UNIVERSITÄT LEIPZIG

Energiemanagement und Nachhaltigkeit

Economic Potential of the "Power-to-Heat" Technology in the 50Hertz Control Area

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Agenda

- Motivation
- Methodology
- Theoretical and Technical P2H-Potentials
- Costs for P2H-Systems and Heat Storages
- Model Assumptions
- Model Results
- Conclusion

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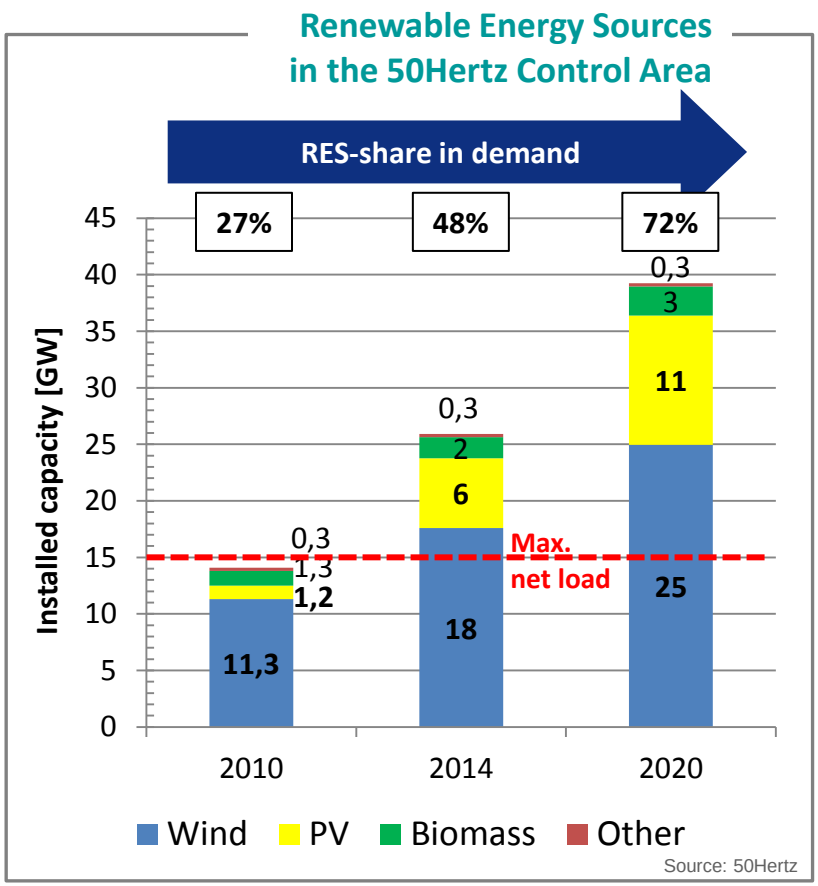
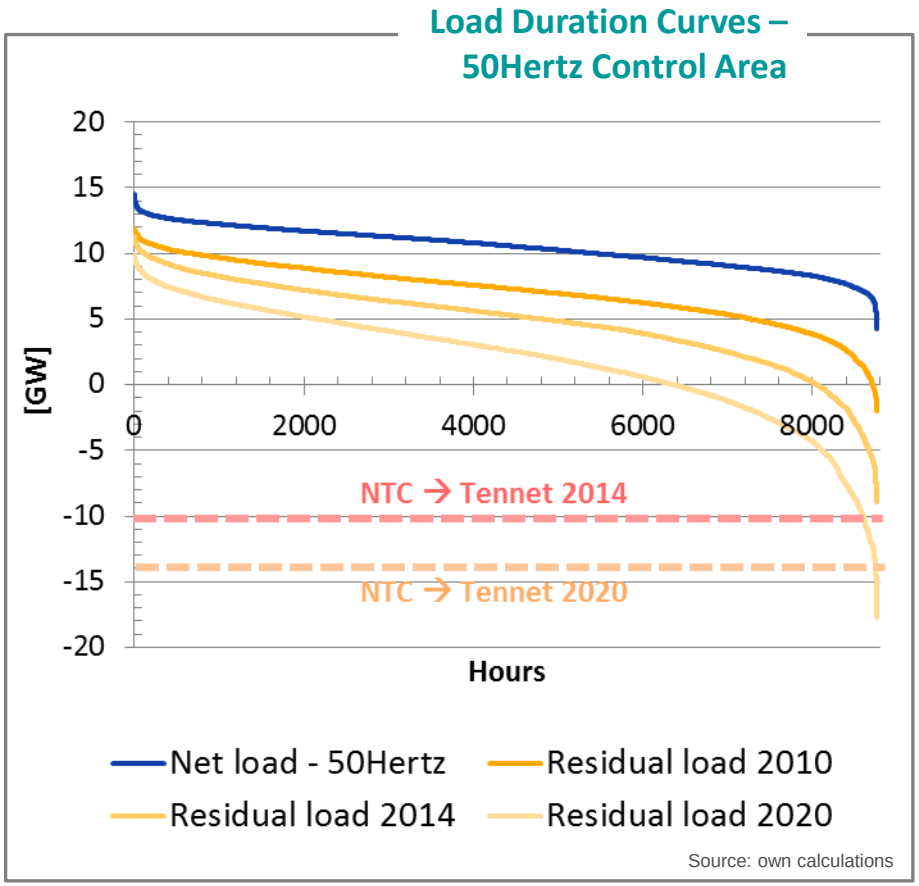
Motivation





- Mathematically, the demand for base-load power plants disappears in the control area.

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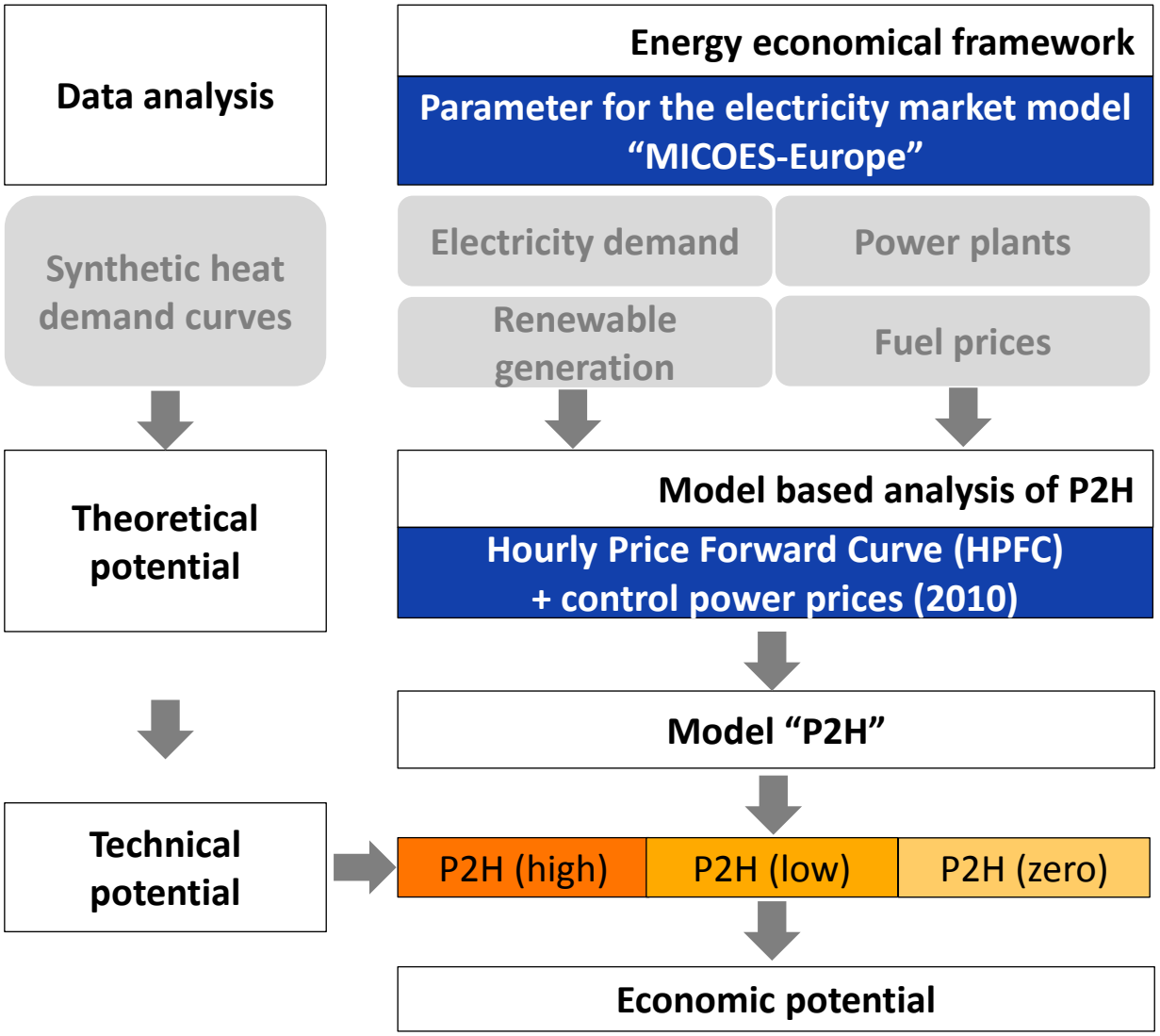
Methodology



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Theoretical and Technical P2H-Potentials

- The largest 10 district heating grids account for 76 % of the heat sink.
- The technical potential of the supply side is sufficient in 2014, to operate the one on the demand side at all times.
- In 2020, the power demand of the technical P2H-potential is significantly higher than the technical potential of the supply side.

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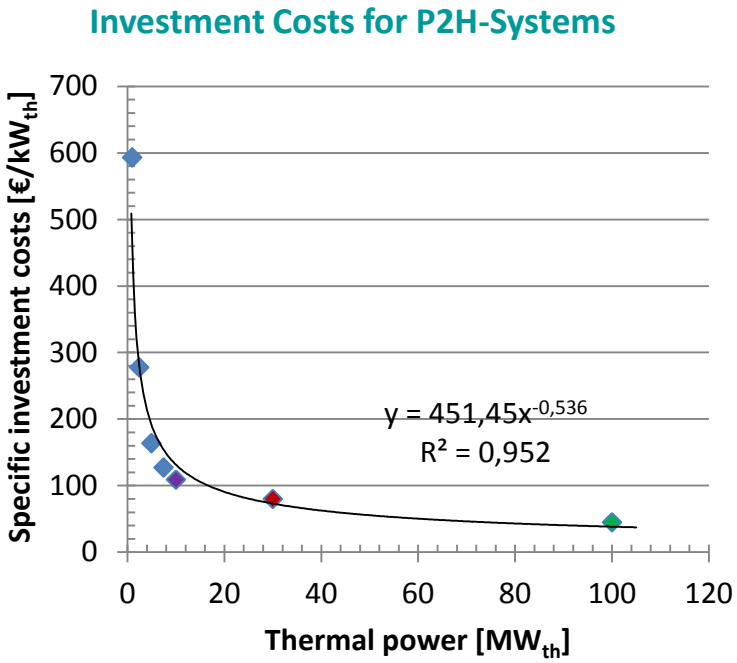
Costs for P2H-Systems and Heat Storages



Variable Costs	Unit	2013
FIT surcharge	€/MWh	52.77
Grid usage fee	€/MWh	25.20
Electricity tax	€/MWh	20.50
§19 StromNEV surcharge	€/MWh	1.51
Concession levy	€/MWh	1.10
CHP surcharge	€/MWh	0.50
Offshore surcharge	€/MWh	0.00
PEF compensation	€/MWh	31.00
Displaced heat generation	€/MWh	-24.00
Sum	€/MWh	108.58

Dimension in percentage of peak heat load	Heat storages			P2H-systems			Sum of investment costs	
	Volume	150 €/m³	1000 €/m³	P_{th}	45.00 €/kW	109.10 €/kW		
	GWh$_{th}$	Mio. €	Mio. €	GW$_{th}$	Mio. €	Mio. €	Mio. €	Mio. €
20 %	22	63	419	2.2	99	240	**162**	**659**
50 %	55	157	1047	5.5	247	600	**404**	**1647**

- The total investment amounts to between € 162 million and approximately € 1.7 billion.

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Model Assumptions for Heat Storages and P2H

- Modeling of six large district heating systems with heat storages and P2H-systems
- Heat storages: Absorption or release of 50 % of the maximum thermal load for 10 hours
- Dimensioning of the P2H-systems: 50 % of the maximum thermal load

	Unit	Berlin East	Berlin West	Leipzig	Dresden	Chemnitz	Halle	Sum
Max. thermal load 2010 (core grid)	MW_{th}	1,568	2,763	595	657	455	280	**6,003**
Heat demand 2010 (core grid)	GWh_{th}	5,500	5,258	1,812	1,890	1,116	948	**16,321**
Thermal output of CHP-plant	MW_{th}	651	2,024	534	265	475	140	**4,089**
Thermal output of boilers	MW_{th}	1,422	105	266	522	232	190	**2,737**
Modeled max. storage output (50% of max. thermal load)	MW_{th}	790	1,380	300	330	230	140	**3,170**
Modeled storage capacity (10h)	MWh_{th}	7,900	13,800	3,000	3,300	2,300	1,400	**31,700**
Modeled P2H-output (50% of max. thermal load)	MW_{th}	790	1,380	300	330	230	140	**3,170**

Scenarios

Scenario	P2H (high)	P2H (low)	P2H (zero)
Description	Full technical potential of 50 % of the max. heat load	Full technical potential of 50 % of the max. heat load **with exemption from FIT-surcharge and PEF-compensation**	Full technical potential of 50 % of the max. heat load **with full exemption** of government induced cost elements
Variable costs 2014 (w/o opportunity costs)	€ 124.16/MWh	€ 67.96/MWh	€ 0.00/MWh
Variable costs 2020 (w/o opportunity costs)	€ 148.25/MWh	€ 92.05/MWh	€ 0.00/MWh

- Analysis based on modeled spot market prices from *MICOES-Europe* for 2014 and 2020 and historical control power prices from 2010.
- Consideration of three different configurations of dimensions and variable costs of P2H
- CHP-systems optimize their output on the basis of the spot market, the control power market and the thermal load as price taker with perfect foresight.

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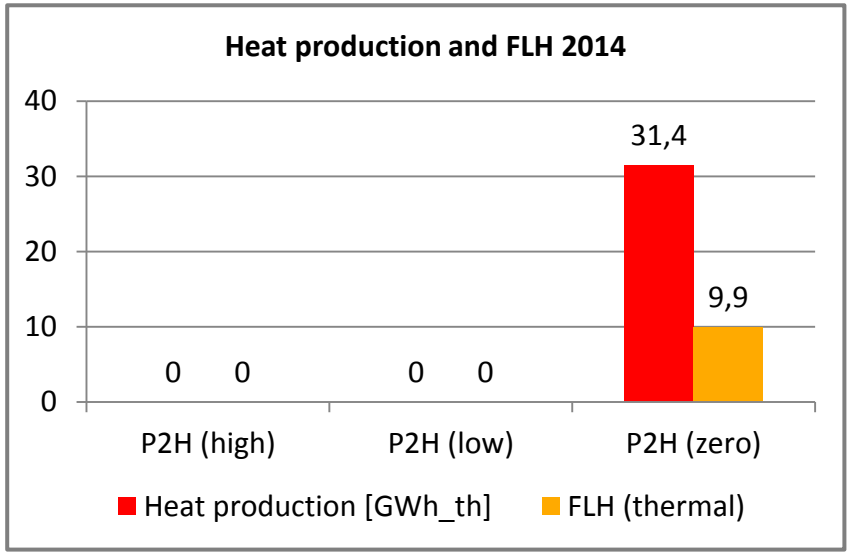
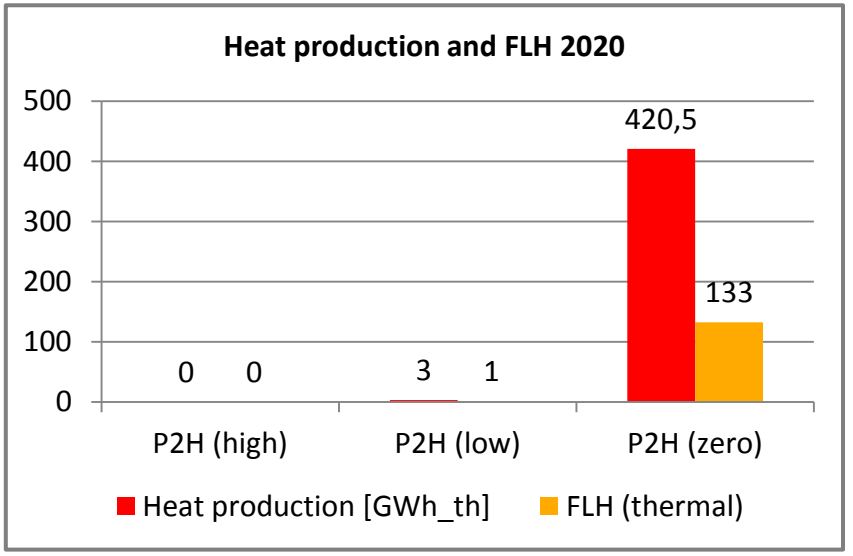
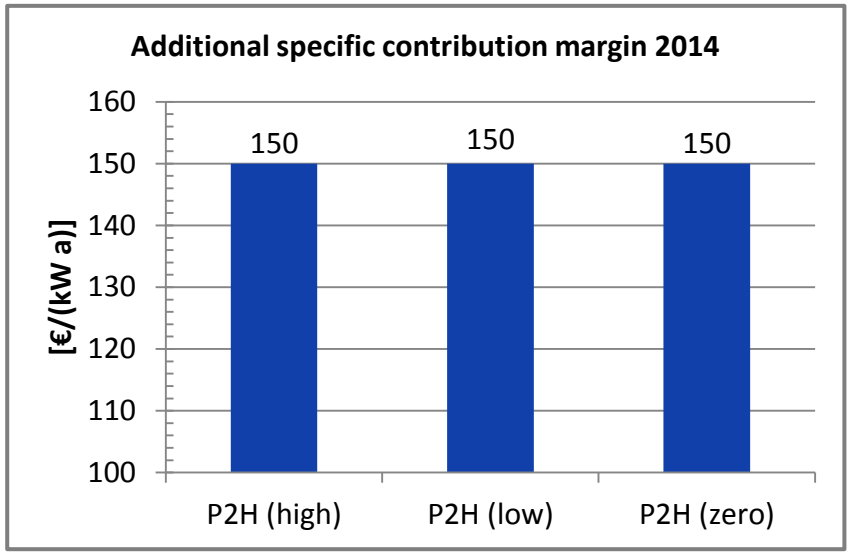
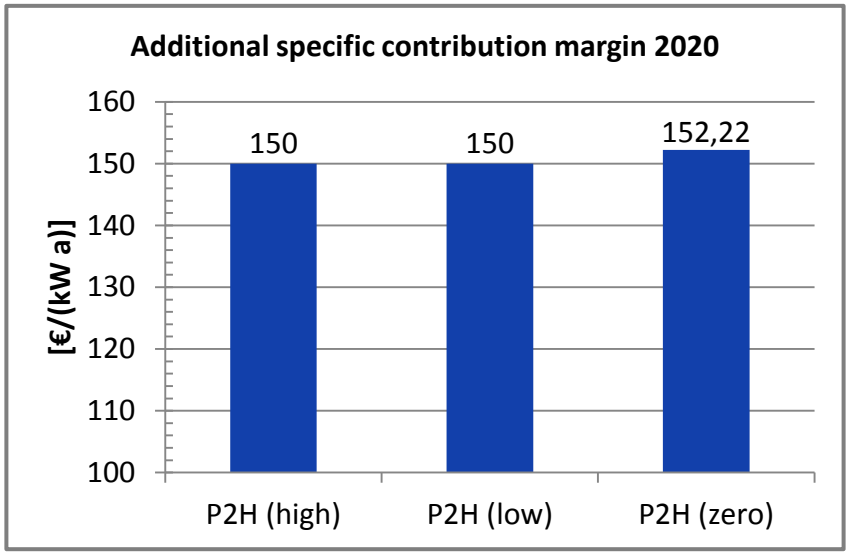
Model Results – P2H









Model Results – Payback Period

Output [MW_{th}]							
		2.5	5	7.5	10	30	100
	Capacity costs €/(kW a)						
Specific contribution margin [€/(kW a)]		103.07	56.87	41.69	34.19	20.16	11.47
	20					5.9	3.0
	40			7.7	5.1	2.1	1.3
	60		6.2	3.5	2.6	1.3	0.8
	80	16.9	3.5	2.2	1.8	0.9	0.6
	100	7.6	2.5	1.7	1.3	0.7	0.5
	120	4.9	1.9	1.3	1.1	0.6	0.4
	140	3.6	1.5	1.1	0.9	0.5	0.3
	160	2.9	1.3	0.9	0.8	0.4	0.3
	180	2.4	1.1	0.8	0.7	0.4	0.3
	200	2.0	1.0	0.7	0.6	0.3	0.2

- Economical lifetime of P2H-systems: 10 years.
- Capacity costs calculated for WACC = 7 %.
- High profitability by providing negative control power can lead to an extremely short payback period.

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Conclusion I

- The theoretical potential to increase the load with the P2H technology is max. 12 GW_{el}.
- The largest 10 district heating grids in the control area provide more than ¾ of the heat sink.
- Given a suitable design of the heat storages and P2H plants (20-50 % of the maximum thermal load) the aggregated technical potential on the supply side would be at 2.2 to 5.6 GW_{el}. This will require investments of € 0.2 to 1.7 billion.
- The maximum technical potential on the demand side is 5.6 GW_{el} in 2014 and 8 GW_{el} in 2020.

Conclusion II

- At the current regulatory framework P2H-systems are used for providing negative control power only – but with high profitability. This leads to short payback periods.
- Heat production only takes place at significantly low or negative spot market prices in 2020 at scenarios without state charges.
- For unleashing the potential for the integration of excessive vRES, it is necessary to adjust the regulatory framework.

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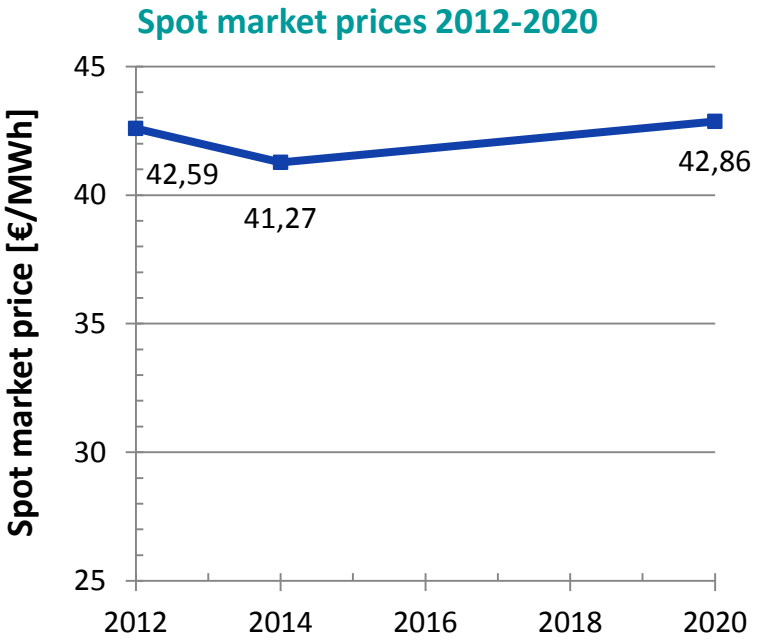
Thank you!

BACK UP

Model Results – Spot Market Prices until 2020



Fuel/Demand	Unit	2014	2020
Uranium	€/MWh$_{fuel}$	3.70	4.00
Lignite	€/MWh$_{fuel}$	4.51	4.69
Hard coal (import)	€/MWh$_{fuel}$	9.95	9.81
Natural gas	€/MWh$_{fuel}$	23.00	25.14
Light fuel oil	€/MWh$_{fuel}$	73.61	82.69
Heavy fuel oil	€/MWh$_{fuel}$	40.37	45.35
CO_2	€/t	10.00	20.00
Net electricity consumption	TWh	548.2	548.2

- Model assumptions for *MICOES-Europe* base on the *Netzentwicklungsplan 2012*, the *BMU-Leitstudie 2011* and own assumptions.
- The annual average spot market prices will remain until 2020 almost constant.

Technical Potential of P2H and Heat Storages on the Supply Side

Flexible dispatch of CHP-plants with heat storages

- Technical integration of P2H-plant with heat storage
- Heat storages increase flexibility in district heating grids:
  - A) Increase of CHP power production in case of high (residual) load by reduction of power loss (extr.-cond.)
  - B) Decrease of CHP-plant to minimum load or shut-down in case of low (residual) load
  - C) Shut-down of CHP-plant and supply of heat demand with P2H/ heat storage in case of very low/ negative residual load

Storage capacity (proportional to peak demand of 11 GW_{th})	Dimensioning of heat storages	
	% of peak heat load	Capacity [GW_{th}]
	20 %	**2.2**
	30 %	**3.3**
	40 %	**4.4**
	50 %	**5.5**

	Cases for CHP-plants for use of heat storages and P2H		
	A) Increase of power production	B) Decrease of power production	C) Decrease of CHP power production + P2H
% of peak heat load	[GW_{el}]	[GW_{el}]	[GW_{el}]
20 %	**0.4**	**1.4**	**3.6**
30 %	**0.7**	**2.0**	**5.4**
40 %	**0.9**	**2.7**	**7.2**
50 %	**1.1**	**3.4**	**9.0**

Source: *AGFW, own calculations*

- Today, heat storages with a capacity of 3.5 GWh_{th} (0.35 GW) are installed in the 50Hertz control area.

Technical Potential of P2H on the Supply Side

- Regional technical potential of P2H in the control area of 50Hertz amounts to between 2.2 GW_{el} and 5.6 GW_{el}.

  (without additional shut down potential of CHP plants through heat storages).

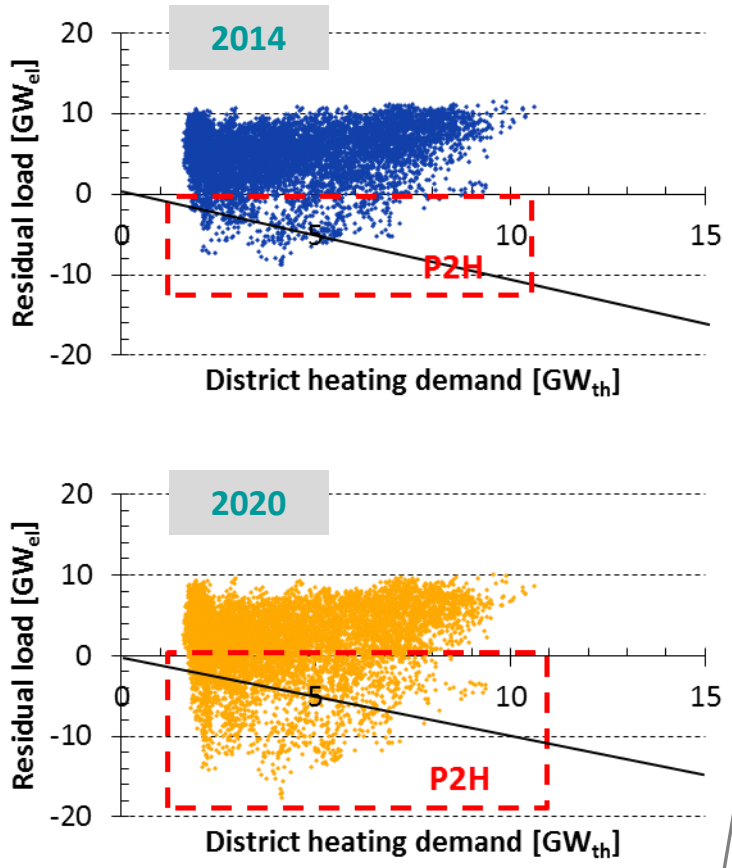
Area		Control area		Branden-burg	Berlin	Mecklen-burg-West Pomerania	Saxony	Saxony-Anhalt	Thuringia	Hamburg
(thermal efficiency 98%)		**[MW_{th}]**	**[MW_{el}]**	[MW_{el}]	[MW_{el}]	[MW_{el}]	[MW_{el}]	[MW_{el}]	[MW_{el}]	[MW_{el}]
Dimensioning of the P2H-Systems in Percentage of the max. thermal load	**20%**	**2,199**	**2,243**	292	730	147	463	161	168	284
	30%	**3,298**	**3,365**	438	1,095	220	694	242	251	426
	40%	**4,397**	**4,487**	583	1,460	293	925	322	335	567
	50%	**5,496**	**5,609**	729	**1,826**	367	**1,156**	403	419	**709**

Source: *AGFW, own calculations*

Technical Potential of P2H and Heat Storages on the Demand Side – 2014/2020

- The maximum available P2H potential is 5.6 GW_{el} (2014) and 8 GW_{el} (2020).

Residual load and heat demand



Technical potential

- The district heating demand in the control area is at least 1.7 GW_{th} and thus forms a lower limit for technical P2H.
- Negative residual loads can exceed the heating demand and vice versa.
- Technical potential in every hour of the year: minimum of excessive electricity and heating demand