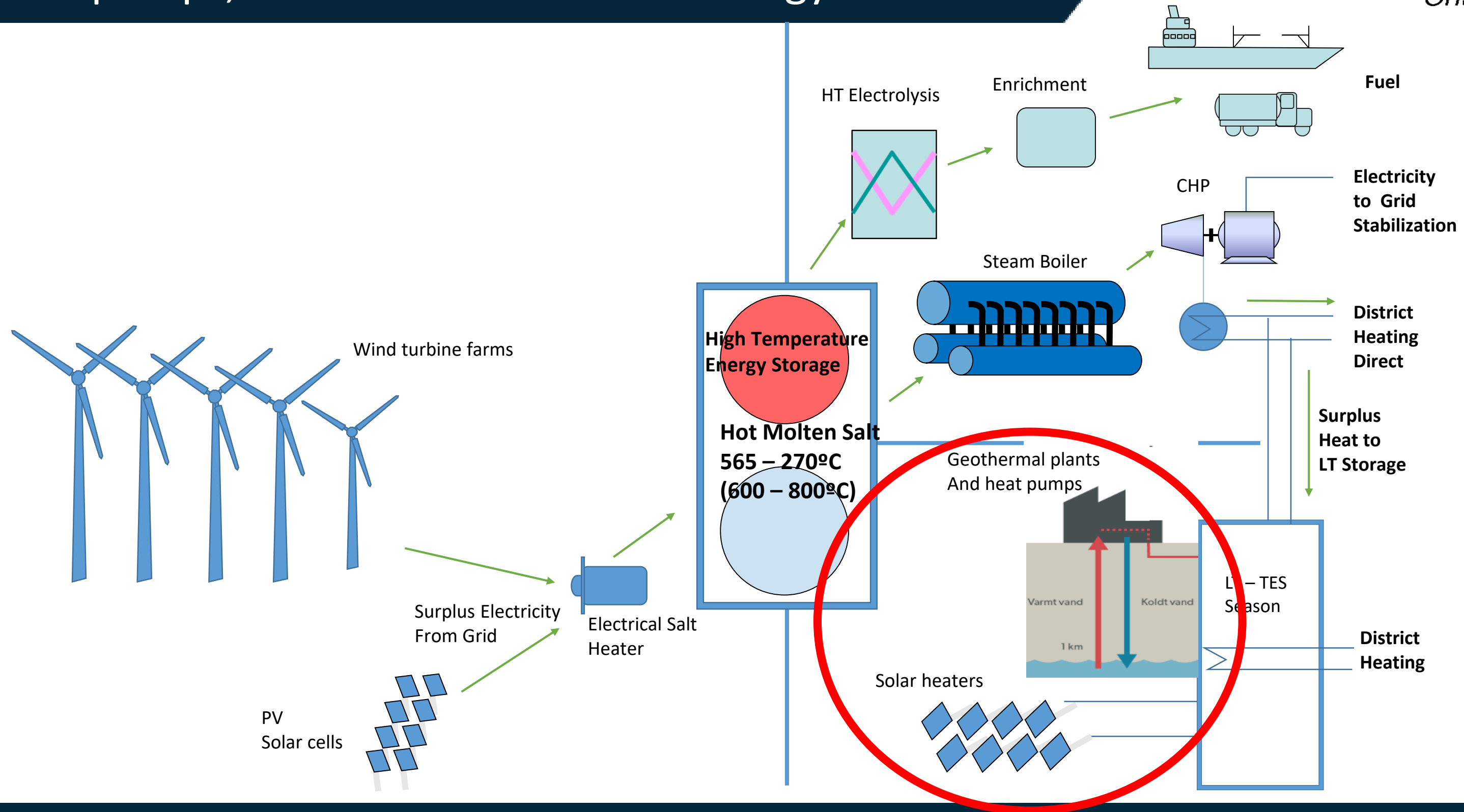
BASE CASE



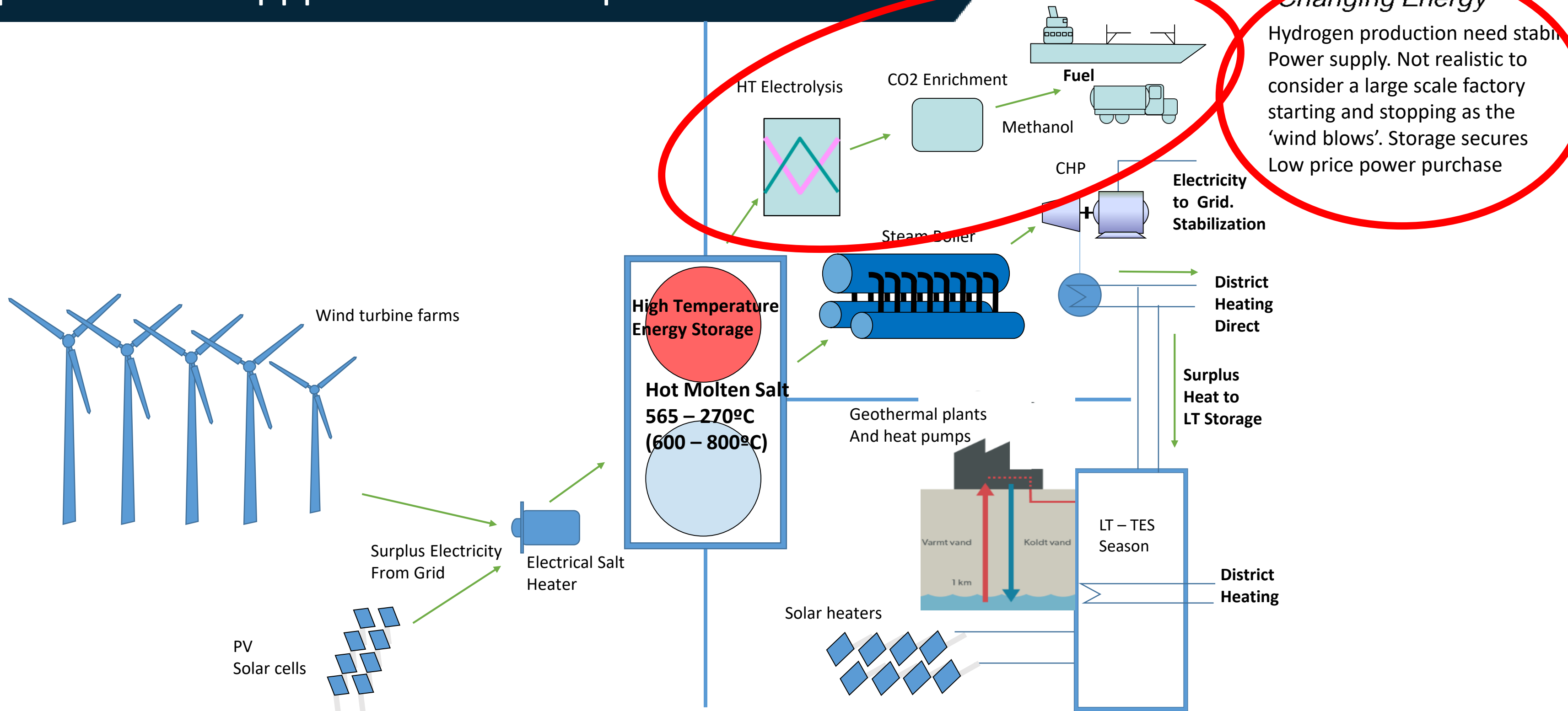
Integration with low temperature energy Storage (Dam-lager)



Integrated optimized operation through use of Heatpumps, Solar and Geothermal energy



Possible Sector-integration to Hydrogen and fuel production. Support Green Transport Sector



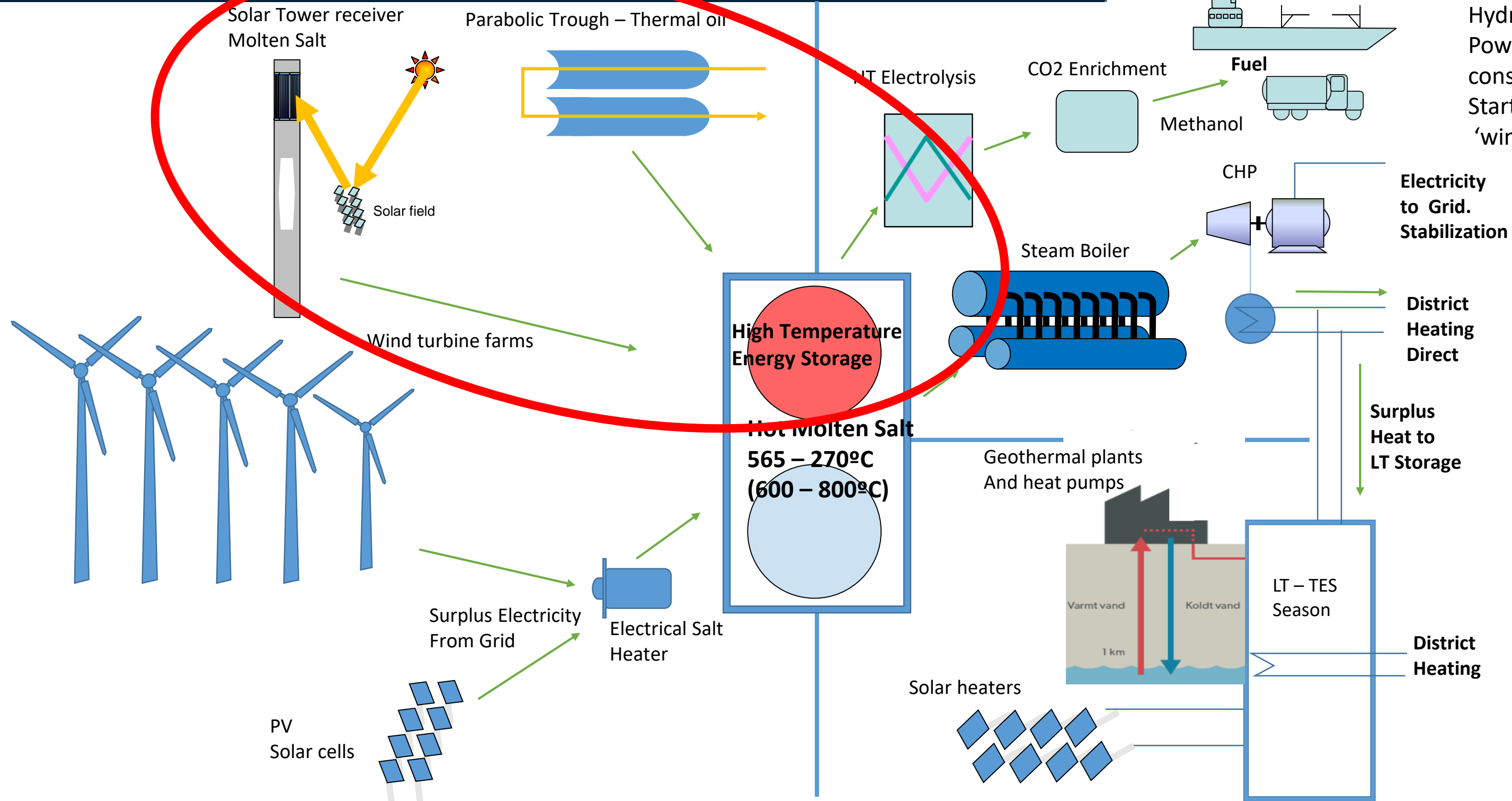
Hydrogen production need stable Power supply. Not realistic to consider a large scale factory starting and stopping as the 'wind blows'. Storage secures Low price power purchase

Possible integration with CSP Solar plants for Export opportunities

AALBORG CSP

- Changing Energy

Hydrogen production need stabil Power supply. Not realistic to consider a large scale factory Starting and stopping as the 'wind blow'



70% National CO2 reduction goal

United Nations Sustainable Development Goals

