Is sector coupling a well-defined strategy?

Concept analysis and an example of P2G to guarantee supply security in a renewable power market

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The concept of Sector Coupling and Sector Integration

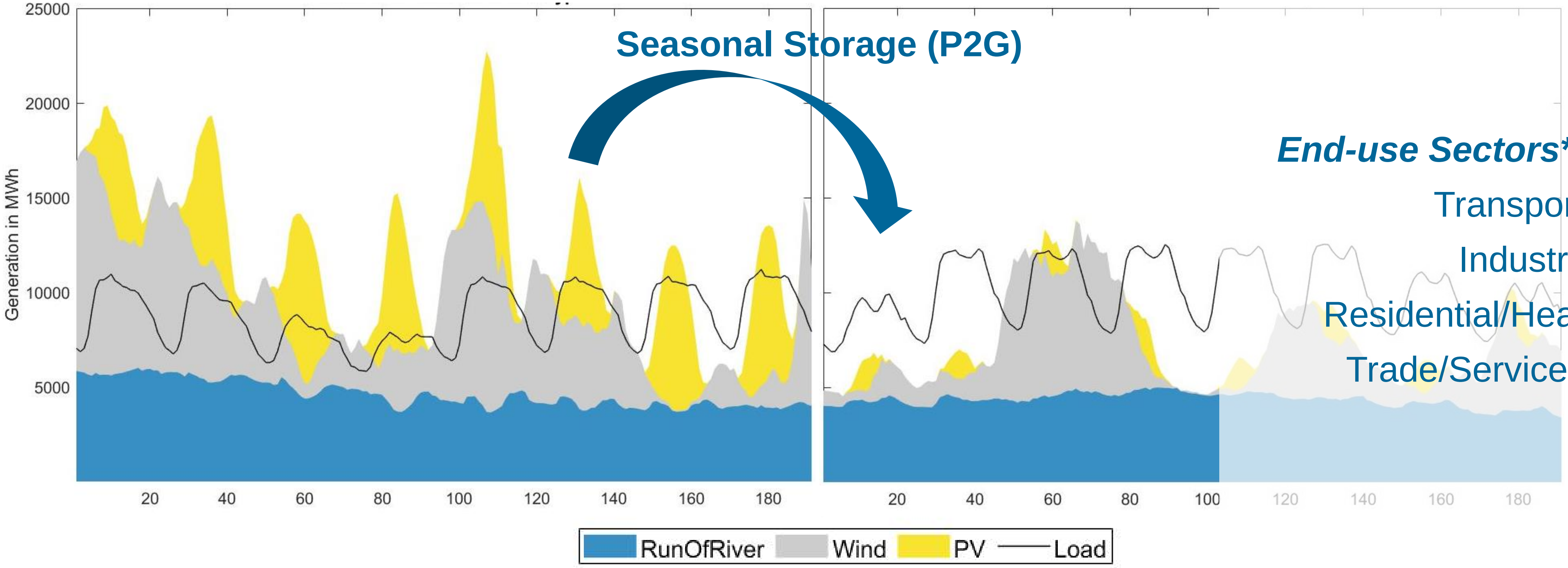
- Background and Objectives
- Potential pathways and enabling technologies

Future Energy Systems will be characterized by Variable Renewable Energy (VRE) Sources

Typical patterns of VRE and the potential for Sector Coupling

Summer 2030 **Winter 2030**

Seasonal Storage (P2G)



End-use Sectors*:

Transport

Industry

Residential/Heat

Trade/Services

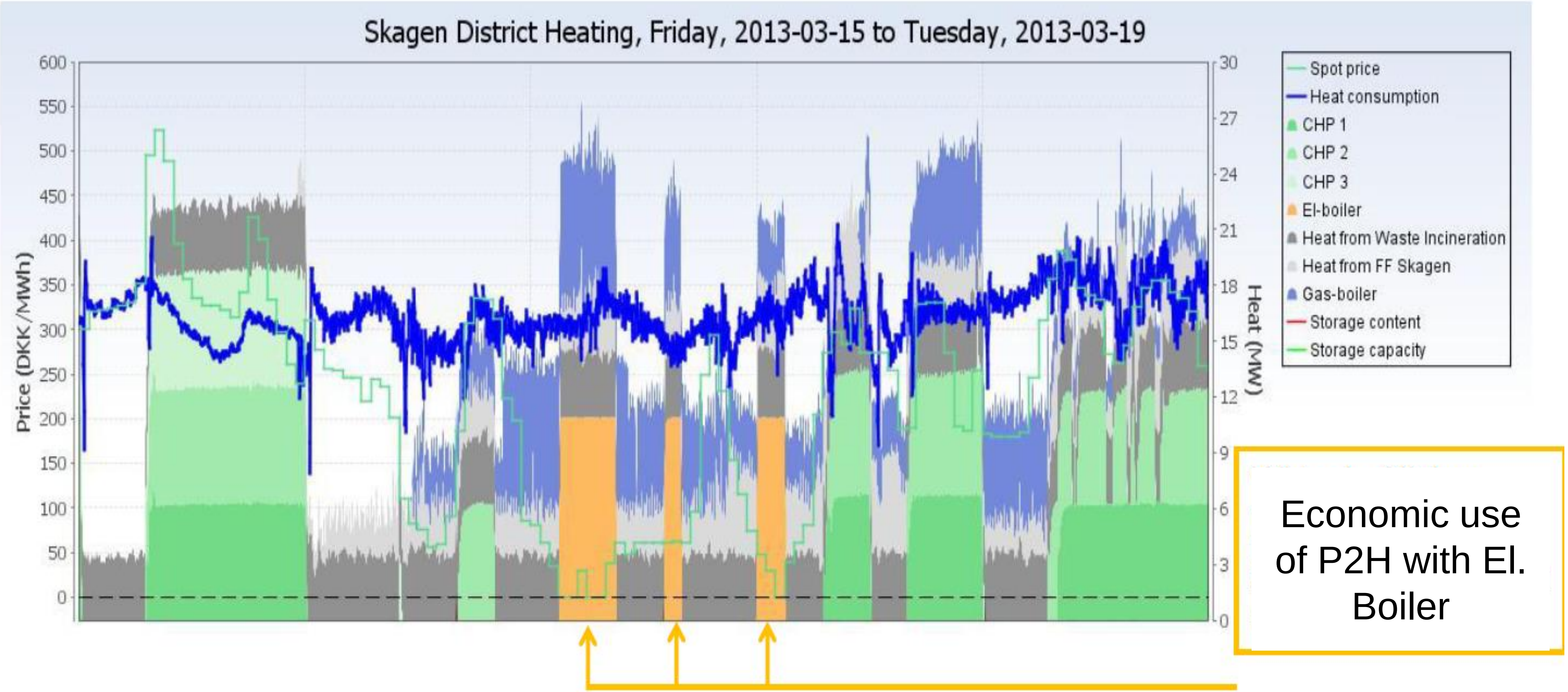
This situation basically initiated the concept of **Sector Coupling**

Stromzukunft Österreich 2030, TU Wien (2017)

**Robinius et al.(2017), BDEW(2017), Ausfelder et al.(2018), Dena(2017)*

Danish District Heating: Economic Power2Heat operation

P2H is economic in times of excess power generation



„As often as “Sector Coupling“ (SC) is used in energy policy debates, as unclear and diverse it is in meaning“

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Selected References

Scorza et al. (2018):

*“…SC is the **use of electricity** as a source of energy **in consumption sectors** ... **in which it still plays little or no role**... This interpretation becomes even more limited ... if **only the surplus electricity** is included ..."*

Van Nuffel et al. (2018)

*“**End-use SC** involves the **electrification of energy demand** while reinforcing the interaction between electricity supply and end-use. **Cross-vector coupling** involves the **integrated use of different energy** infrastructures and **vectors**, in particular **electricity, heat and gas**,…“*

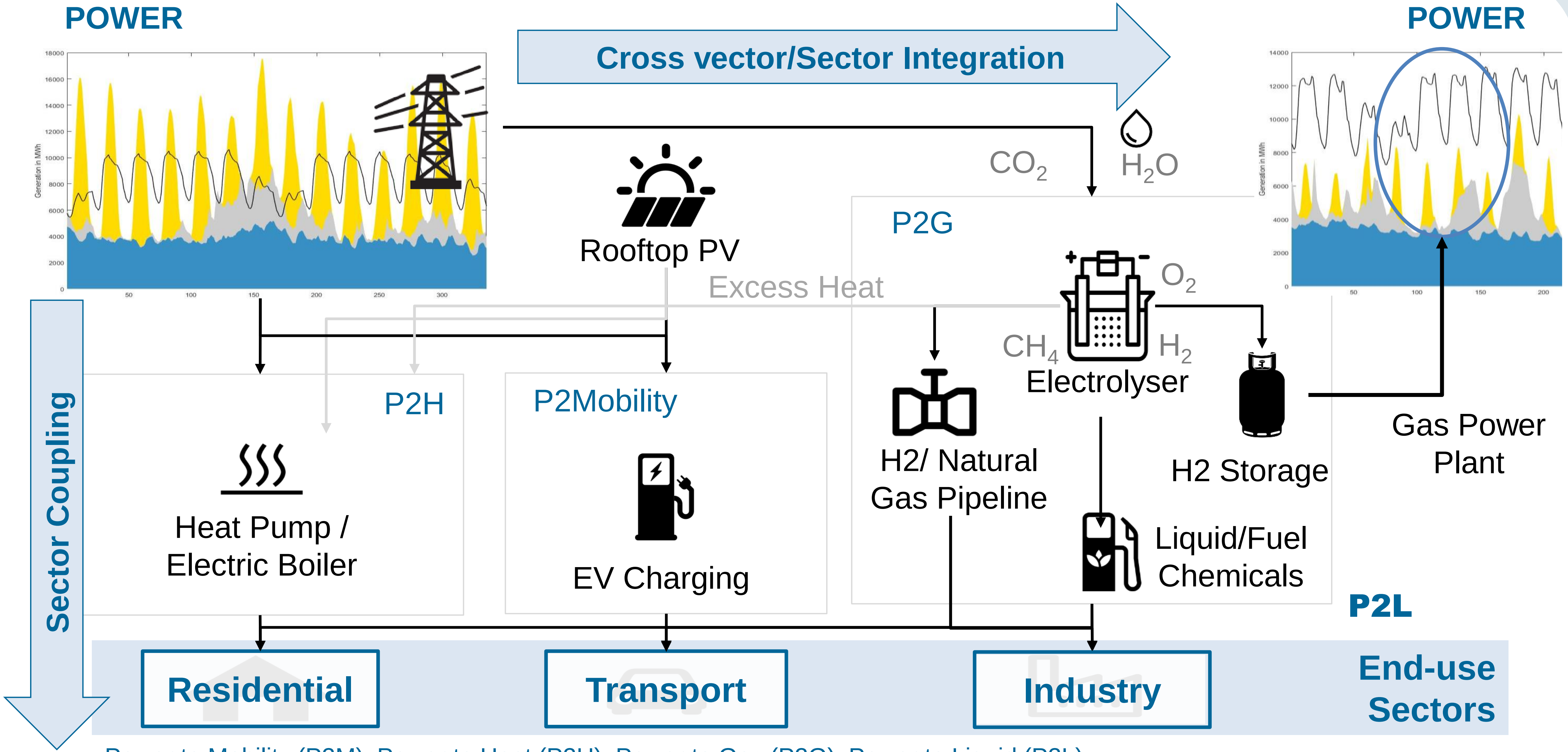
Wietschel (2018)

*“SC refers to the ongoing process of **substituting fossil fuels with electricity**, predominantly **from renewable sources** or with other renewable energy sources and sustainable forms of energy use, such as the **use of excess heat**, in new or known cross-sector applications”*

narrow

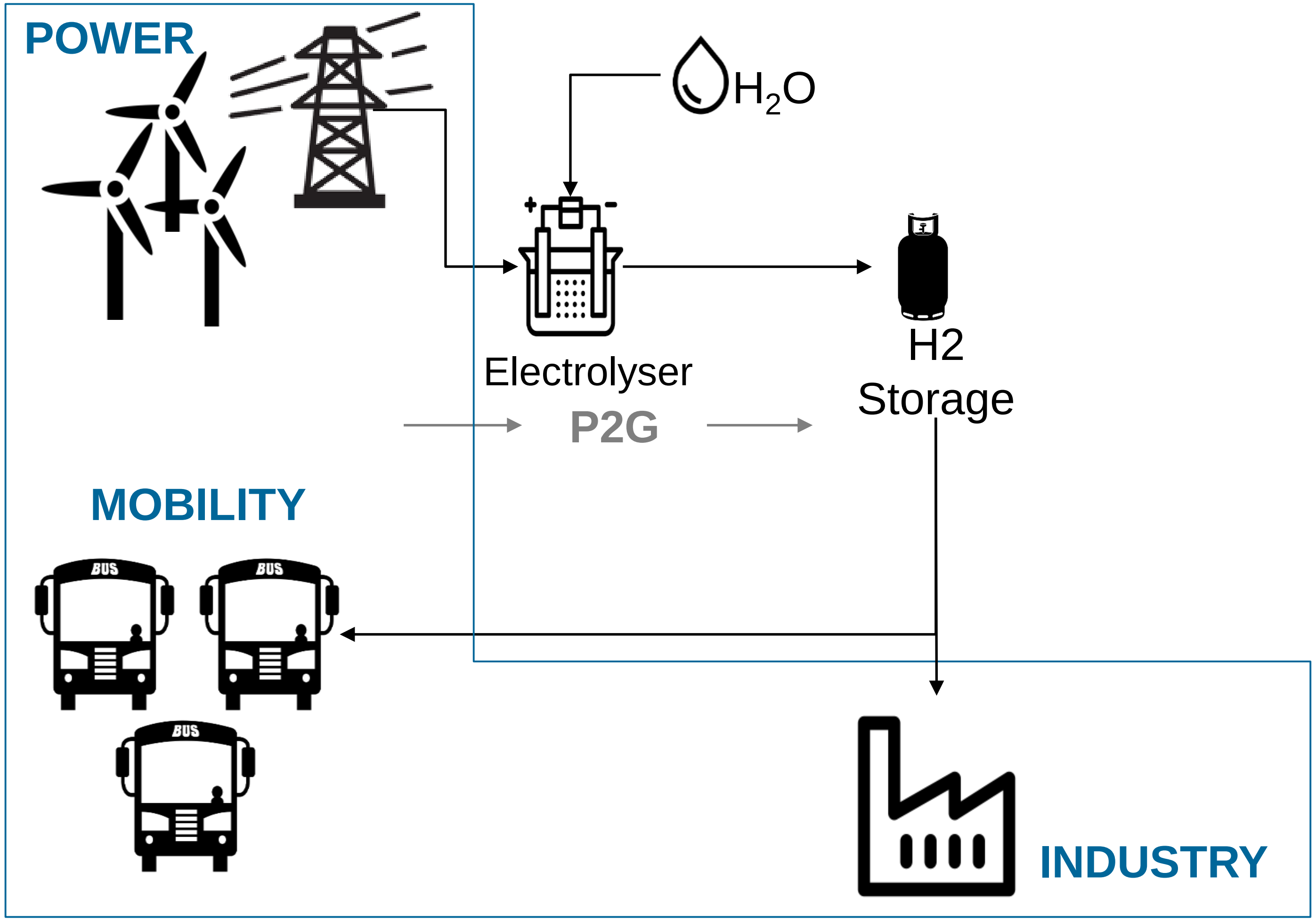
broad

Sector Coupling to achieve Renewable Energy Systems



Power to Mobility (P2M), Power to Heat (P2H), Power to Gas (P2G), Power to Liquid (P2L)

P2M for Hydrogen (H2) Buses - Pilot Project Austria



Goals:

- 15 public H2 buses
- Use high wind potential
- Reach climate goals
- Become H2 first mover

ÖBB Test Bus by ÖBB/Knopp

P2G to secure supply in a 100% renewable power scenario in 2030

An example of Sector Integration through P2G

- Case Study for Austria
- Transforming surplus power to H2 for seasonal storage

Achieving 100% renewable power with H2 storage

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Main climate goals for the Austrian power market

1	The main aim is to establish a **100% renewable power balance** in **Austria** until **2030**
2	P2G currently represents the most promising flexibility technology for **seasonal storage of surplus electricity**
3	Are the expected **full load hours until 2030** sufficient for economic operation?

Full load hours are the key to economic feasibility

The economics of a P2G Investment

Challenges are the achievement of reasonable **full load hours** $\boldsymbol{T}$ and the respective average **electricity price** $\boldsymbol{C_E}$**.**

$$LCOE = \frac{\frac{I \cdot \alpha + C_{BW}}{T} + C_E}{\eta_{P2G}} \text{ €/kWh}$$

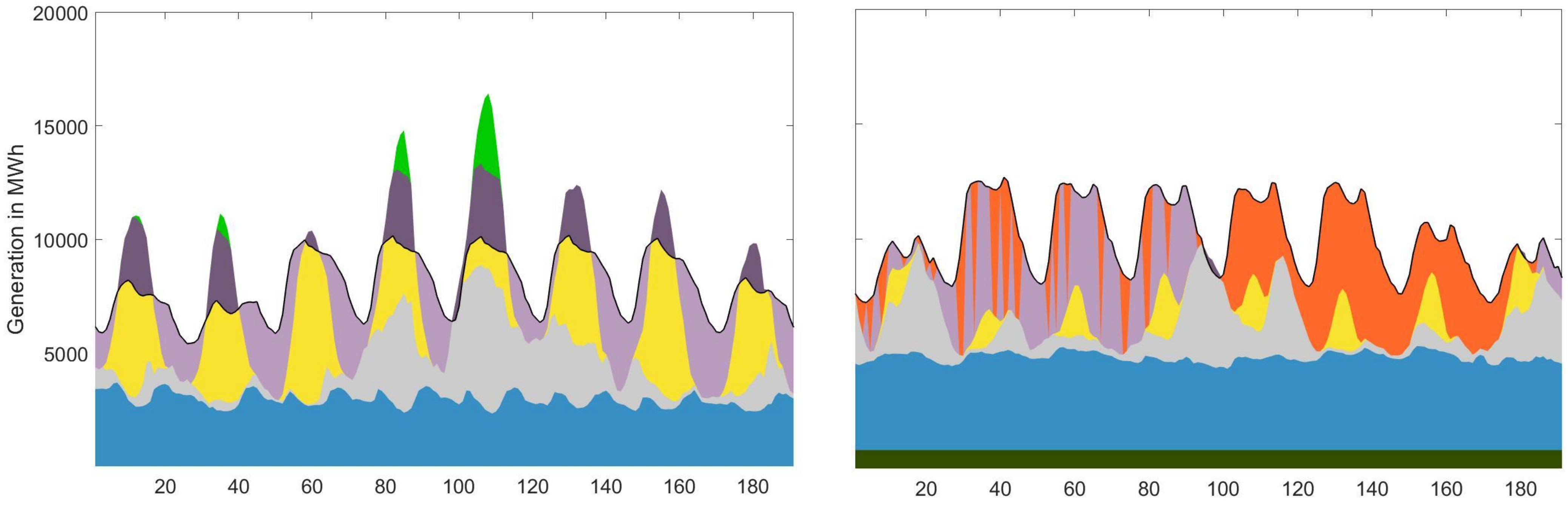
C_E	Average electricity cost (€ /kWh)
C_{BW}	Operation and maintenance cost (€ /kWh)
I	Investment cost depending on T (€/kW)
α	Annuity factor
T	Full load hours (h/year)
η_{P2G}	Efficiency of P2G plant

Up to 8.8 TWh of scarcity in winter require seasonal flexibility

Capacities 2030*: Wind 7GW, PV 12GW, Run of River 6.7GW

Summer | Winter

1.1 - 2.2 TWh/a Excess power **≤** **5.6 - 13 TWh/a Scarcity**



*TU Wien (2017)

Sufficient hydrogen generation to cover winter scarcity requires additional wind capacity!

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Model Expansion

- P2G Plant 2 GW [η=0.65]
- H2 Capacity 7,000 [GWh]
- Gas Power Plant 4.5 GW [η=0.55]

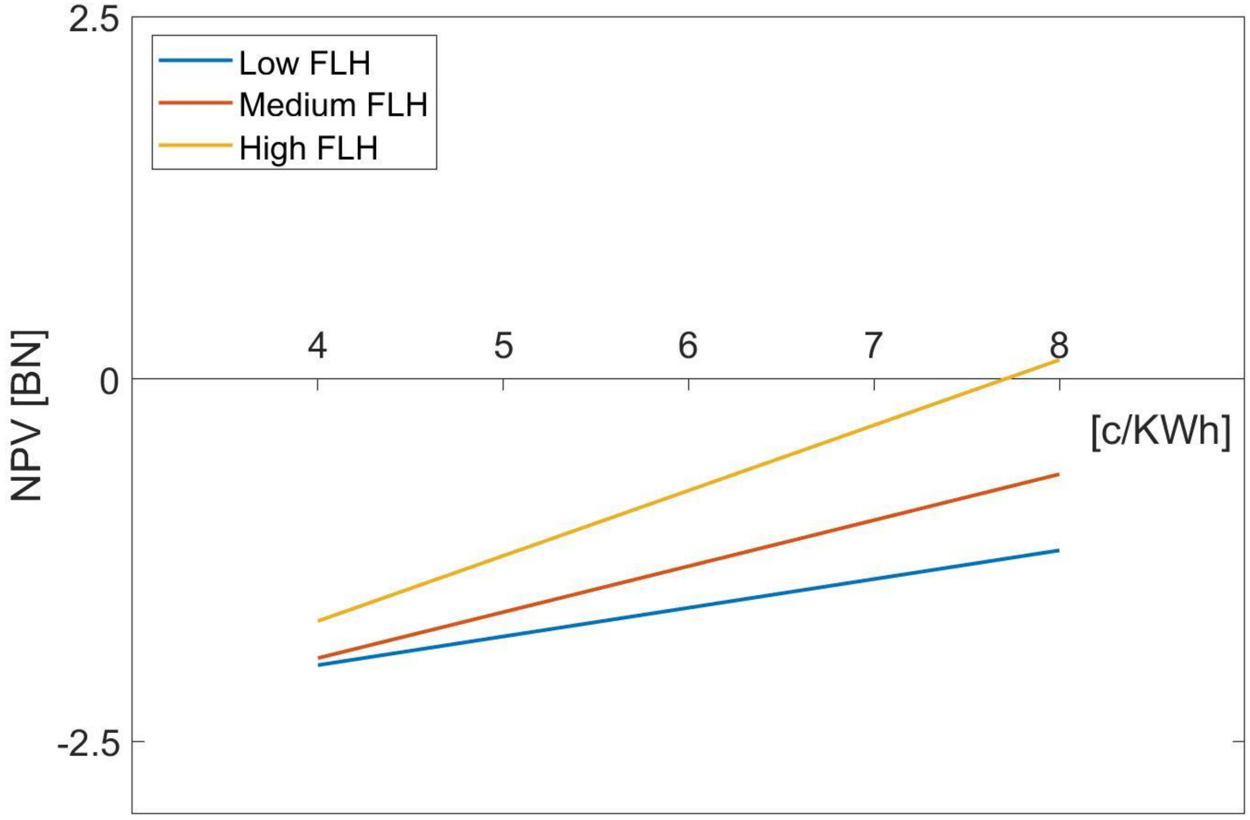
- Calculated for 4 years
- **Additional Wind Capacity! 6.5GW**

Results

	FLH [h]		[TWh/a]
P2G Plant	1630 – 2882	PowerIn	3.2 – 5.7
Gas Power Plant	312 – 710	PowerOut	1.4 – 3.2
		Excess Power	0.9 – 1.2

Even in the long term a positive business case for P2G remains challenging

NPV* depending on estimated green gas market value and varying full load hours



Electricity Price	[c/KWh]	2
Market Value Gas	[c/KWh]	4-8
Investment cost*	[€/KW]	600
Depreciation	[y]	25
i	[%]	5

*

*Net Present Value (NPV), Power to Gas (P2G)
Full Load Hours (FLH)

* *Agora (2018)

Conclusions and further research

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1	Sector Coupling still requires clearer, more standardized understanding and borders
2	Sector Coupling represents one tool in energy systems to efficiently integrate VRE* power
3	The P2G** study requires much more VRE capacities installed than expected until 2030
4	Further research: Detailed analysis of expected market values and electricity prices Specific timeline for feasibility of P2G project

*Variable Renewable Energy (VRE)
**Power to Gas (P2G)

**EP (2018), Buttler et al. (2018)*

References

Ausfelder, F., Drake, F., Erlach, B., Fischedick, M., Kost, C., Münch, W., . . . Wagner, U. (2017). *Sektorkopplung – Untersuchungen und Überlegungen zur Entwicklung eines integrierten Energiesystems (Energiesysteme der Zukunft).* Deutsche Akademie der Technikwissenschaften.

Agora Energiewende. (2018). *Die zukünftigen Kosten strombasierter synthetischer Brennstoffe*

BDEW. (2017). 10 Thesen zur Sektorkopplung. Berlin.

Buttler, A., & Spliethoff, H. (2018). Current status of water electrolysis for energy storage, grid balancing and sector coupling via power-to-gas and power-to-liquids: A review. *Renewable and Sustainable Energy Reviews*(82), pp. 2440-2454.

DEA. (2017). *Regulation and planning of district heating in Denmark.*

Dena. (2017). *Leitstudie Integrierte Energiewende: Impulse und Erkenntnisse aus dem Studienprozess – Zwischenfazit.* Berlin.

MVV Energie. (2013). *Hybridnetze und ihre Relevanz für einen Energieversorger*. Presented at netconomica 2013.

Robinius, M., Otto, A., Heuser, P., Welder, L., Syranidis, K., Ryberg, D. S., . . . Stolten, D. (2017). Linking the Power and Transport Sectors - Part 1: The Principle of Sector Coupling. *Energies, 10*(7), 956ff.

TU Wien, EEG. (2017). *Stromzukunft Österreich 2030 - Analyse der Erfordernisse und Konsequenzen eines ambitionierten Ausbaus erneuerbarer Energien.* Endbericht der gleichnamigen Studie, Wien.

Van Nuffel, L., Gorenstein Dedecca, J., Smit, T., & Rademaekers, K. (2018). Sector coupling: how can it be enhanced in the EU to foster grid stability and decarbonise? *Energy, Climate, Environment - ICYMI*. Retrieved August 22, 2019, from http://www.europarl.europa.eu/RegData/etudes/STUD/2018/626091/IPOL_STU(2018)626091_EN.pdf