# Sector Coupling – Implications for Power Market Design

## IEA, IX Electricity Security Advisory Panel Workshop, Paris

17 June 2019

Confidential

# Outline - Full decarbonisation leads to “Sector Coupling” and requires regulatory and market design reform in the gas and power sectors

**1 Climate policy targets imply full carbon neutrality of the economy**

- **Paris Climate Accord** and **EU Climate Policy target** require almost full decarbonisation of the economy (not just the power sector!) - 80-95% reduction of CO2 emissions (compared to 1990) until 2050 and ultimately **full carbon neutrality**

**2 This drastically limits the sources of primary energy supply**

- **Renewable electricity (mainly wind and solar)**
- Nuclear – but politically ruled out in many countries
- Hydrogen (from natural gas with CCS/U or from renewable electricity)
- Biofuels/biogas

EU: A significant share of primary energy will still have to be imported
(EU import dependency 50-66% (gross / net)

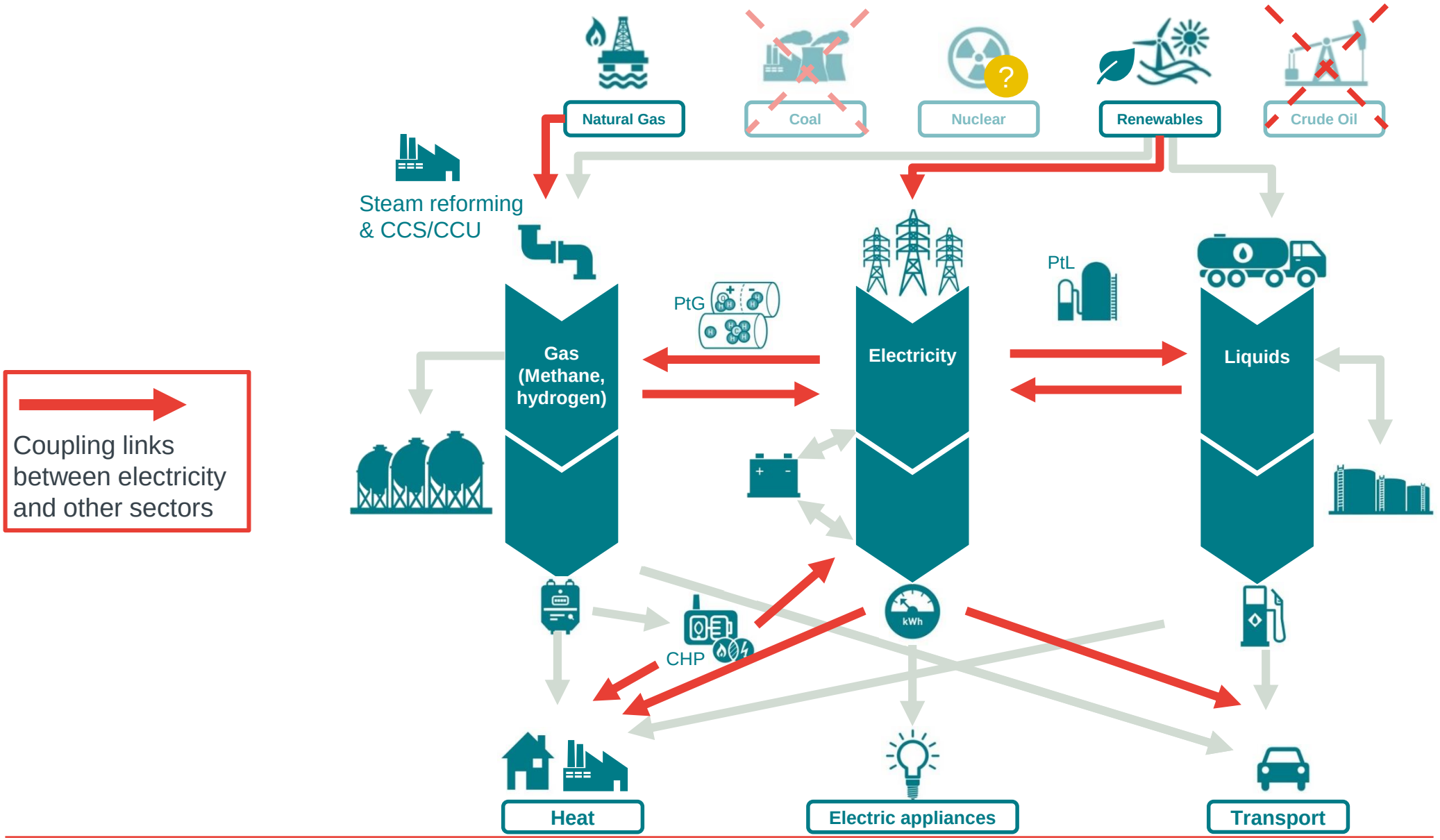
**3 Sector coupling – transition requires use of electricity in production of gas and liquid fuels**

- This will lead to **increased electrification**, but full electrification is neither technically feasible nor efficient
- Chemical forms of energy (**gas, liquids), in part produced from renewable and nuclear power**, required to deal with bulk energy storage and long distance transportation

**4 Regulations and market design need to be aligned across power and gas sectors**

- This requires an increased (and **two way) integration between electricity and gas/fuel markets**
- To be efficient this requires regulatory alignment between the sectors –implies **reforms in the gas and power sectors**

# Carbon neutrality leads to increasing interaction between electricity and gas, as well as between different types of gases



See Annex for enlarged versions of graphs

# Several benefits of combining power and gas infrastructure

Both domestic as well as for import!

## Transportation

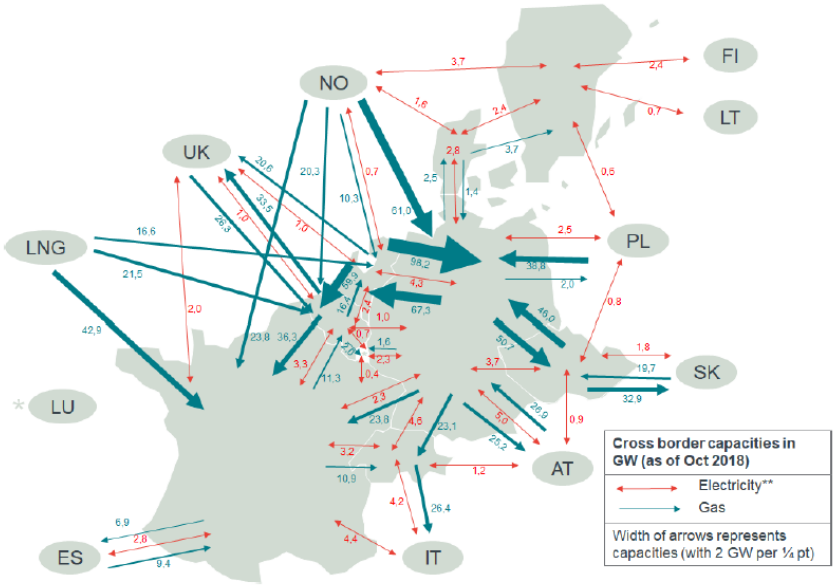
## Storage

Use of existing infrastructure

Cost of infrastructure

Acceptance in the population

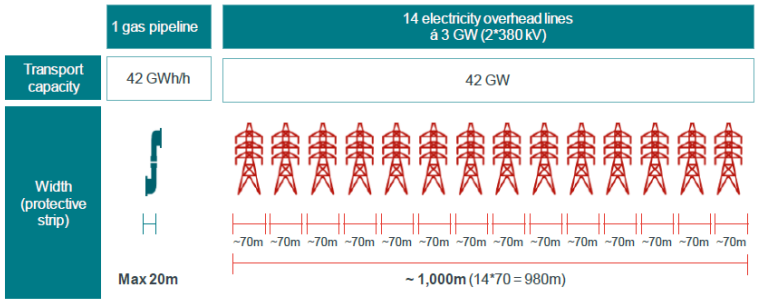
Figure 1 Cross-border transport capacities for gas exceed those of electricity by large




Source: Frontier Economics based on ENTSO-E and ENTSOG

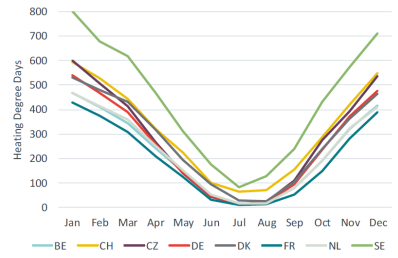
Note: ** In some cases published capacities vary slightly between flow directions. In such cases, the higher figures are shown above.

Figure 5 Space requirement of gas vs. electricity transmission



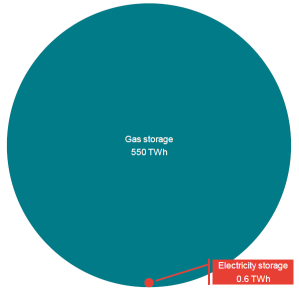

Source: Frontier Economics

Figure 12 Seasonality of heat demand in the countries analysed



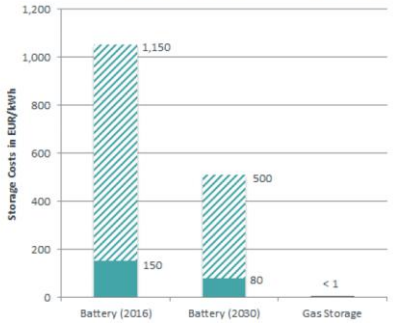

Source: Frontier Economics based on Eurostat, Cooling and heating degree days by country - monthly data [mg_chdd_m], retrieved in April 2018

Figure 16 Gas storage volume is almost 1000 times as large as electricity storage volume in analysed countries




Source: Frontier Economics based on Gas Infrastructure Europe and Geth et al. (2015)

Figure 22 Comparison of battery and gas storage costs in EUR/kWh




Source: Frontier Economics based on IRENA (2017a) and Le Fevre, C. (2013)

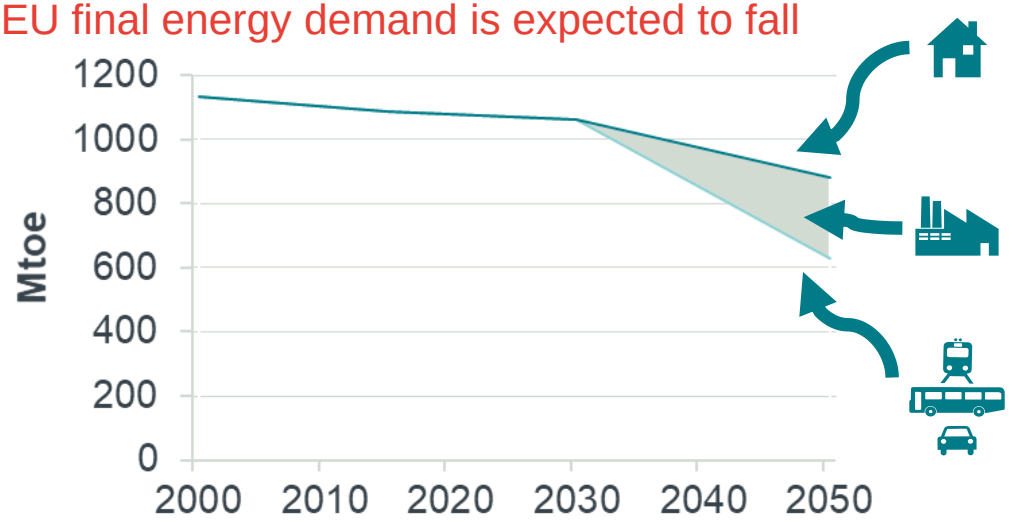
- Storage of gas and liquids typically underground.
- Therefore no competition for alternative space use.



*Source: Frontier Economics/IAEW (2019): The value of gas infrastructure in a carbon-neutral Europe, study commissioned by Green Gas Initiative (https://www.frontier-economics.com/media/3120/value-of-gas-infrastructure-report.pdf)*

# Despite the uncertainties, scenario studies consistently find a long-term role for gases and in part produced from renewable electricity

## EU final energy demand is expected to fall

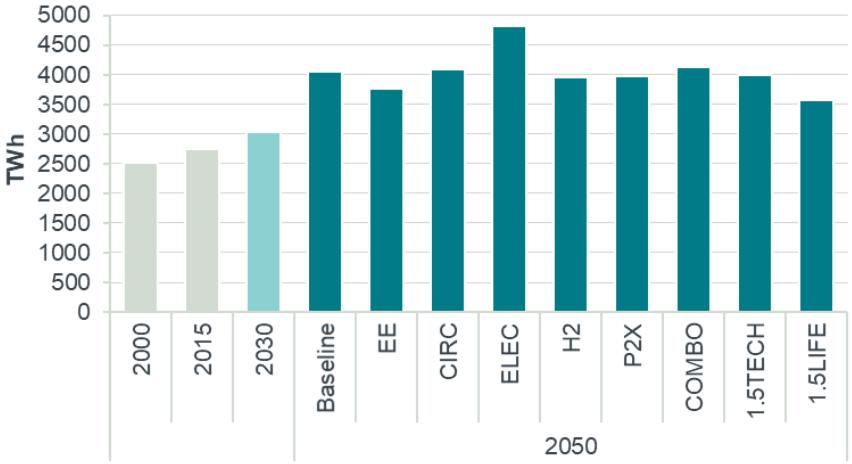



*Source: Frontier Economics and CE Delft, based on EC (2018)*

## With renewable electricity accounting for a high share of the mix by 2050

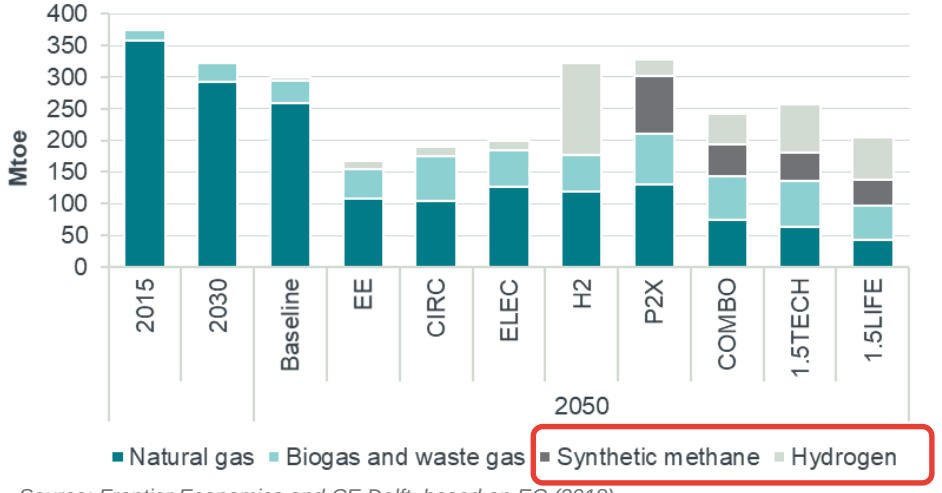

*Source: Frontier Economics, based on sources indicated.*

## While electricity demand is expected to increase




*Source: Frontier Economics, based on EC (2018)*

## Gases help with transport / (seasonal) storage needs

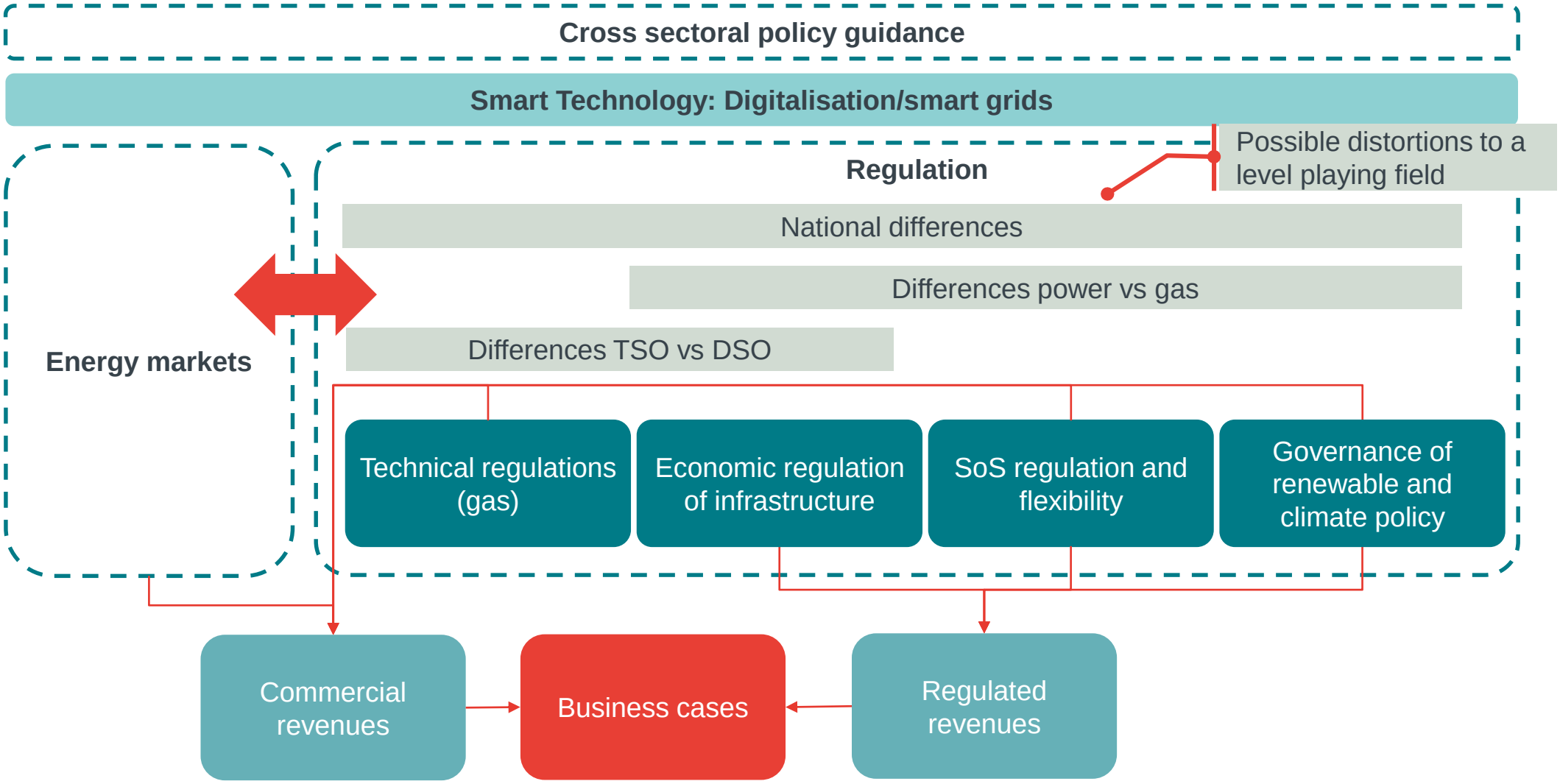



*Source: Frontier Economics and CE Delft, based on EC (2018)*



*Source: Frontier Economics/CE Delft (2019): Potentials of sector coupling for decarbonisation - Assessing regulatory barriers in linking the gas and electricity sectors in the EU, presented at EU Regulatory Forum Madrid, 6 June 2019 (https://ec.europa.eu/info/sites/info/files/frontier_-_potentials_of_sector_coupling_for_decarbonisation.pdf)*

# Market design and regulation therefore need to be consistent and technology neutral in a range of areas

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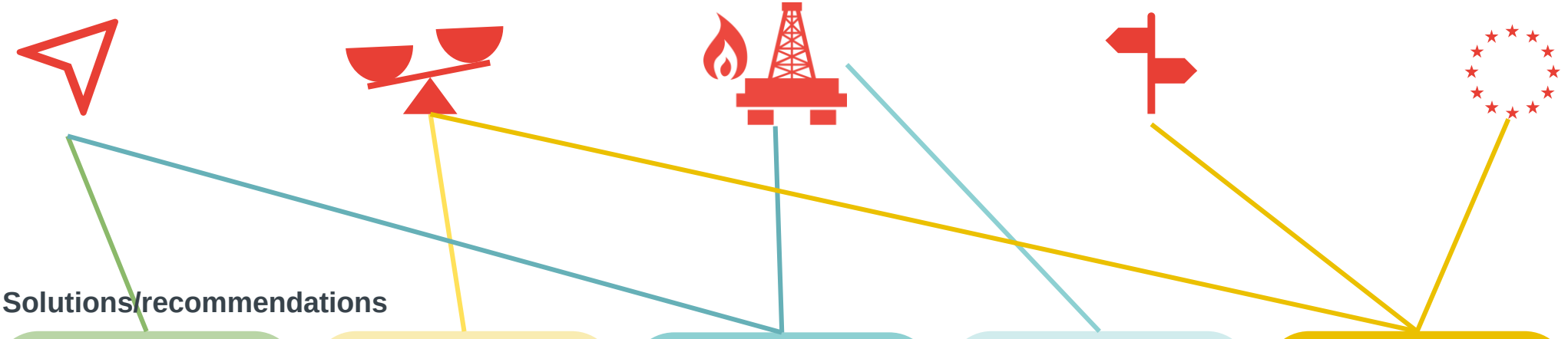
# A range of solutions will be required to address the barriers and gaps for improved sector coupling

**Barriers**

1. Relative immaturity of relevant technologies
2. Unlevel playing field due to sector- and technology-specific tariffs and levies
3. Focus on natural gas in (gas) infrastructure regulation
4. Uncoupled and uncoordinated infrastructure planning
5. Risk for interoperability across markets and borders



**Solutions/recommendations**

- Climate / renewable policy and support for innovation
- Regulatory toolbox to address cost recovery issues
- Fit for purpose market design and charging arrangements
- Clarity on access to infrastructure
- Co-ordinated infrastructure planning and decommissioning

Regulatory clarification – role of grid operators in PtG for R&D/pilots

Clarify who is best placed to bear the cost of stranded assets (and other legacy costs, e.g. for RES support)

Clarify under what conditions Regulations on TPA / unbundling apply to hydrogen (and other gases)

*Source: Frontier Economics/CE Delft (2019): Potentials of sector coupling for decarbonisation - Assessing regulatory barriers in linking the gas and electricity sectors in the EU, presented at EU Regulatory Forum Madrid, 6 June 2019 (https://ec.europa.eu/info/sites/info/files/frontier_-_potentials_of_sector_coupling_for_decarbonisation.pdf)*

# This raises multiple questions in relation to regulatory and market design in the power sector

**Cross sectoral policy guidance**

## Energy market design

- **Power-to-Gas** conversion as a **system service** (bookable or socialised)?
- **Balancing arrangements** to encompass power and gas?
- Harmonisation of **settlement periods** between electricity and gas (if electricity becomes more easily storable)?

## Economic regulation of infrastructure

- Harmonise **network tariff structures** and **locational incentives** across power and gas
- Clarify **TPA and unbundling** arrangements in relation to power-to-gas (and similar conversion) facilities
- Decide on **stranded cost and dismantling cost recovery** of underused infrastructure

## SoS regulation and flexibility

- Harmonise **capacity incentives** across power and gas
- Integrate **infrastructure planning** across power and gas and T&D
- Develop capacity **adequacy assessments** to combine power and gas
- Consider interaction of **ancillary services** between power and gas

## Governance of renewable and climate policy

- Synchronise **climate policy instruments** across power, gas and liquids (e.g. EU ETS as anchor for all sectors)
- Use of **guarantees of origin**, compatible across power, gas, liquids
- **Life cycle analysis** of carbon impact of different fuel chains
- Hamonise **taxes and levies** across sectors

# Thank you for your attention!

**Dr Christoph Riechmann**

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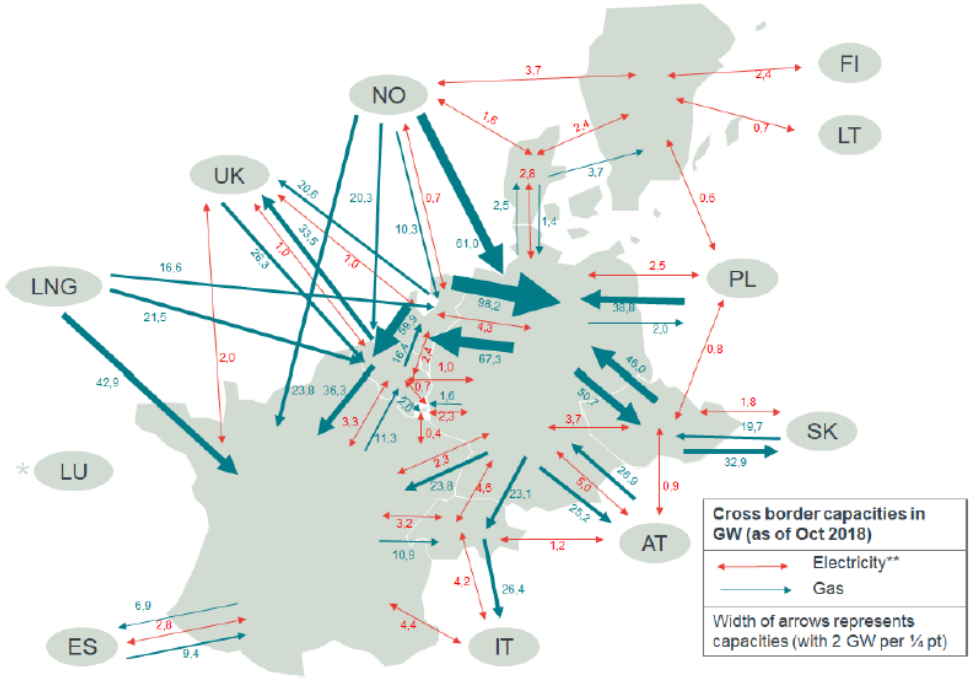
# Annex – Further documentation and data sources

- On the the **value of gas infrastructure** (in 8 European countries; study for the Green gas Initiative, GGI): https://www.frontier-economics.com/media/3120/value-of-gas-infrastructure-report.pdf
- On the **cost of synthetic fuels** (study providing a projection of cost for Europe, The Gulf region and Iceland; for Agora Verkehrswende):
  - The report - https://www.agora-energiewende.de/fileadmin2/Projekte/2017/SynKost_2050/Agora_SynKost_Study_EN_WEB.pdf
  - The calculator - https://www.agora-energiewende.de/en/publications/ptgptl-calculator/
  - Background data - https://www.agora-energiewende.de/veroeffentlichungen/datenanhang-zur-studie-die-zukuenftigen-kosten-strombasierter-synthetischer-brennstoffe/
- On an international **Roadmap for Power to X** (PtX Roadmap, study for World energy council, German Chapter) –
  - Report - https://www.weltenergierat.de/wp-content/uploads/2018/10/20181018_WEC_Germany_PTXroadmap_Full-study-englisch.pdf
  - Data Annex - https://www.frontier-economics.com/media/2644/20181018_frontier_wec_germany_ptxroadmap_annex-document.pdf

*Note: hyperlinks as available at the time of presentation, 17 June 2019*

# Annex – existing infrastructure (7 countries, enlarged)

**Figure 1 Cross-border transport capacities for gas exceed those of electricity by large**




*Source: Frontier Economics based on ENTSO-E and ENTSOG*

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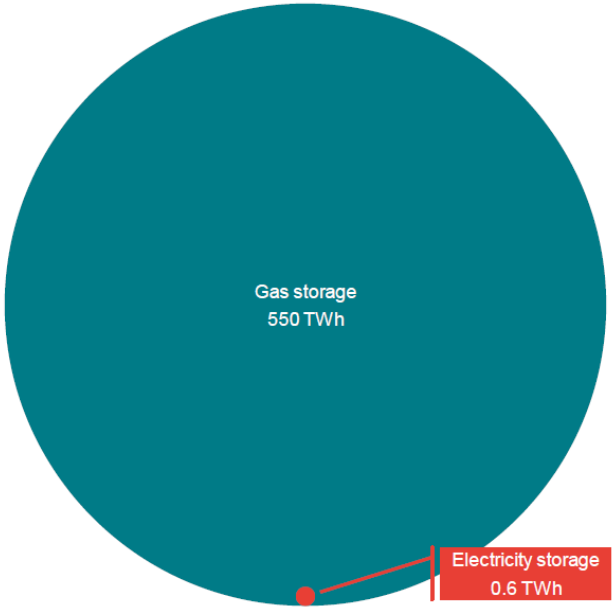
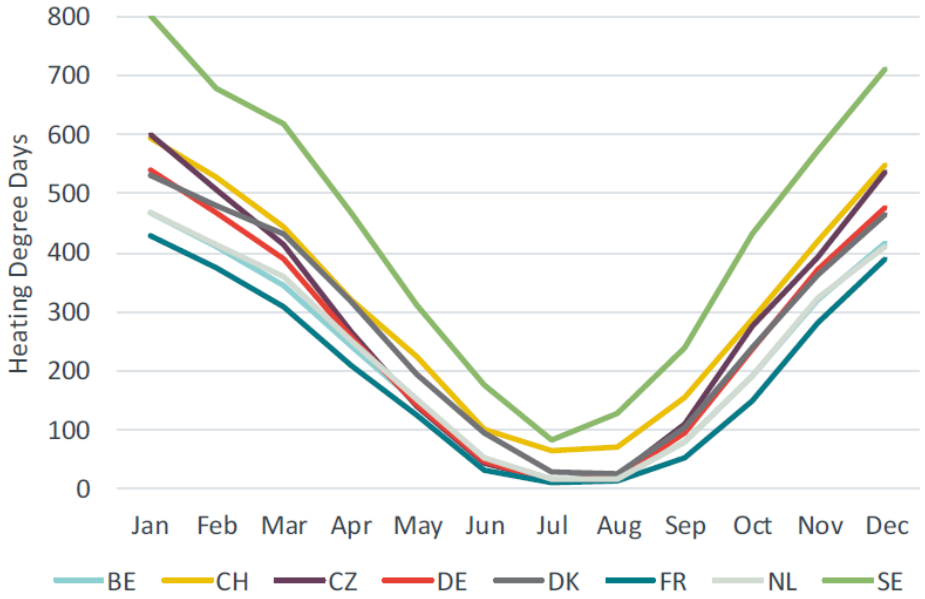



*Source: Frontier Economics based on Gas Infrastructure Europe and Geth et al. (2015).*

*Source: Frontier Economics/IAEW (2019): The value of gas infrastructure in a carbon-neutral Europe, study commissioned by Green Gas Initiative (https://www.frontier-economics.com/media/3120/value-of-gas-infrastructure-report.pdf)*

# Annex – Profile and cost of seasonal energy storage (enlarged)

**Figure 12 Seasonality of heat demand in the countries analysed**




*Source: Frontier Economics based on Eurostat, Cooling and heating degree days by country - monthly data [nrg_chdd_m], retrieved in April 2018*

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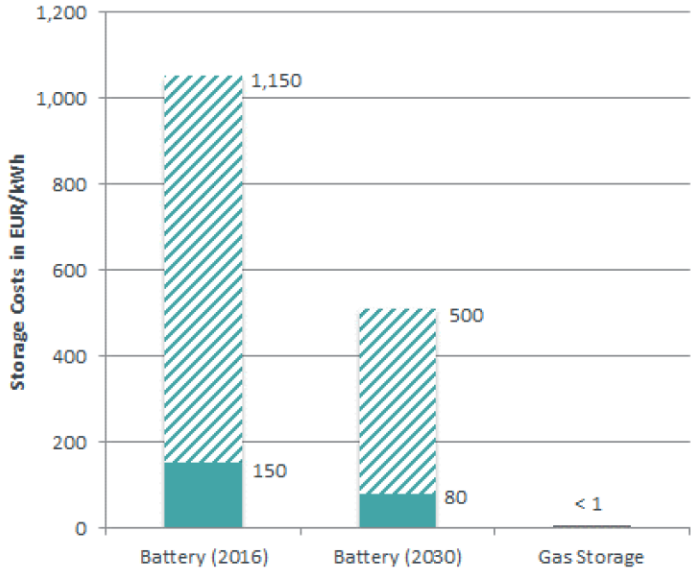
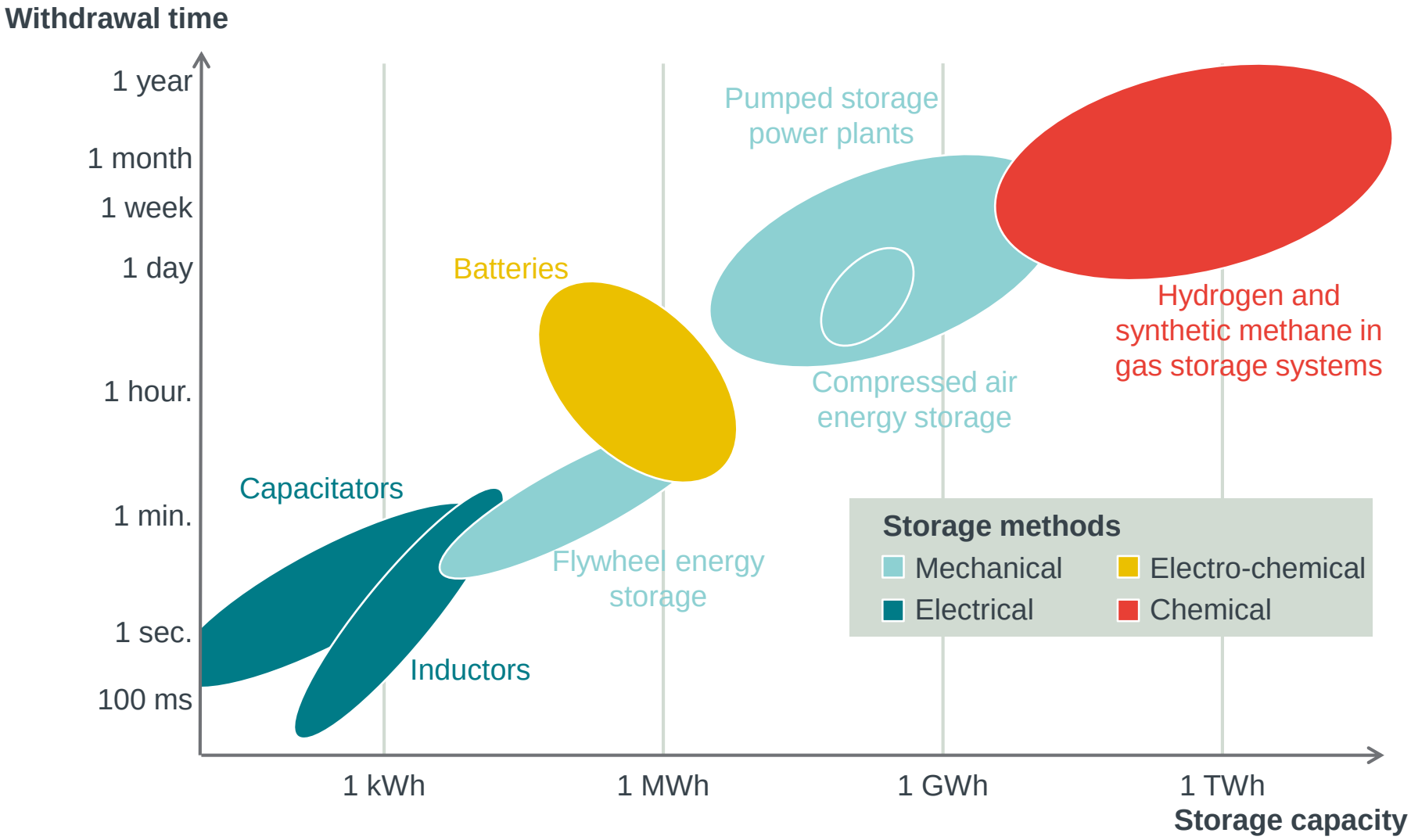



*Source: Frontier Economics based on IRENA (2017a) and Le Fevre, C. (2013)*

*Note: Costs for batteries are illustrated for a range of different lead acid, high-temperature, flow and lithium-ion battery technology types. The minimum costs are based on flooded lead acid batteries in 2016 (~EUR 150/kWh) and 2030 (~ EUR 80/kWh). Gas storage costs are based on investment costs for gas storage in caverns, aquifers and depleted oil and gas fields, which are around EUR 0.1 to 0.3/kWh, see e.g. Stronzik, M., Rammerstorfer, M. and Neumann, A. (2008), Le Fevre, C. (2013).*

*Source: Frontier Economics/IAEW (2019): The value of gas infrastructure in a carbon-neutral Europe, study commissioned by Green Gas Initiative (https://www.frontier-economics.com/media/3120/value-of-gas-infrastructure-report.pdf)*

# Annex - Comparion of key energy storage technologies




*Source: Frontier Economics/IAEW (2019): The value of gas infrastructure in a carbon-neutral Europe, study commissioned by Green Gas Initiative (https://www.frontier-economics.com/media/3120/value-of-gas-infrastructure-report.pdf)*

# Annex – Various studies conclude on the benefits of Power-to-X and E-Fuels in Europe

Selection

| Titel (Year) | Author | Commissioned by | Scope | PtX / E-Fuels advantageous? |
|---|---|---|---|---|
| Klimapfade für Deutschland (2018) | BCG prognos | BDI | DE, all sectors, 3 scenarios: Reference (current path), 80% and 95% climate path | ✓ (PtG, PtL) |
| FVV-Kraftstoffstudie (2018) | FVV | | DE, transport sector, 3 extreme scenarios: 100% electric (BEV), 100% $H_2$ FCEV, 100% E-Fuels | ✓ (PtG, PtL) |
| «E-Fuels» Studie (2017) | dena Deutsche Energie-Agentur; ludwig bölkow systemtechnik | VDA | EU, transport sector, 4 scenarios depending on vehicle drives (PtL, PtG, eDRIVES) | ✓ (PtG, PtL) |
| Status und Perspektiven flüssiger Energieträger (2018) | prognos; Fraunhofer UMSICHT; DBFZ | MWV MINERALÖL WIRTSCHAFTS VERBAND e.V. IWO, MEW, UNITI | DE, all sectors, 3 scenarios: Reference (current trend), PtX 80 and PtX 95 | ✓ (PtG, PtL) |
| Der Wert der Gasinfrastruktur für die Energiewende (2017) | frontier economics; IAEW; FMCEL; 4MANAGEMENT | FNB Gas DIE FERNLEITUNGSNETZBETREIBER | DE, all sectors, Electricity & Gas Storage‘ vs. ‚Electricity & Green Gas‘ scenario | ✓ (PtL, H2, $CH_4$) |
| dena-Leitstudie Integrierte Energiewende (2018) | dena Deutsche Energie-Agentur | | DE, all sectors, 5 scenarios: reference, electrification 80 and 95, technology mix 80 and 95 | ✓ (PtG, PtL) |
| Fully decarbonising Europe’s energy system by 2050 (2018) | PÖYRY | | EU, all sectors, All-Electric‘ pathway vs. ‚“Zero Carbon Gas‘ pathway | ✓ (hydrogen) |
| **The Value of Gas Infrastructure in a Climate Neutral Europe (2019)** | frontier economics; IAEW | ontras Gastransport GmbH; gaz nat; GRTgaz; ENERGINET; gasunie; SWEDEGAS; FLUXYS | 8 European countries (DE, FR, NL, DK, SE, BE, CH, CZ), all sectors, Electricity & Gas Storage‘ vs. Electricity & Green Gas‘ scenario | ✓ (PtL, H2, $CH_4$) |

… and in many other studies across Europe:

| Country | Author | Sponsor | (short) Name | Date |
|---|---|---|---|---|
| | netbeheer nederland | | Grids for the future | Oct 2017 |
| | gasunie | | Survey 2050 | March 2018 |
| | WORLD ENERGY COUNCIL | Various | Bringing North Sea Energy Ashore Efficiently | 2018 |
| | Solagro | GRDF | A 100%renewable gas mix in 2050? | Jan 2018 |
| | McKinsey&Company | Air Liquide | Développons l'Hydrogène pour l'économie française | Apr 2018 |
| | ENERGINET | | Benefits of the gas system to society in 2035 (in Danish) | Nov 2015 |
| | Professor Brian Ó Gallachóir | | Blog: The future of renewable energy in Ireland | Sep 2015 |
| | CNG | | Biomethane: A sustainable choice for the economy and the environment | Feb 2017 |
| | KPMG | ena | The UK Gas Networks role in a 2050 whole energy system | Jul 2016 |
| | frontier economics | Cornwall Insight | Impacts and institutional implications of UK gas grid future scenarios | Jun 2016 |
| | Northern Gas Networks | | H21: Leeds City Gate | Apr 2017 |
| | nationalgrid | | The Future of Gas: How gas can support a low carbon future | Mar 2018 |

| Country | Author | Sponsor | (short) Name | Date |
|---|---|---|---|---|
| | Various | dena | Dena lead study Integrated Energy Transition (German) | 2018. |
| | enervis | INES | Renewable Gas – A System Update of Energy Transition (German) | Dec 2017 |
| | ewi | Open Grid Europe et al. | Energy market 2030/2050 – Contribution of gas and heat infrastructure (German) | Nov 2017 |
| | ewi | dena | Building study – Scenarios for Climate Policy in the building sector 2050 (German) | Oct 2017 |
| | nymoen strategieberatung | ontras | PtG potential in ONTRAS grid area (German) | Jun 2017 |
| | enervis | DEA et al. | Climate protection through sector coupling (German) | Mar 2017 |
| | frontier et al. | FNB Gas | Importance of Gas Infrastructure for Germany's energy transition | Oct 2017 |
| | | | Global Energy and Climate Outlook 2017 | 2017 |
| | E3Mlab | eurogas | Role of renewable gas | Jun 2018 |
| | | | Long-term decarbonisation study (TBC) | 2018 (forth-coming) |

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