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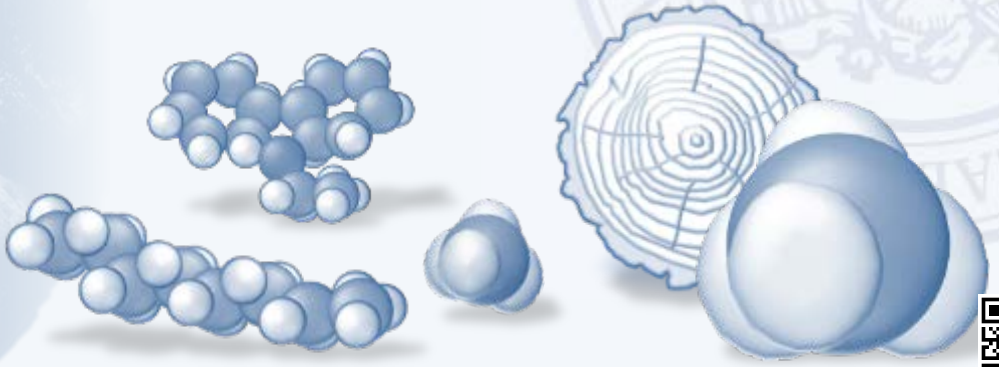
FRQNT Research Day
Montreal, Canada, April 11th, 2011

Balancing renewable energies – the European Challenge

Jürgen Karl

Chair of Energy Process Engineering,
Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany



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Facts
Backup Solutions
Storage Solution
Resreach@FAU
Conclusions

1. Impact of Renewable Energies on the European energy system

- Electricity costs
- Grid stability
- Employment effects
- Security-of-supply

2. Back-up solutions for renewable energies

- Back-up technologies for renewable energies
- Decentralized or centralized generation

3. Storage solutions for the Energiewende

- Storage tasks
- Chemical Storage Solutions

4. Ongoing energy research @ FAU

- Fuel cell reserach
- Biomass gasification
- Methanation of biogenic syngas

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1. Impact of Renewable Energies on the European energy system

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Folie 3

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Impact of the Renewable Energy Law in Germany

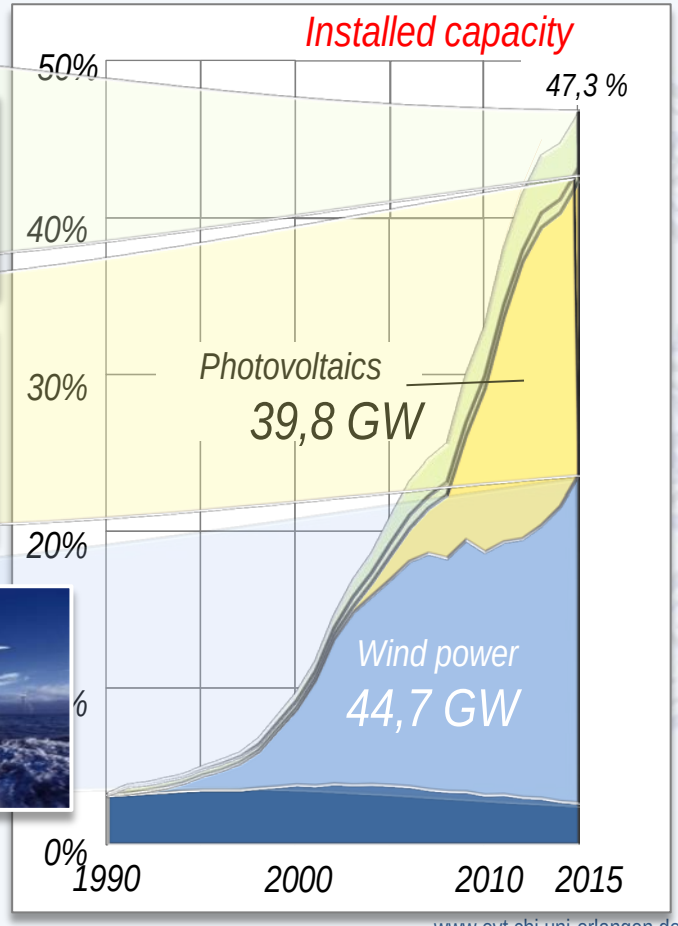
- German Renewable Energy Law („EEG“) initiated a booming industry…
- Biomass, Wind and PV cover up to 88 % of Germany‘s actual power consumption approximately 33% of the annual power consumption in 2015

Installed capacity(kW)

7 x

33 x

37 x



EEG surpassed all expectations …

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Public perception

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- the „Energiewende“ faces an intensive discussion in Germany…

German grid scraped past blackout!

Stupid!

Cheating!


Will Germany face the
total desaster?

Criticism against the German „Energiewende“

	facts	alternative facts
1. Renewables are expensive	☐	☐
2. Renewables put grid stability at risk	☐	☐
3. Renewable energies kill jobs	☐	☐
4. Renewables reduce the security-of-supply	☐	☐

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Electricity prices at the European Energy Exchange

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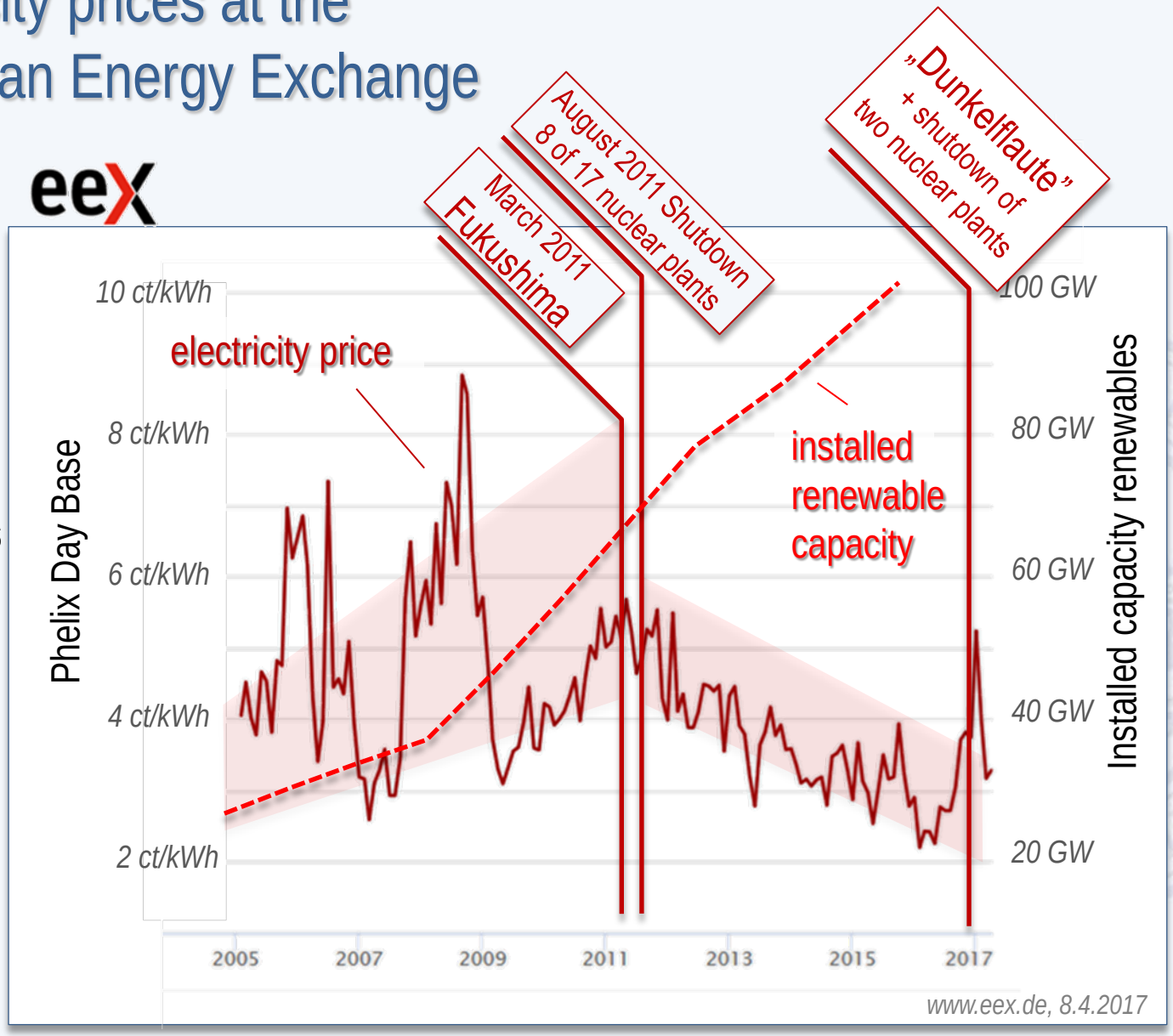
- Excess of renewable electricity droped average electricity prices **from 6 to 2 ct/kWh**
- German **„privileged industries“** *) experienced the lowest power prices in Europe

*) „energy intensive industries“, i.e. 25% of the German power consumption



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[1)] for private consumers and small enterprises only

[2)] scenarios without renewables would have been more expensive

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Discussion grid stability

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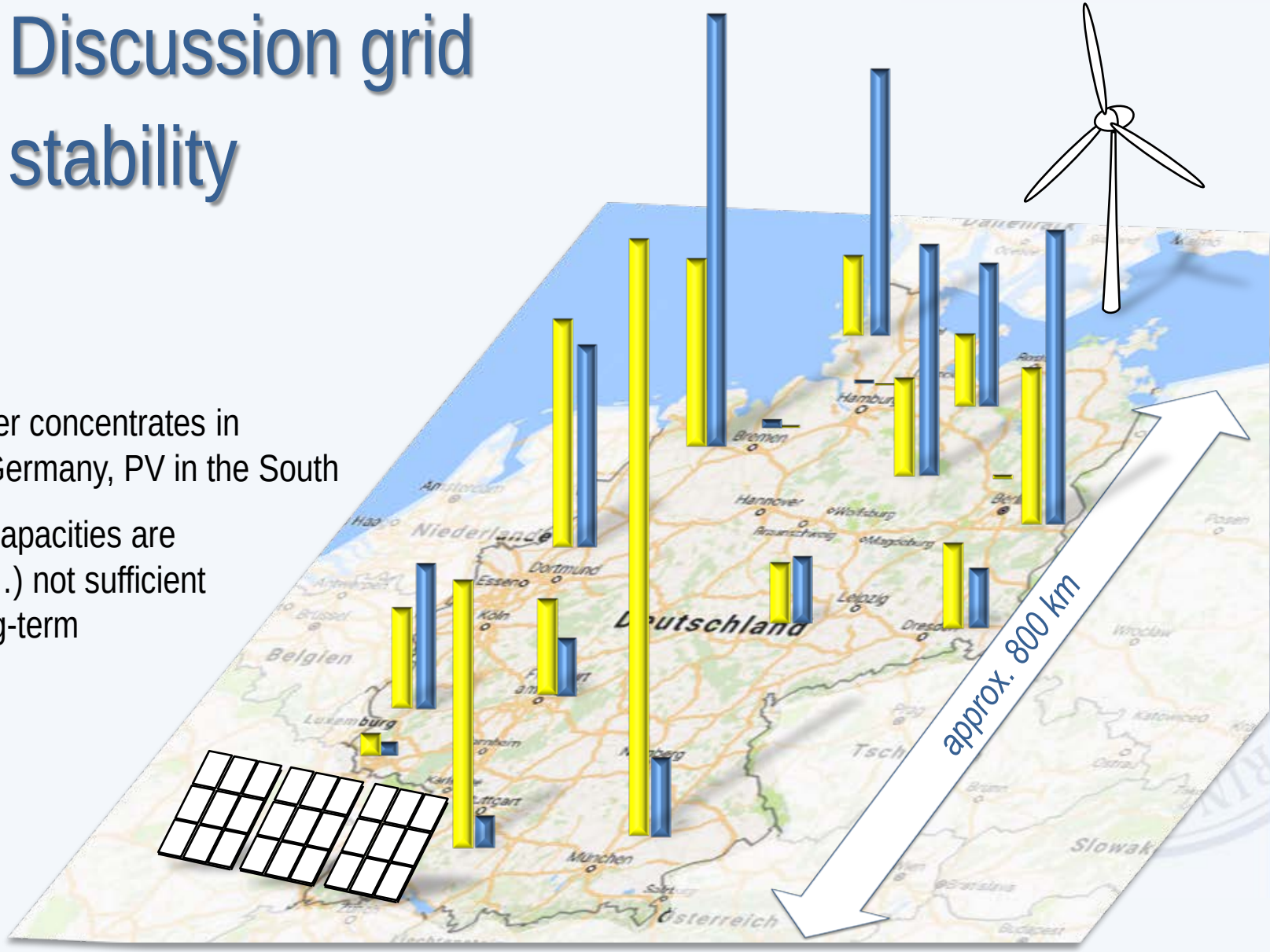
- Wind power concentrates in northern Germany, PV in the South
- transport capacities are (probably…) not sufficient on the long-term



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System Average Interruption Duration – SAIDI Index

- the SAIDI/SAIFI indices describe the reliability of the electricity supply
- The SAIDI index is defined as the system average interruption duration for customers served per year.

$$\text{SAIDI} = \frac{\text{Total Customer-Hours/Minutes of Interruptions}}{\text{Total Customers Served}}$$

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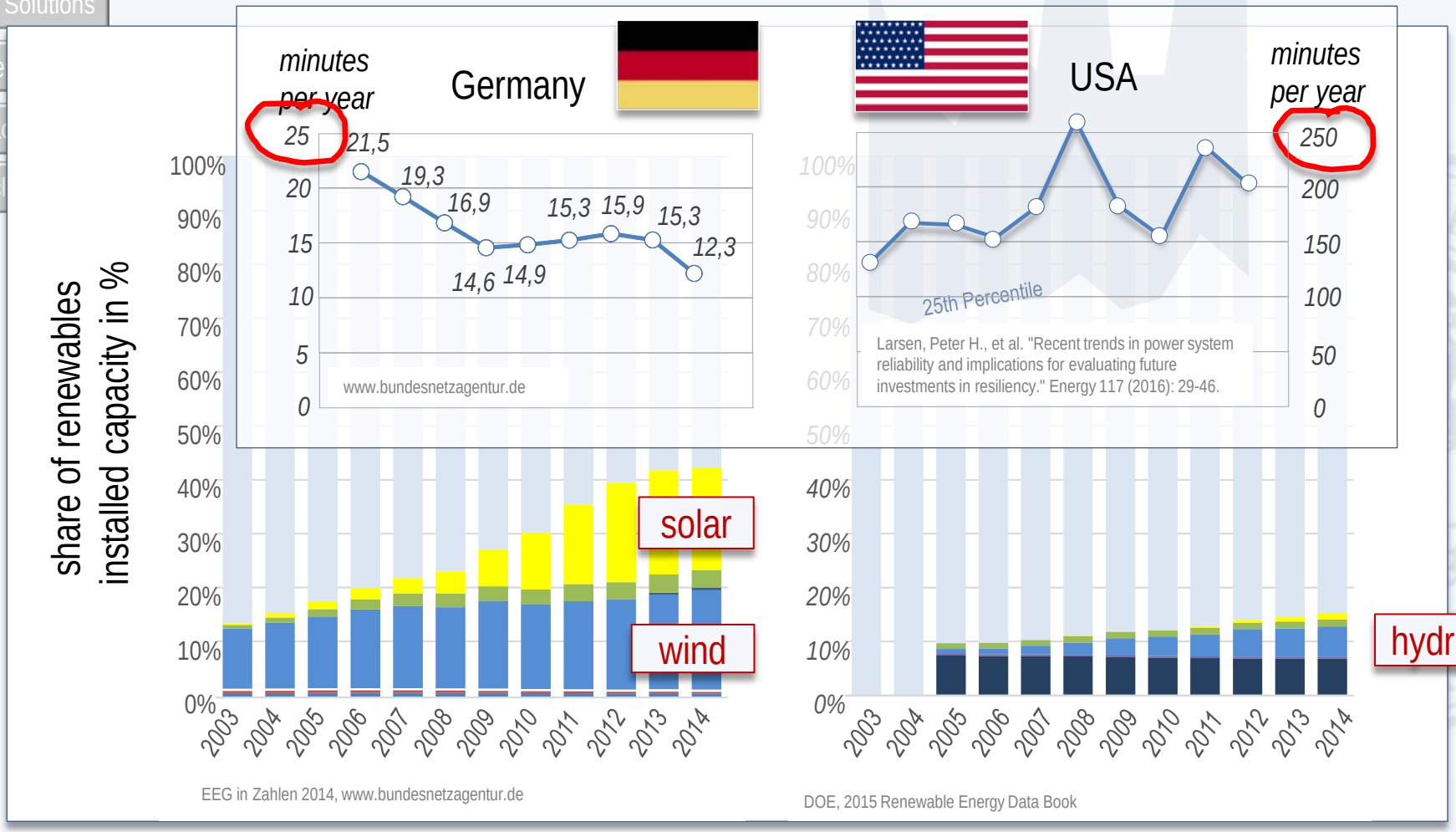

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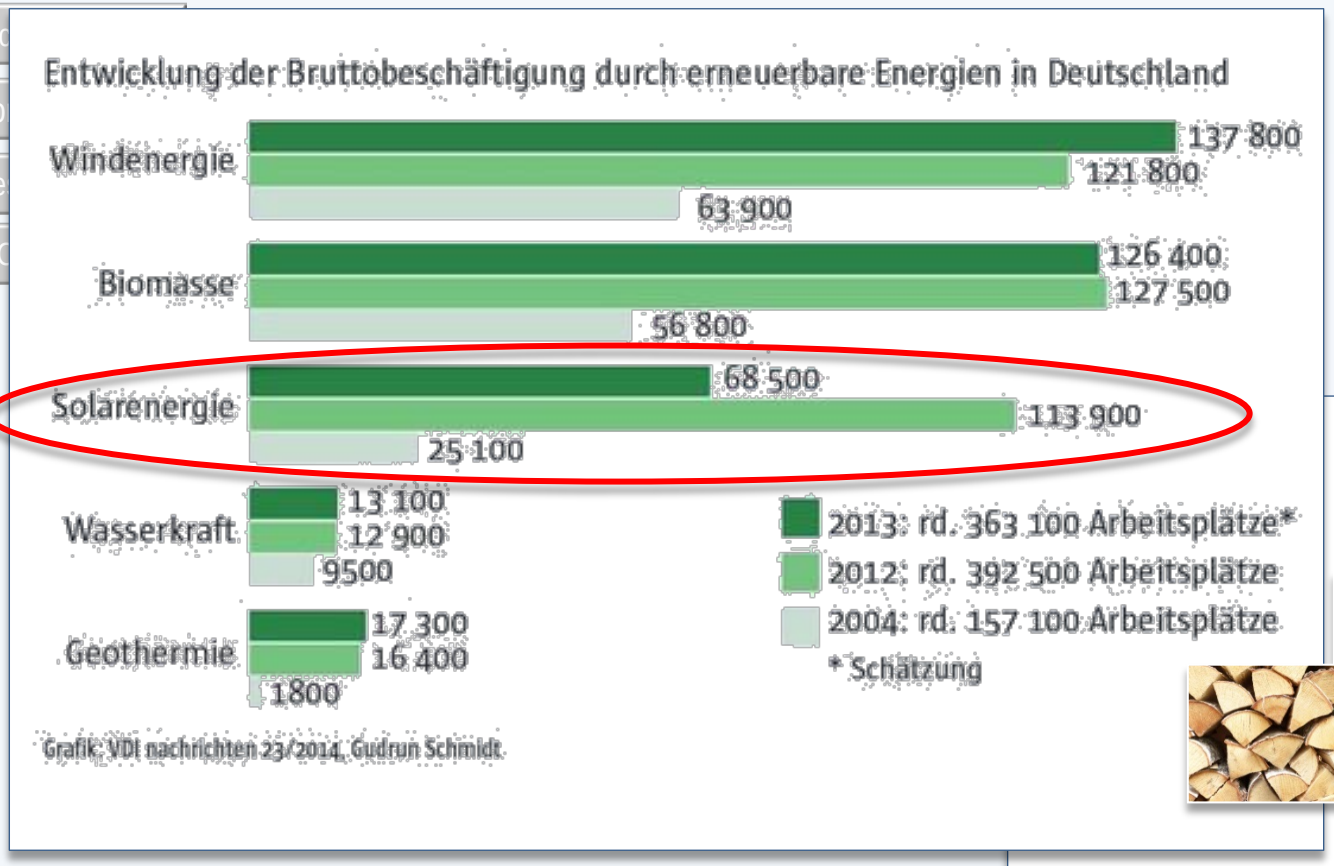
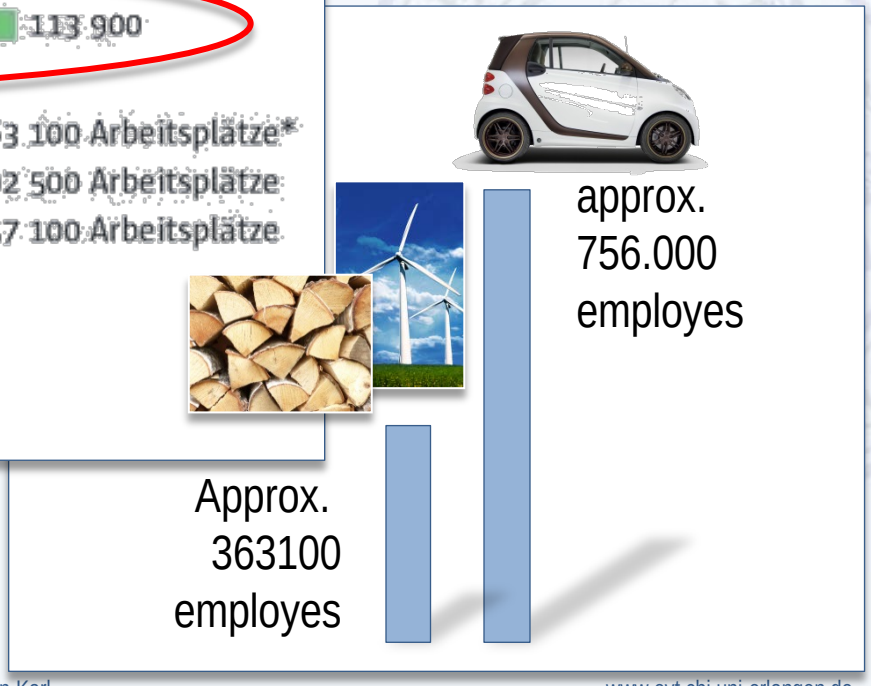
Impact of renewable energies on employment situation in Germany

Facts



- Renewable energies created more than 360.000 thousand jobs
- But volatile markets cause currently large uncertainties …



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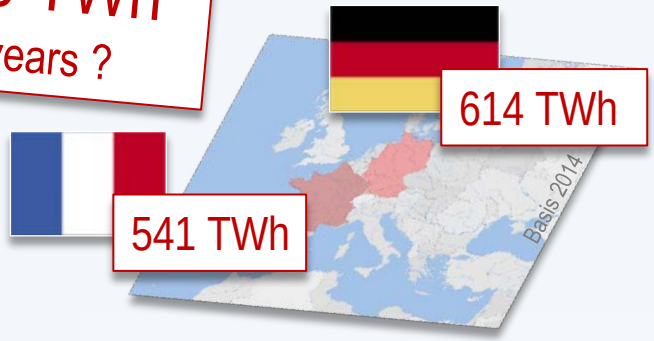
estimated defizit 500 TWh within the next 10 years ?



2nd Challenge:
Age structure of the conventional power plant structure

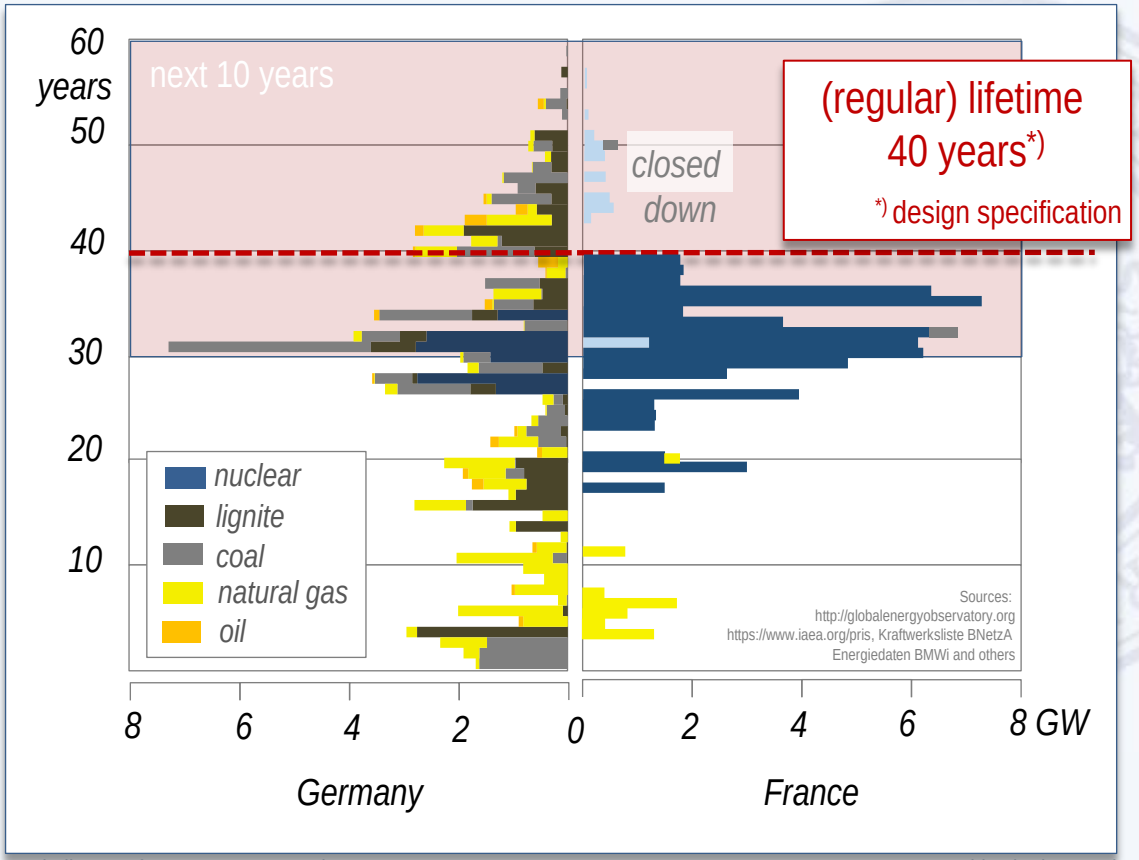
Deficites due to regular shutdowns within the next 10 years:

- Germany - 257 TWh (42%)
- France - 360 TWh (66%)

under construction (gas + coal)

- Germany approx. + 9 TWh
- France approx. + 16 TWh

- planned Renewables in Germany („Ausbaukorridor“) + 113 TWh (18%)



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2. Back-up solutions for renewable energies

- Back-up technologies for renewable energies
- Decentralized or centralized generation

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Why will upcoming energy systems be small?

Facts
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- Public acceptance, investment risks and fossil fuel prices will further delay new conventional power plants
- Renewable energies will have to substitute large conventional power plants…

…but renewable energies need back-up solutions!

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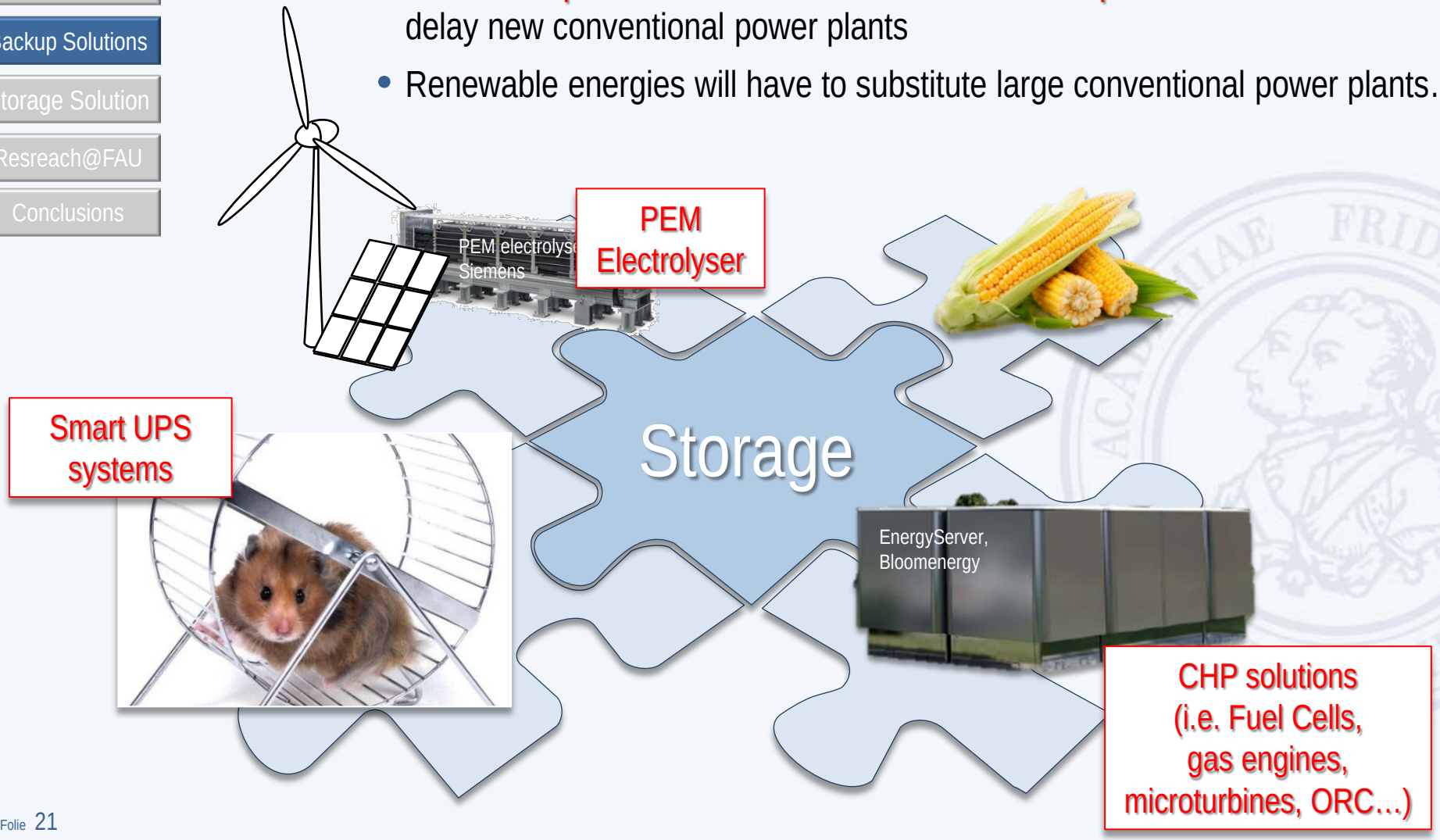

Conclusions

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2. Key technologies on the medium- and long-term are small-scale (CHP-) systems and storage solutions

3. Storage solutions for the Energiewende

- Storage tasks
- Chemical Storage Solutions

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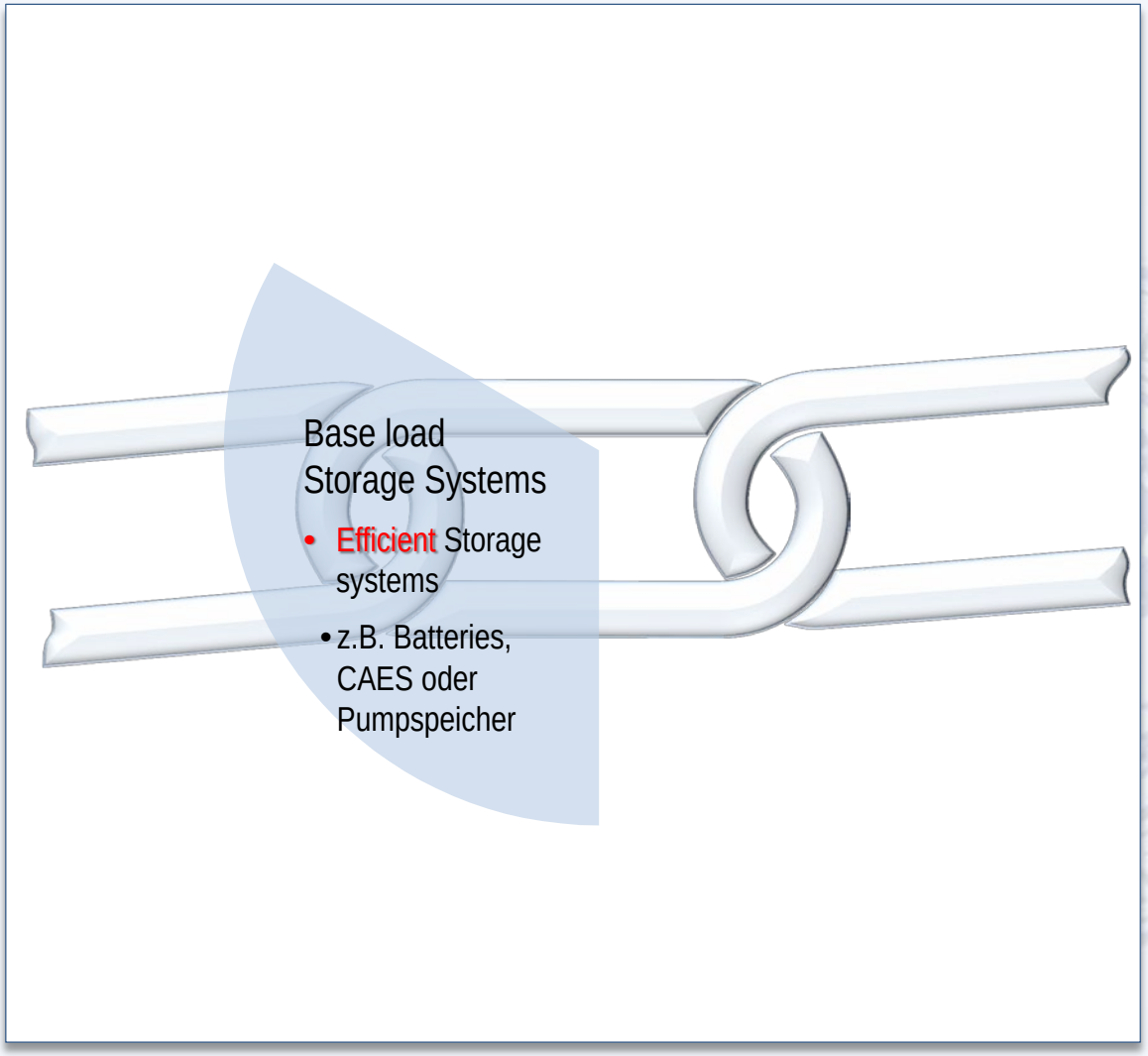
Storage tasks

Storage systems:

- Baseload storage (i.e. Batteries)



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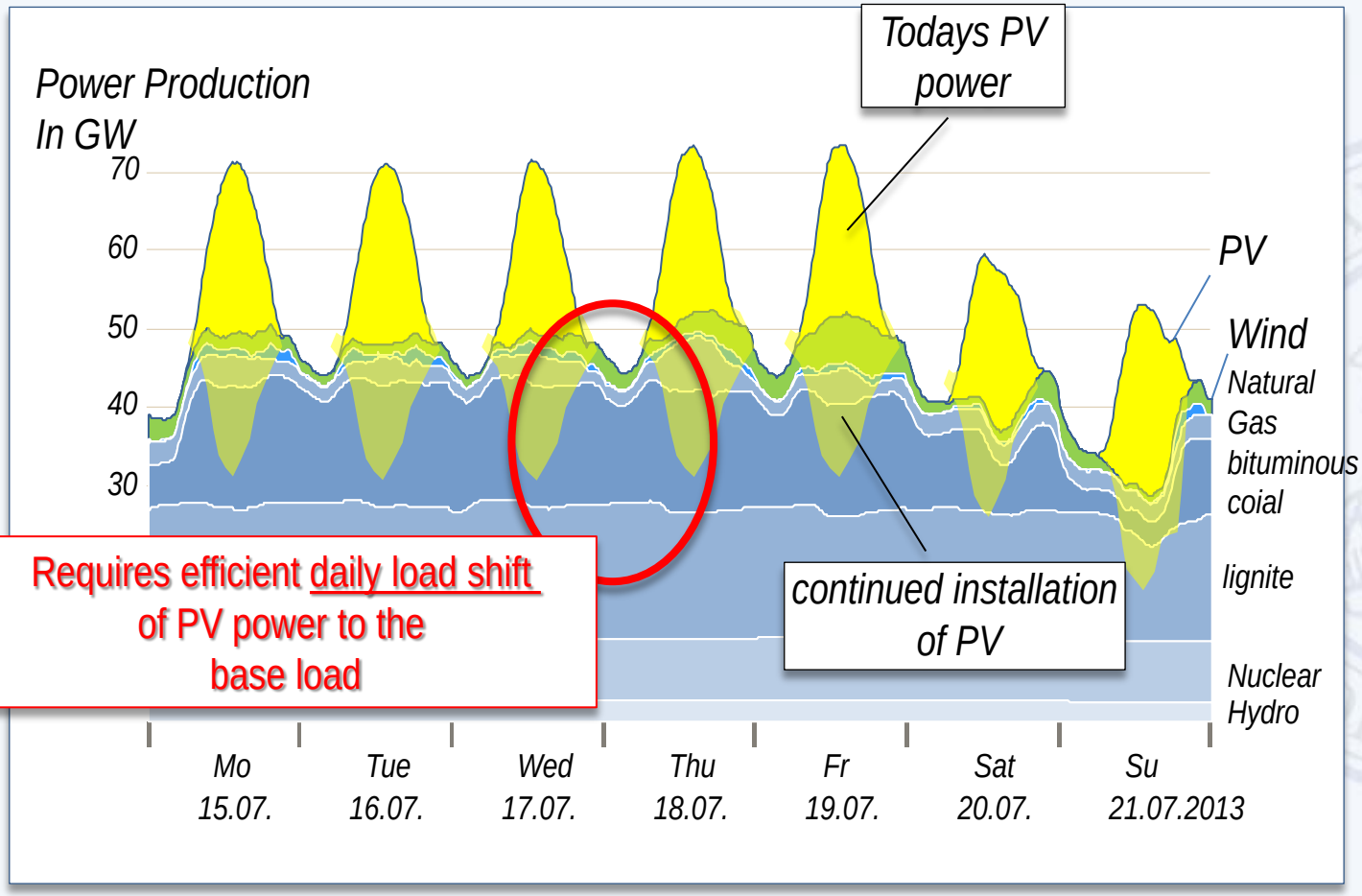
A Summer Week in Germany…

- Increasing the share of wind and PV requires affordable and efficient back-up capacities…



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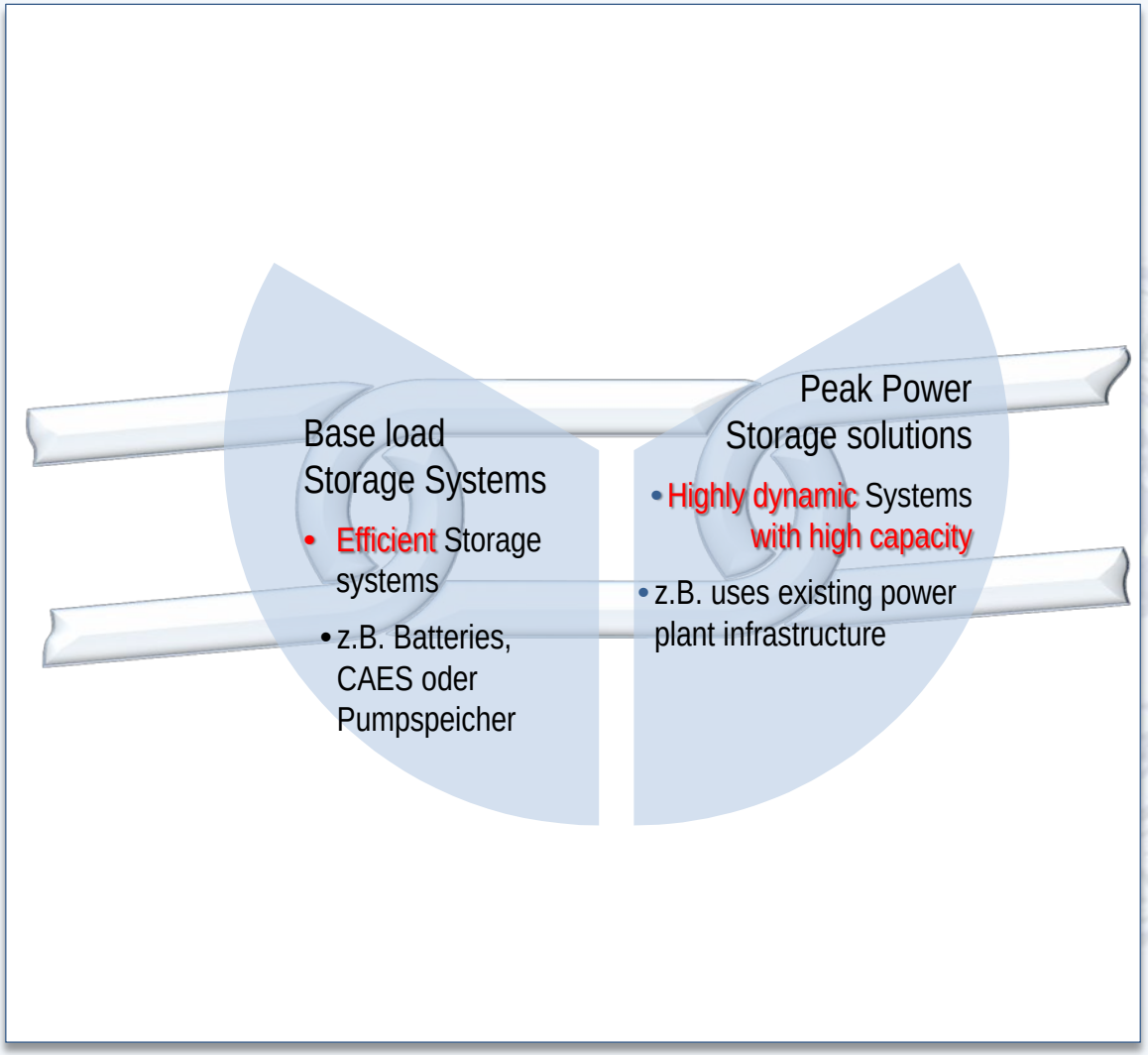
Storage tasks

Storage systems:

- Baseload storage (i.e. Batteries)
- Peak Power Storage systems (z.B. pumped hydro, gas turbines)



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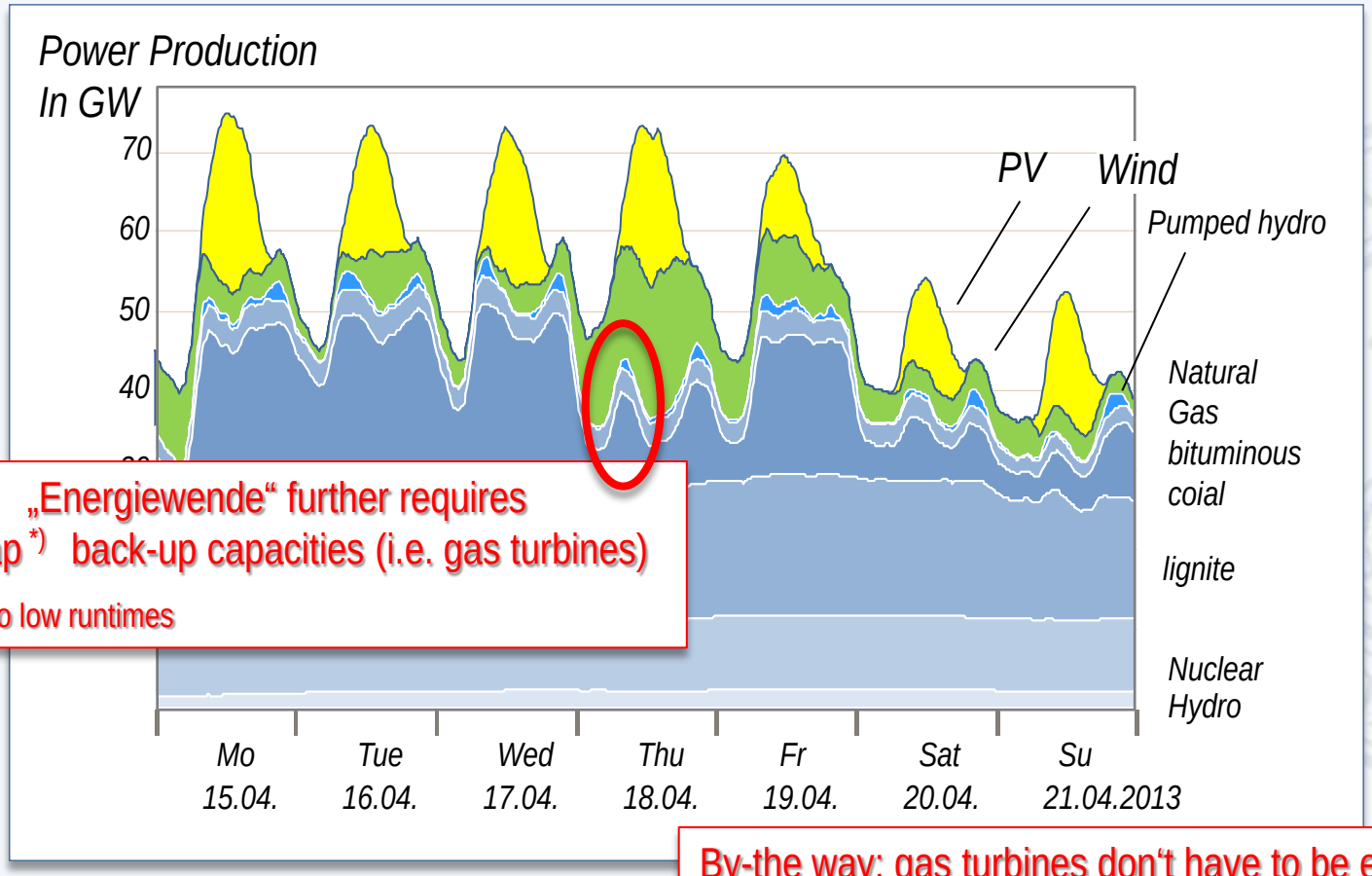
A Spring Week in Germany…

- Increasing the share of wind and PV requires affordable and efficient back-up capacities…
- Increasing the share of wind and PV requires affordable and most flexible back-up capacities…



„Energiewende“ further requires cheap *) back-up capacities (i.e. gas turbines)

*) due to low runtimes

By-the way: gas turbines don‘t have to be efficient…

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Storage tasks

Storage systems:

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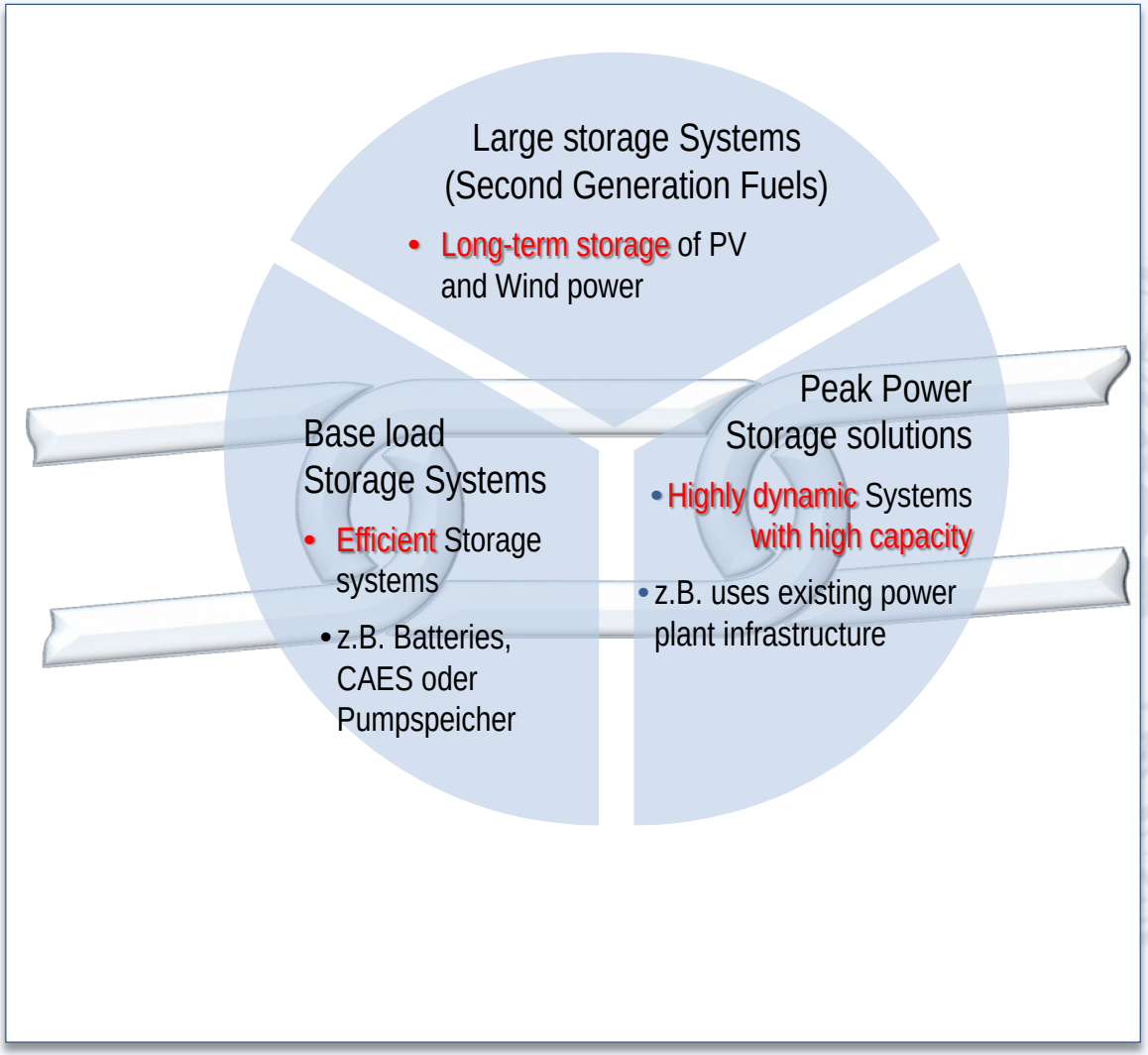
- Systems with large Storage Capacities (Second Generation Fuels and Chemical Storage)



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Power generation in Germany

Winter 2010-2013

- Solar power is generally low in winter times
- Problematic are in particular low wind periods

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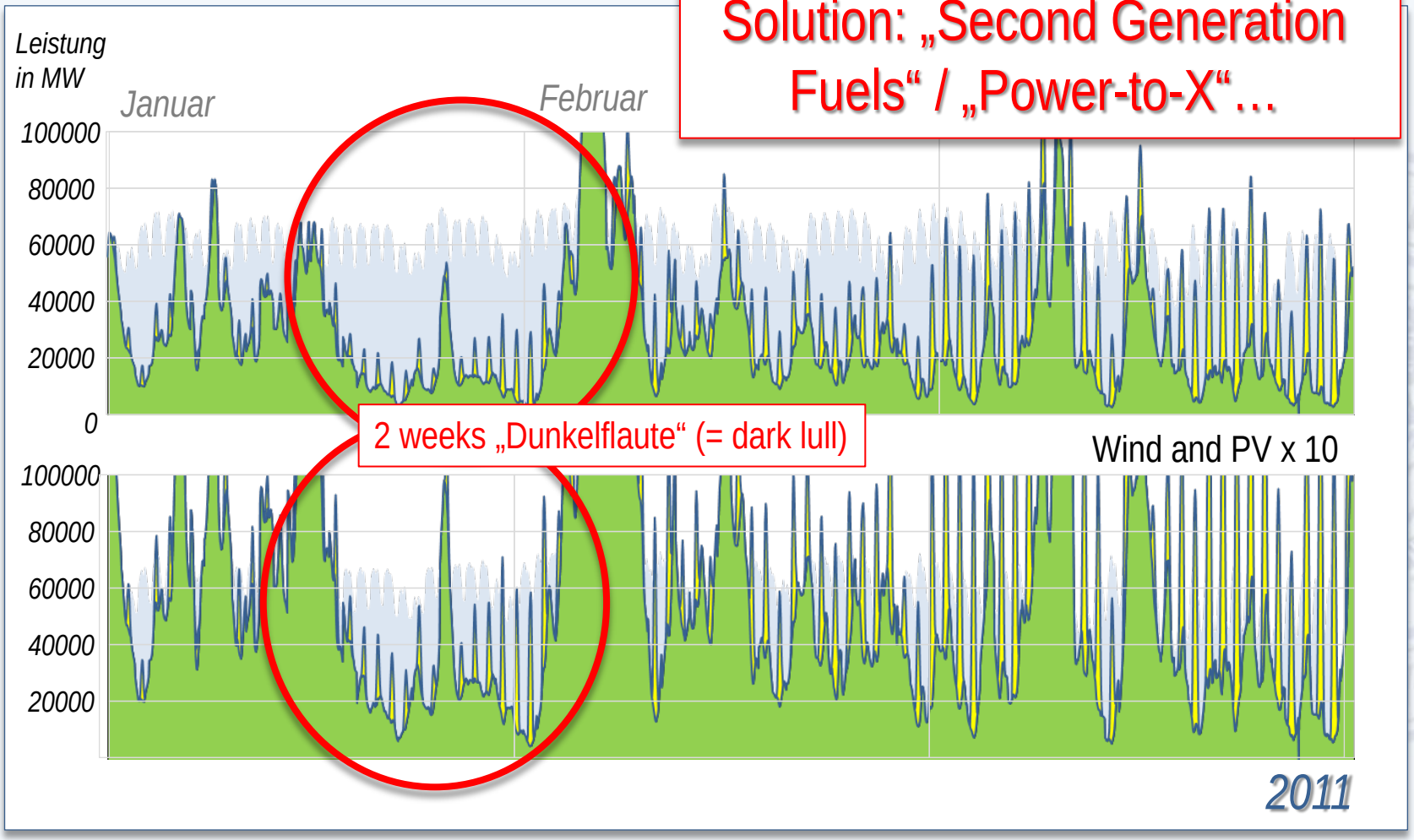
Power production in Germany
Winter 2010-2013

- Solar power is generally low in winter times
- Problematic are in particular low wind periods

- Strategic storage systems have to secure up to two weeks

Solution: „Second Generation Fuels“ / „Power-to-X“…



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Storage tasks

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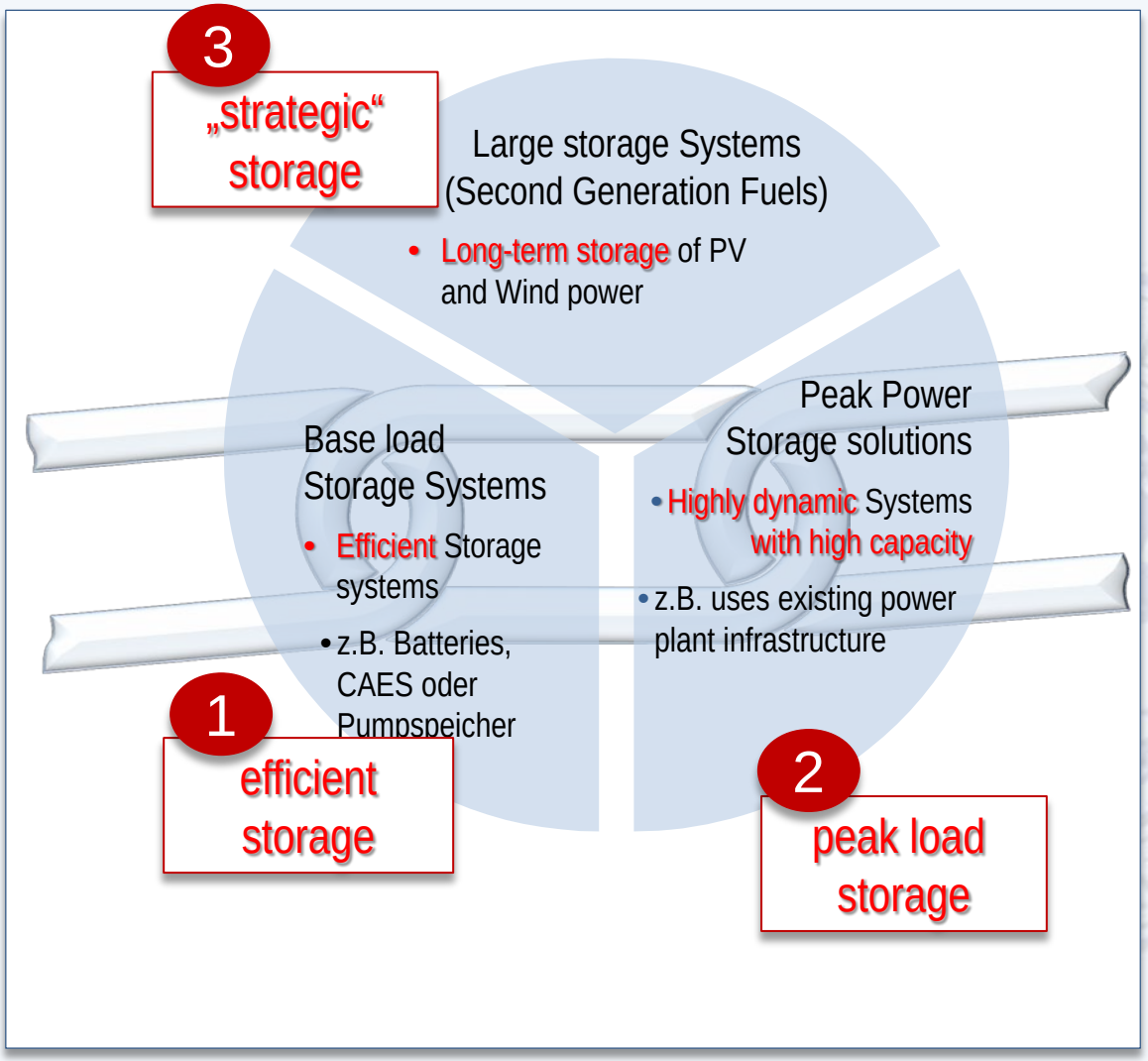

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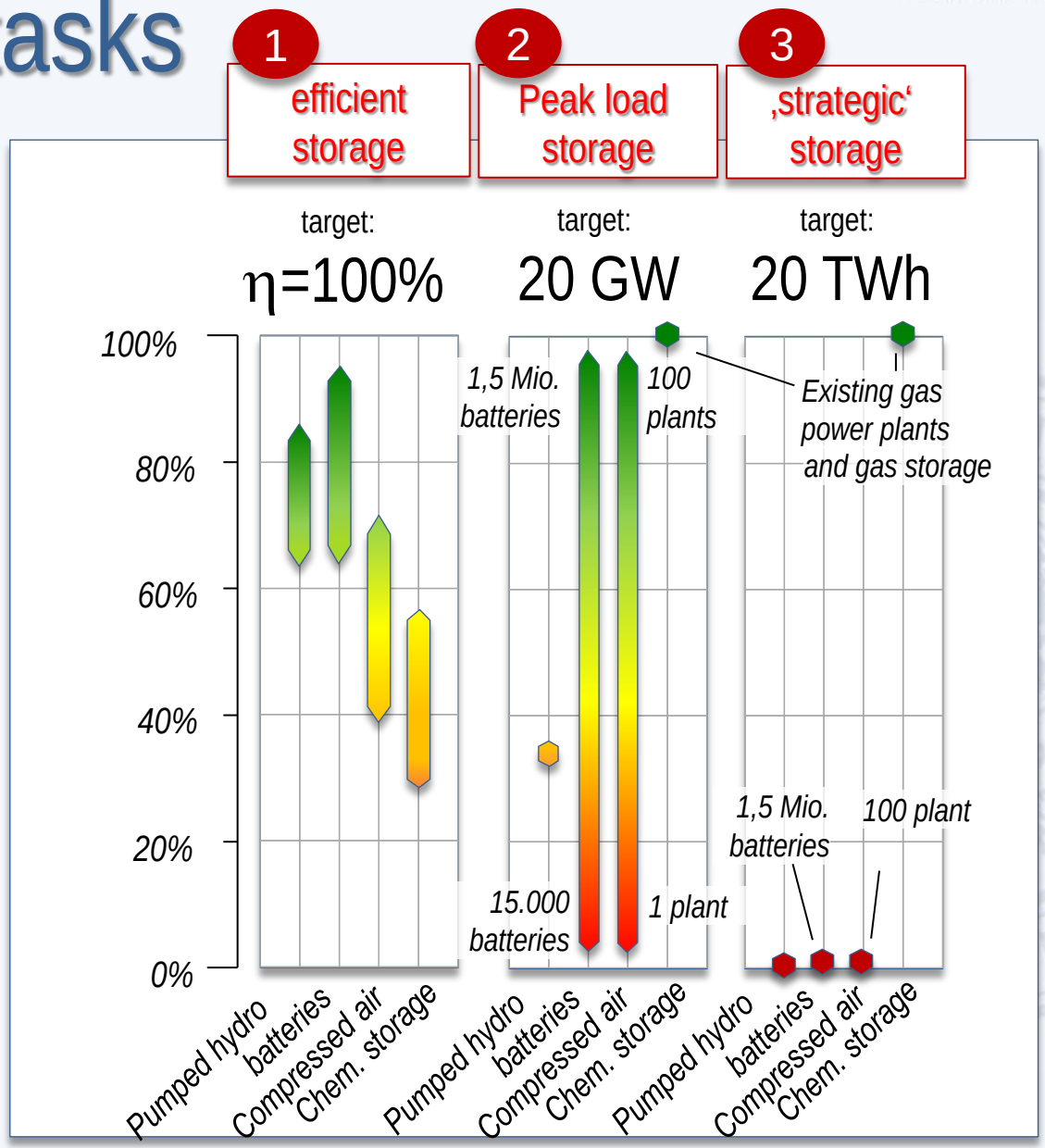

Conclusions

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4. Ongoing energy research @ FAU

- Fuel cell reserach
- Biomass gasification
- Methanation of biogenic syngas

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Example

Fuel Cell / Electrolyser research @ FAU

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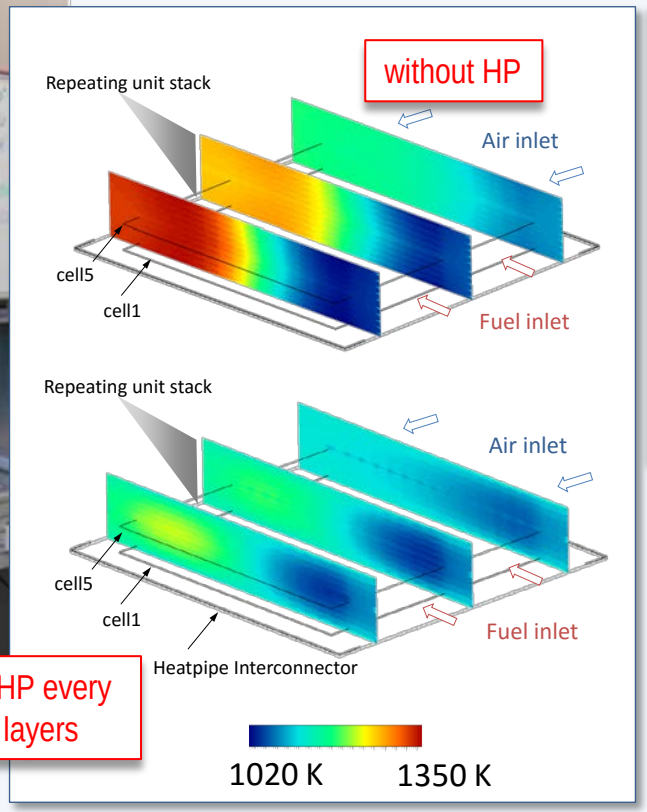
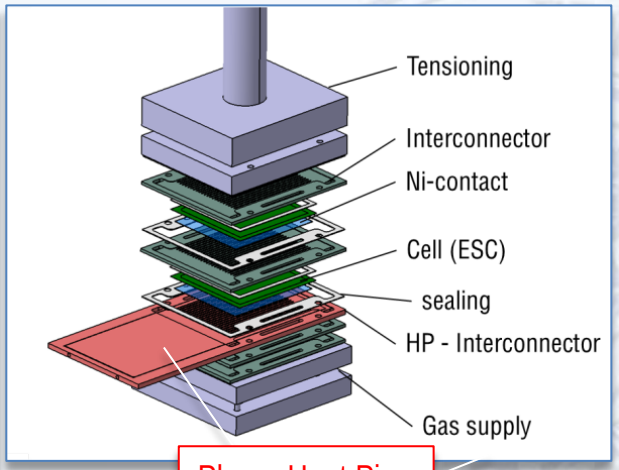
Conclusio

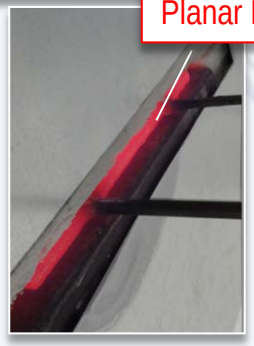
- Load flexible SOFC Fuel Cells / SOEC electrolysers for high temperature electrolysis for the production of renewable hydrogen
- Integration of heat pipes into the stack

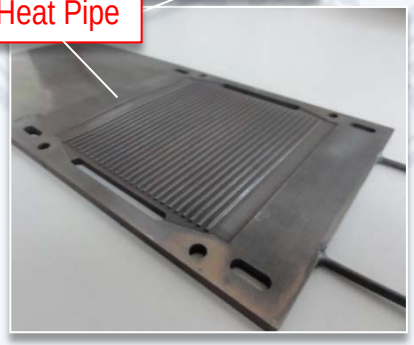


with 1 HP every 10 cell layers



Planar Heat Pipe





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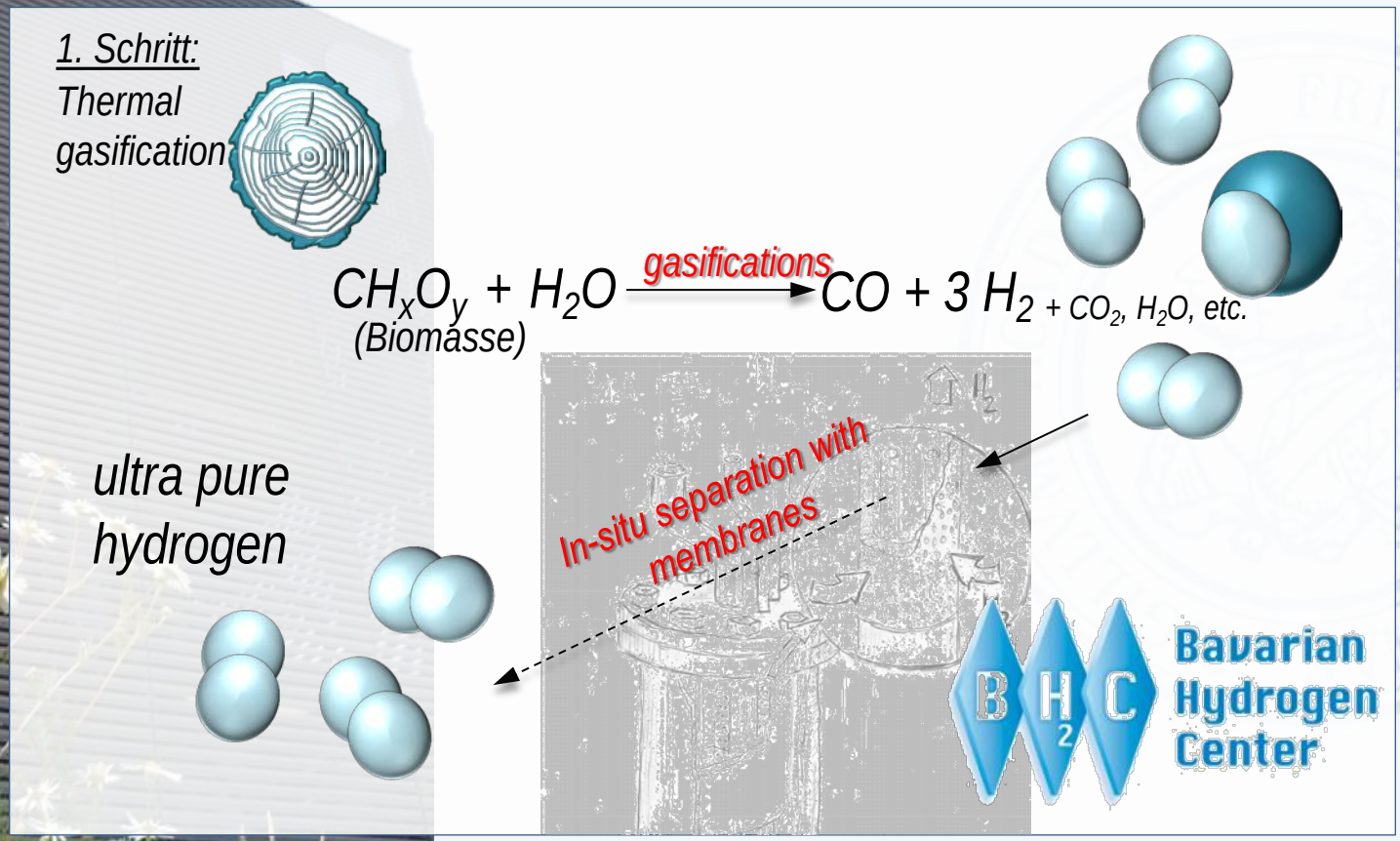
Example

Biomass gasification @ FAU

Hydrogen from Biomass

- In-situ extraction of pure Hydrogen with metallic membranes (technology: Heatpipe Reformer)



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Example

Second Generation Fuels @ FAU

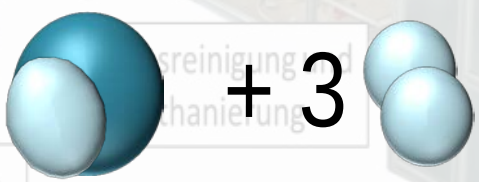
- Allothermal gasification (Heatpipe reformer) SNG production from sulfurous fuels
- Syngas cleaning and process chain demonstration

- Production of synthetic „natural gas" ("Methanation") from biomass and lignite

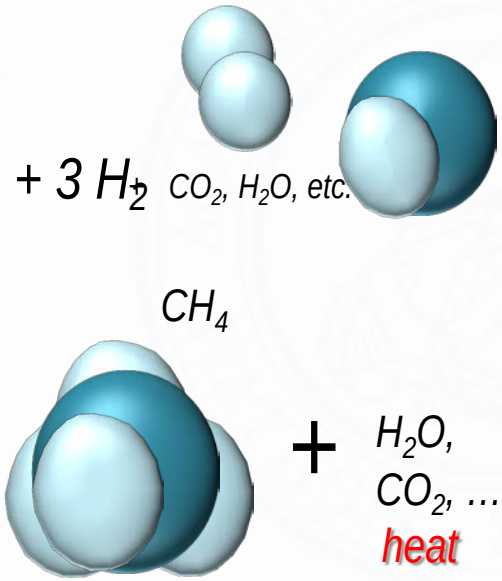
1. Step:
Thermal gasification

$$CH_xO_y + H_2O \xrightarrow{\text{gasification}} CO + 3\,H_2 + CO_2, H_2O, \text{etc.}$$

(Biomass)



$$\xrightarrow{\text{hydrogenation}}$$



2. Step:
Methanation

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4. Upcoming challenges require to maximize our joint research activities and transnational cooperation