A new life for coal fired (and other conventional) power plants

Usage of existing infrastructure as thermal batteries

Deutsches Zentrum für Luft- und Raumfahrt
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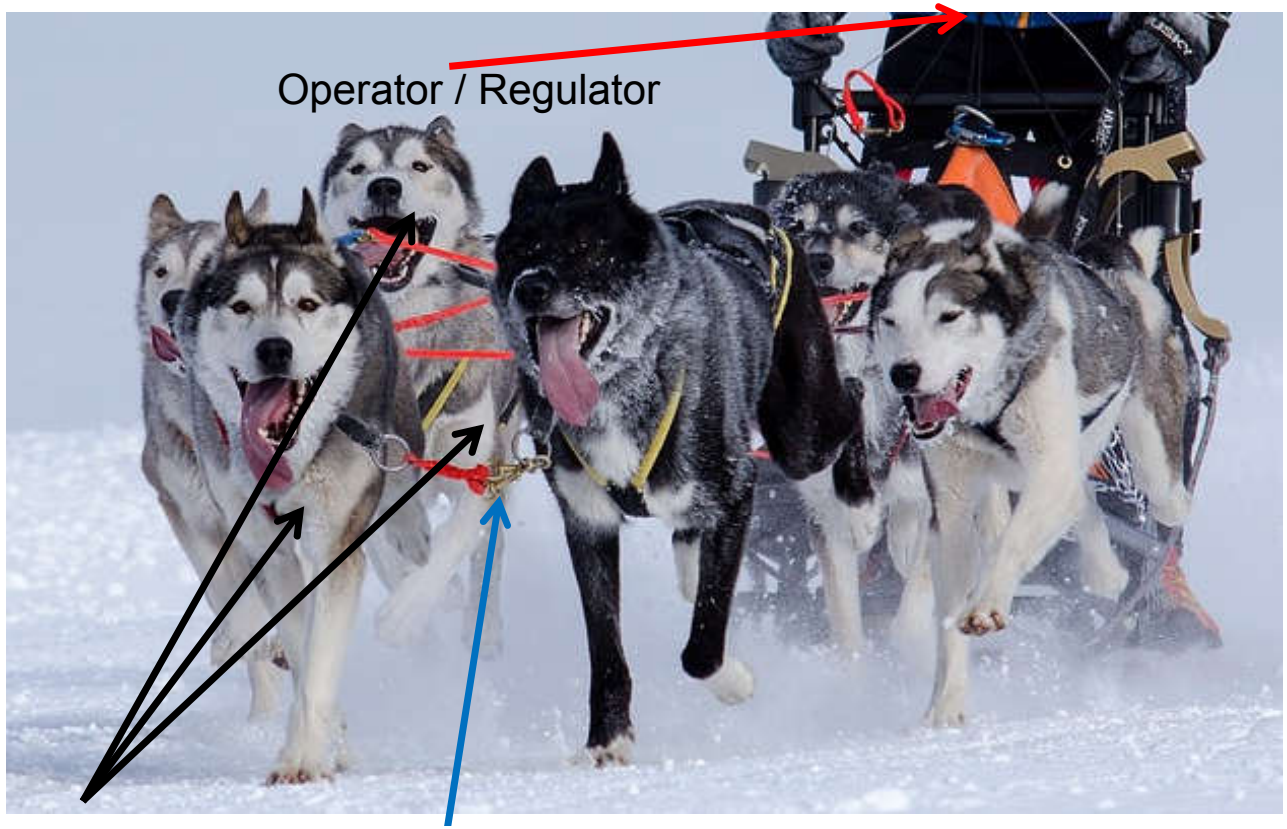
Content: How does that work? 7 Questions!

1. How does our current energy system look like, how will it look in the future ?
2. Why do we need electricity storage?
3. What is a Carnot Battery ?
4. How can Carnot Batteries contribute?
5. Which role can the existing power plants play ?
6. What are the actual approaches?
7. What does the DLR have to do with it ?

1. How does the energy system look like today / in the future?

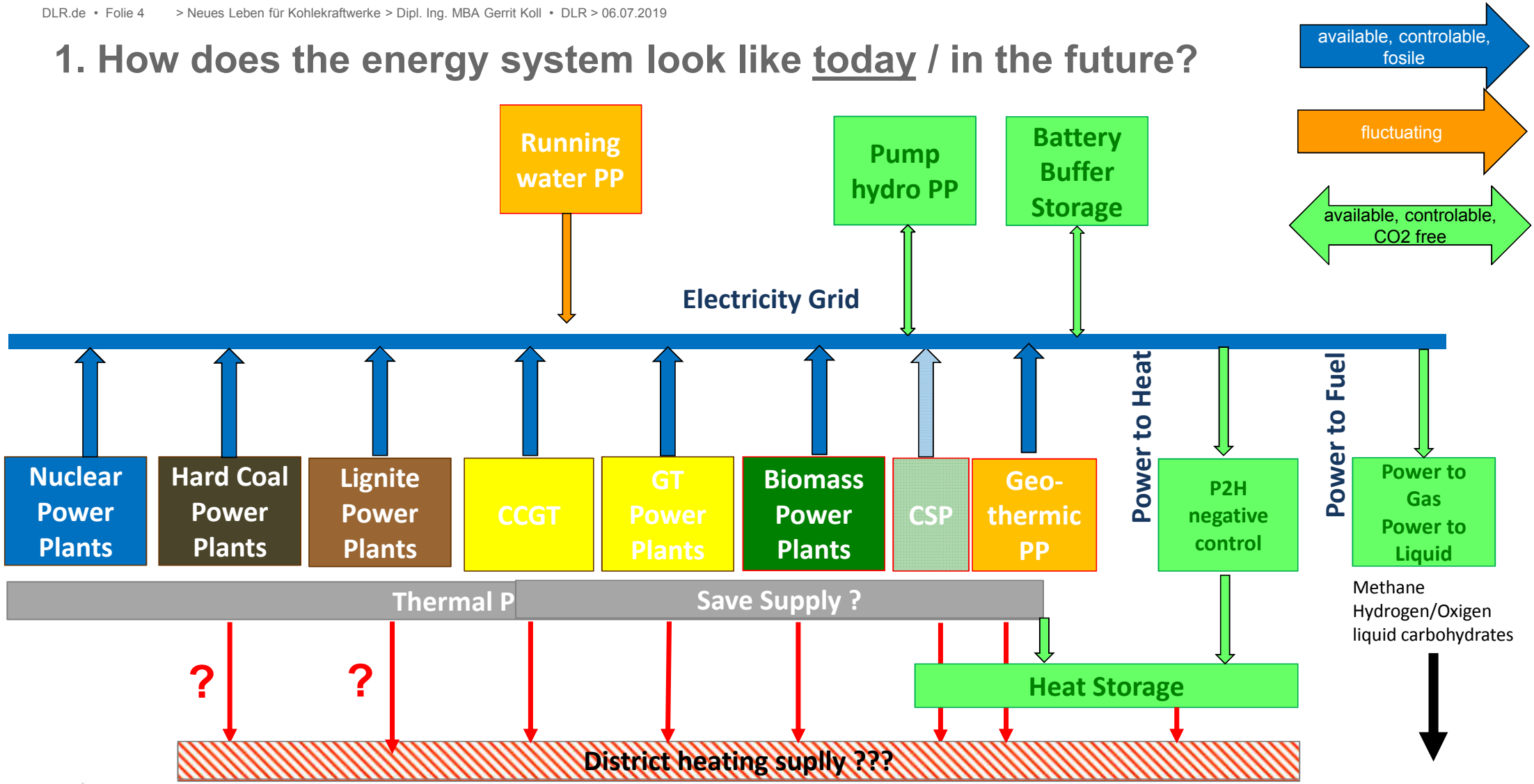
- Our energy system consists of a variety of different PP
- These exchange power and information over the power grid!
- How does every dog know how much load he has to carry?
- What happens if a power plant fails or its power fluctuates greatly?



Every dog feels when others works less and compensates intuitively! This is only possible to a limited extent!

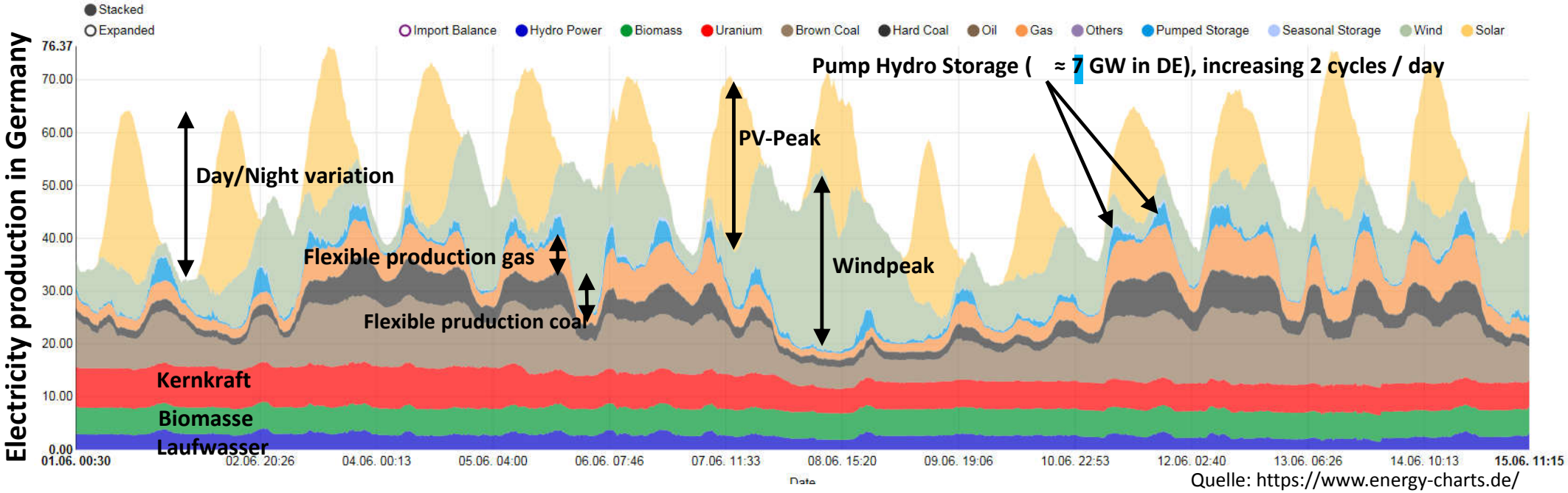
In case of too large fluctuations, the dog sled breaks down !!!

1. How does the energy system look like today / in the future?



from 2020 ties

1. How does the energy system look like today / in the future?



Quelle: https://www.energy-charts.de/

Challenges:

- Withdrawal from nuclear power until 2022 and coal completed by 2038
- 65% Renewable until 2030, installation of volatile wind and PV power as replacement
- Stugling sectors traffic and heat -> sector coupling -> more electricity demand
- Difficult network expansion

2. Why do we need electricity storage?

- Electricity must be moved from the excess times to the demand times:
  - **Short term**: frequency control 1 – actually done by conventional plants
  - **Medium term**: Day times with a lot of production (noon, strong wind) at times with a lot of needs (evening) pumped storage KW, new large electricity storage
  - With every **further expansion of the renewables**: cover (Dunkelflaute), up to 2 weeks without wind in cloudy skies: No battery storage can do that feasibly at the time being !!

Examples of dimensions:

- D installed capacity of pumped storage is about 7 GW, storage capacity about 40 GWh. (That's almost 99%) For replacement of the coal power plants with about 20 GW over 2 Week: 6.720 GWh, => 170 times the amount, that is impossible, neither topography nor acceptance in D present
- An I3 has a storage of 40 KWh, all 50 million vehicles in D would be 2,000 GWh => less than 1/3 of the required storage size

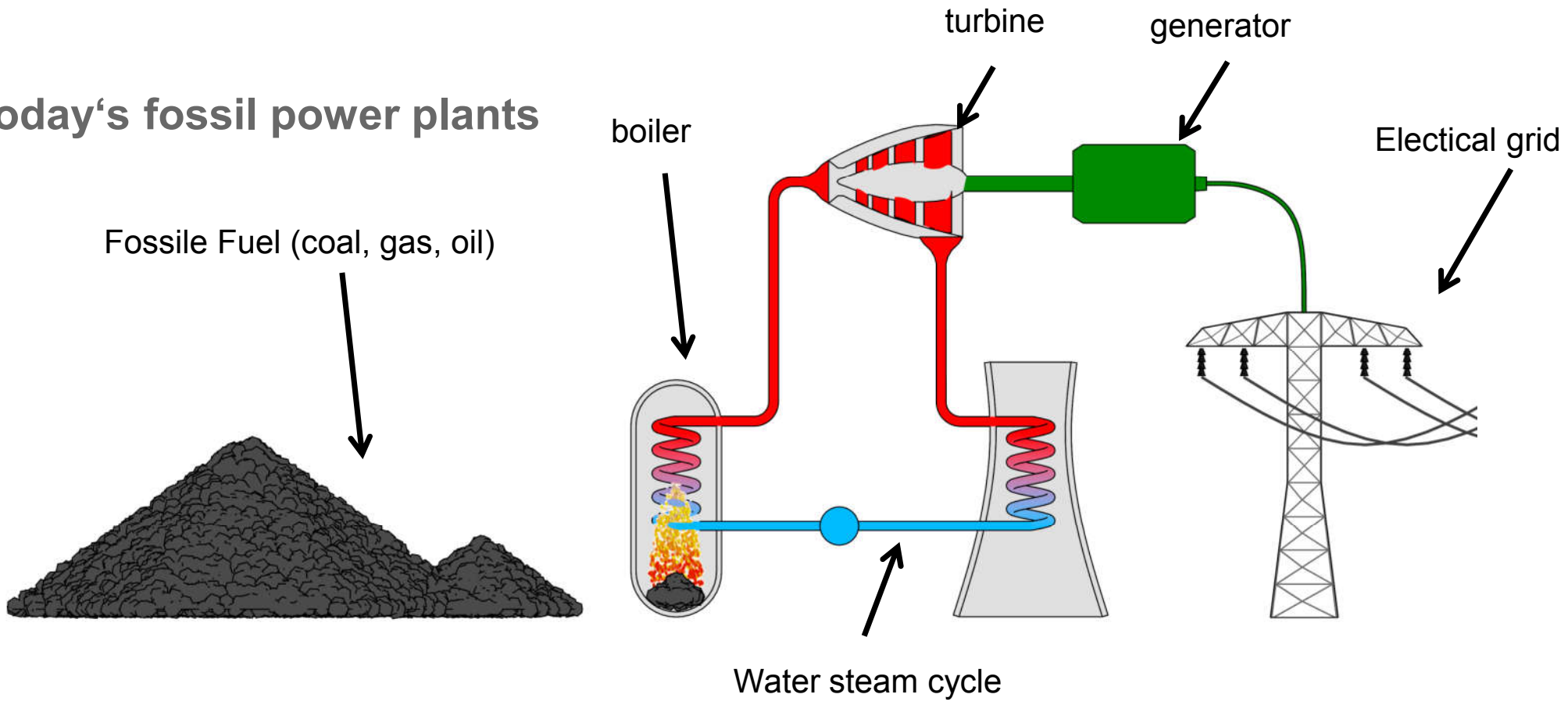
3. What is a Carnot Battery ?

- How could the solution look like?
- How could this solution be implemented using the existing infrastructure?
- How can we bring flexible electricity into and out of the grid?
- How can we manage this challenge without having to develop totally new technologies?
- And how can we achieve all that without being obliged to plan build and invest into large new infrastructure ? (time - cost - acceptance)

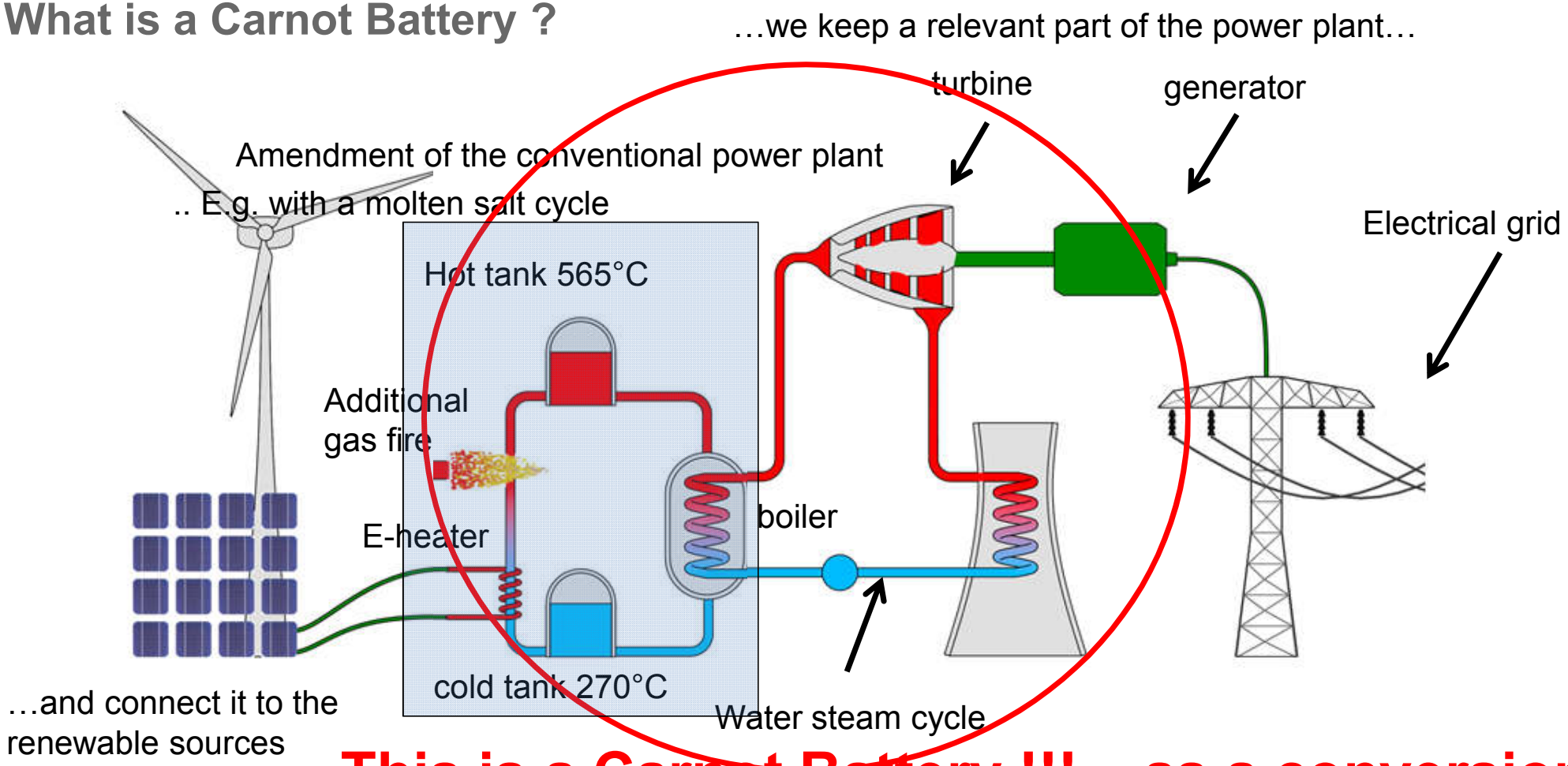
The solution is the Carnot Battery !

3. What is a Carnot Battery ?

Today‘s fossil power plants

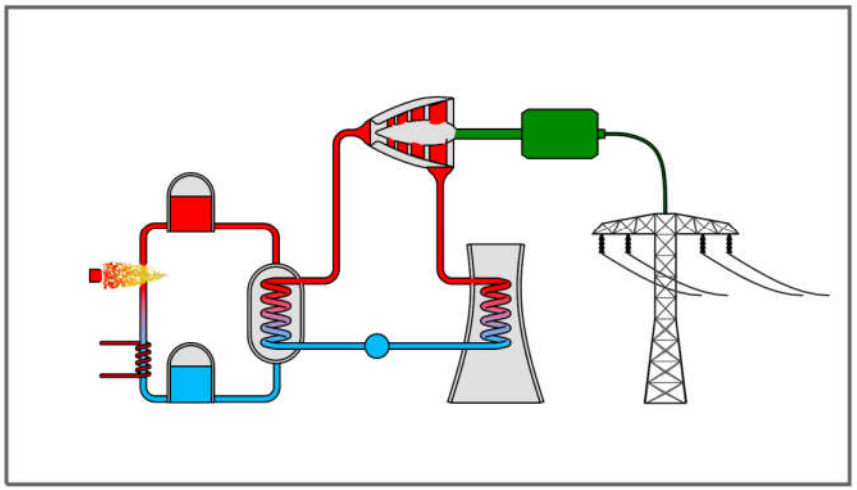


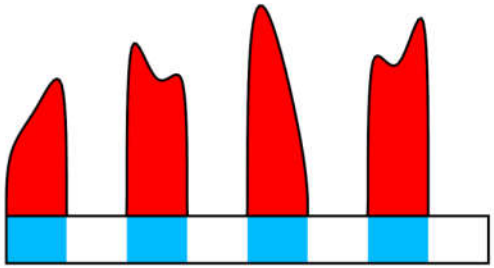
3. What is a Carnot Battery ?

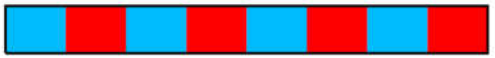


This is a Carnot Battery !!! – as a conversion from a conventional power plant

3. What does Carnot Battery do?

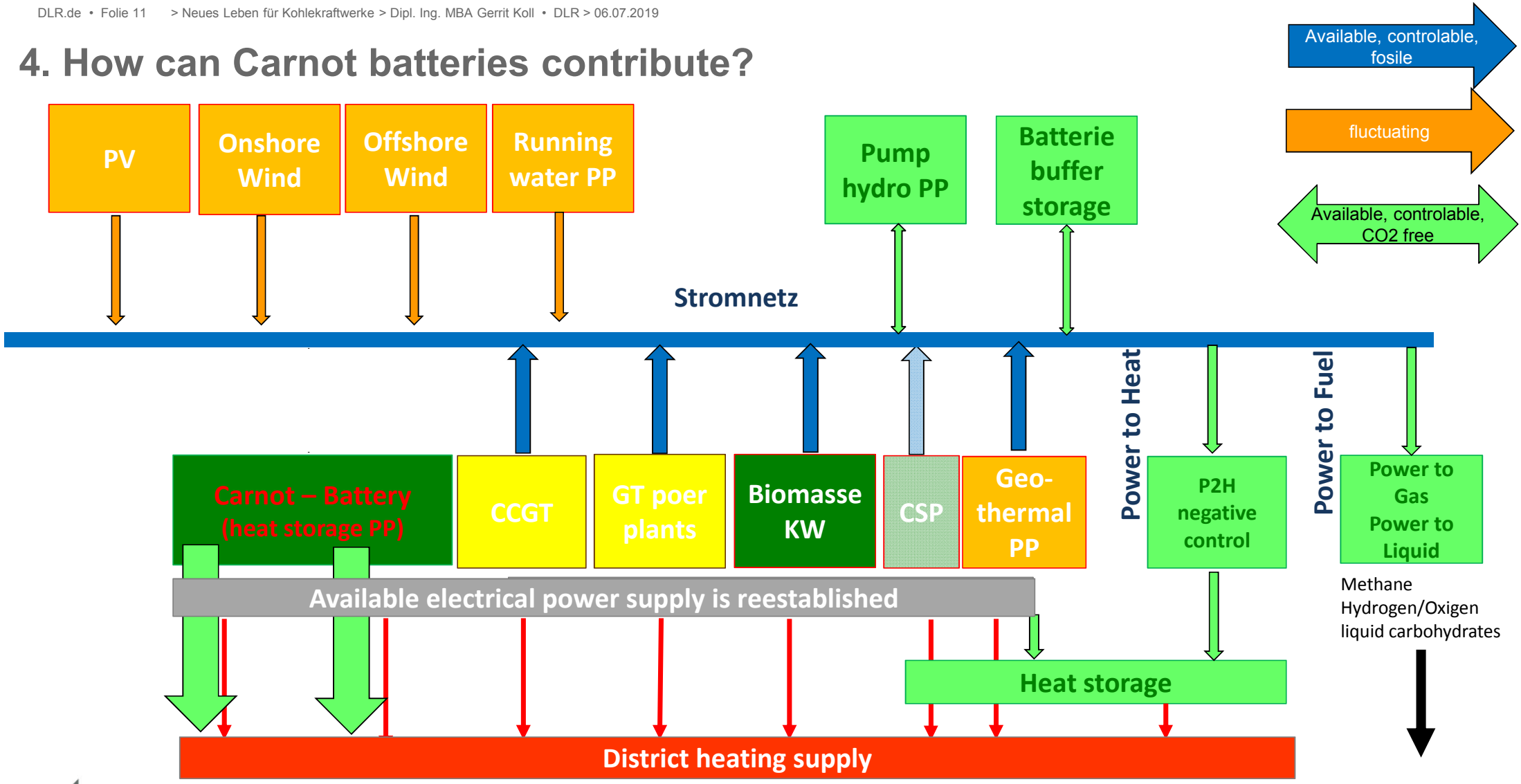






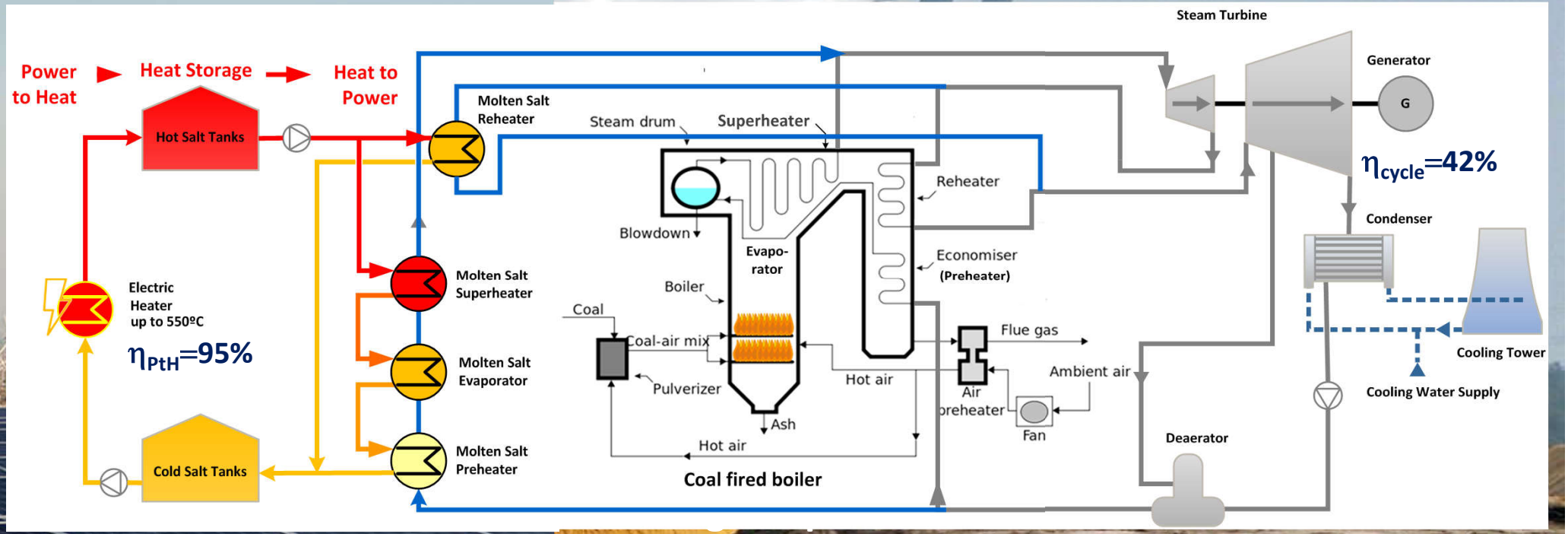
It converts variable electricity from renewables into base load or controlled electrical energy

4. How can Carnot batteries contribute?



5. Which role do existing power plants play herein?

Fase 1: Conversion of an existing brown coal fired power plant with a storage

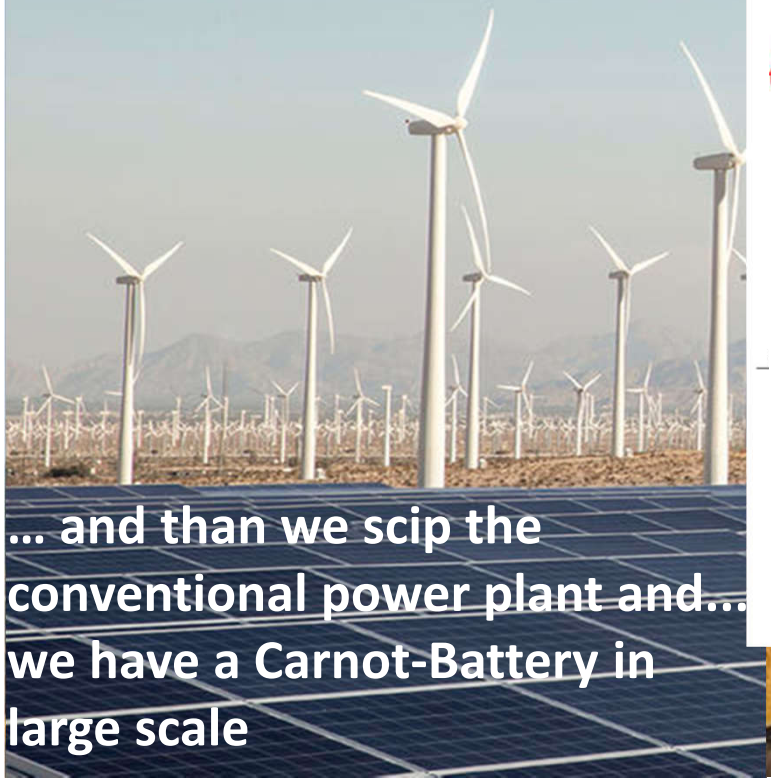


. produce our electricity based on renewables …

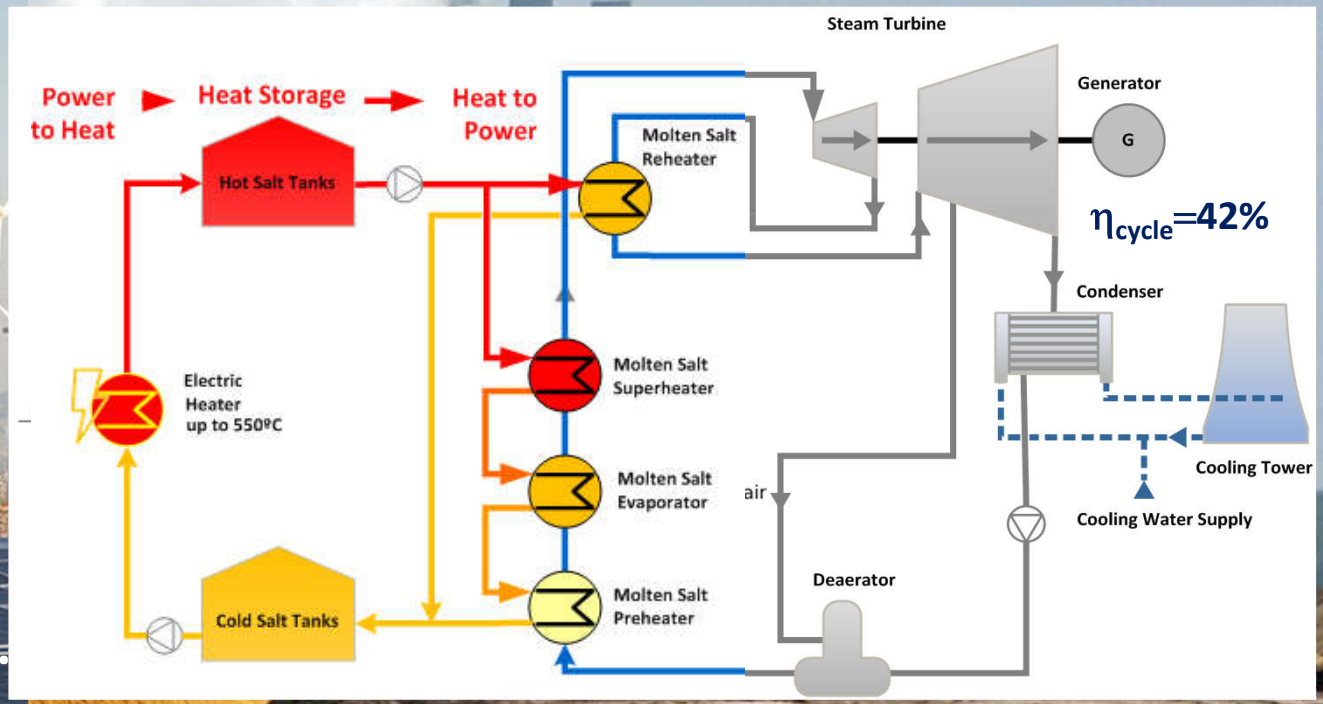
… and add a molten salt storage…

5. Which role do existing power plants play herein?

hase 2: complete conversion into a heat storage power plant



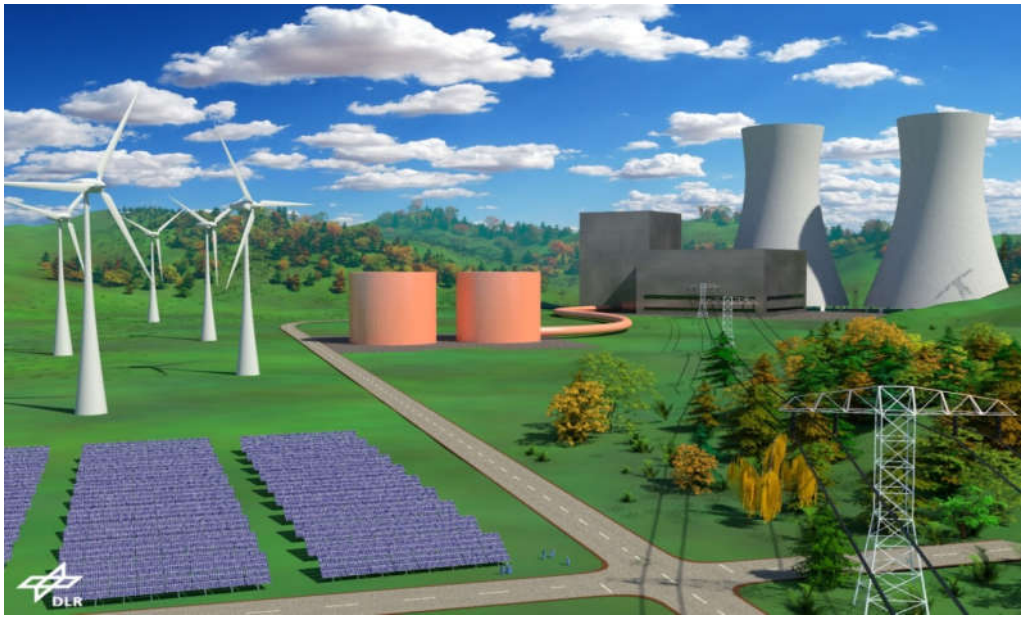
… and than we scip the conventional power plant and… we have a Carnot-Battery in large scale



5. Which role do existing power plants play herein?

Carnot batteries offer:

- Replacing fossil fuels with renewable electricity
- Gradual decarbonization of the power plant park
- 100% availability for the power requirement even without wind and sun for longer periods (Dunkelflaute)
- Opportunity for further massive expansion of renewables
- Use of existing grids and power plant infrastructure
- Preservation of existing jobs especially in structural change regions
- Reduce the carbon footprint.
- Reduction of consumption of critical raw materials (eg lithium)



-> Carnot batteries are a key to the energy transition

5. Which are the actual approaches ?

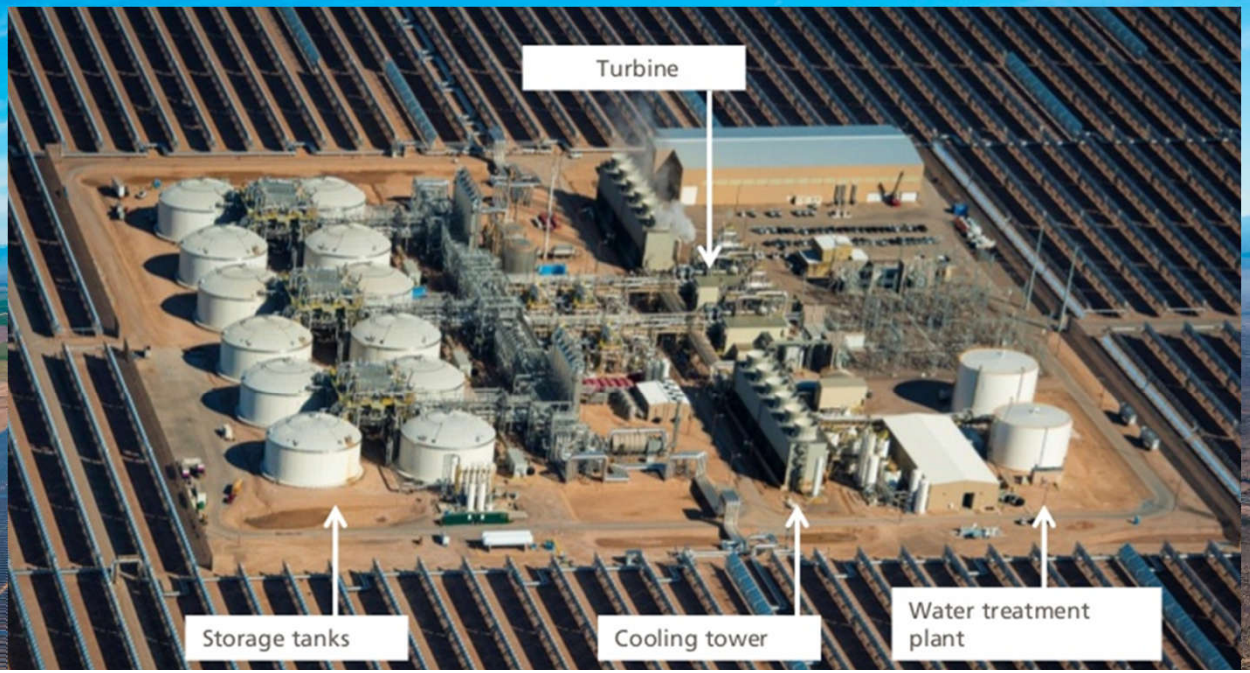
Just taken into operation: 150MWel Molten Salt tower with 7,5 h storage capacity @ 565°C
⇒ 1125 MWh el

Location: Oarzazate , Morocco (DNI 2.635kWh/m²yr)

Source: Masen, Acwa, Sener

5. Which are the actual approaches ?

2012 the world biggest molten salt storage was commissioned in Arizona: CSP PP Solana: 280 MW x 6 h = 1680 MWhel



Germanies largest hydro storage plant is Goldisthal with 1.000MW 8,5 GWh

=> Only 10-15 Arizona type of storage would solve the problem and allow further growth of renewables in Germany

7. What has the DLR to do with it ?

- Basic and application research at high temperature - heat storage
- Many years of experience with HT storage from CS
- DLR TESIS test bench in Cologne with 565 °C
  - Operation of a salt cycle with storage
  - Different tests on storage media, material properties and operating behavior
  - Test stand available for industrial tests
- Participation in many key projects on storage technologies
- Drives implementation in many places, e.g.:
  - Reallabor "Store to Power" with RWE
  - Brainergy - Demo system with Malta

Thanks for your attention

Further questions?

Do not hesitate to contact me:

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