How to Build a Smart and Flexible Energy System?

Roadmap for Establishing a Global Power-to-X industry

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Power-to-X: Conversion of renewable power into various forms of chemical energy carriers

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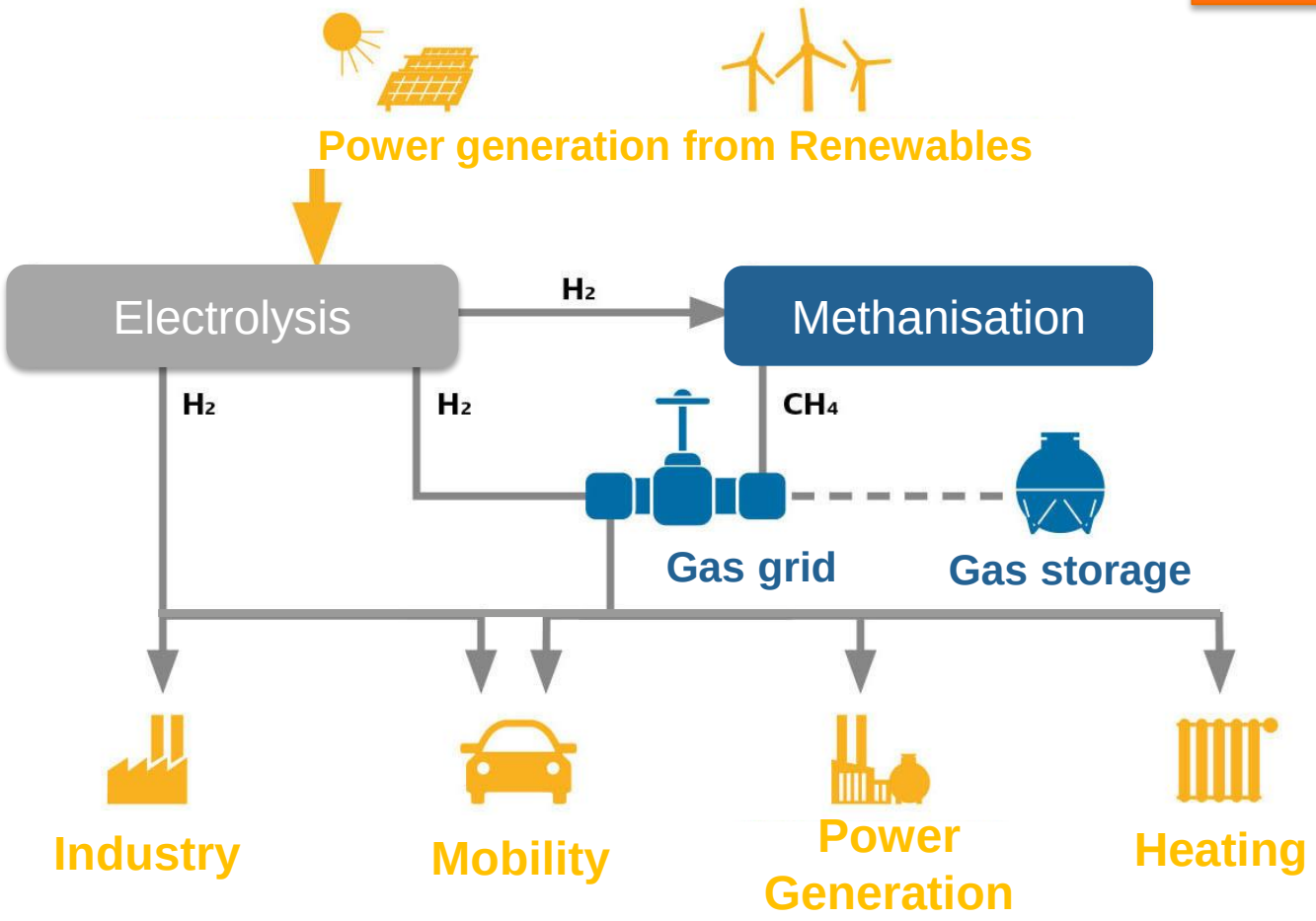
Excursion



Source: www.baunetzwissen.de/ - 2019

Power-to-X …

…are technologies to produce ***green synthetic fuels*** with ***renewable power capacities*** based on gas and liquid reconversion pathways

… therefore allows the ***decoupling of the direct use of power*** from the electricity sector for the use in other sectors

Ambitious Targets for reducing GHG emissions

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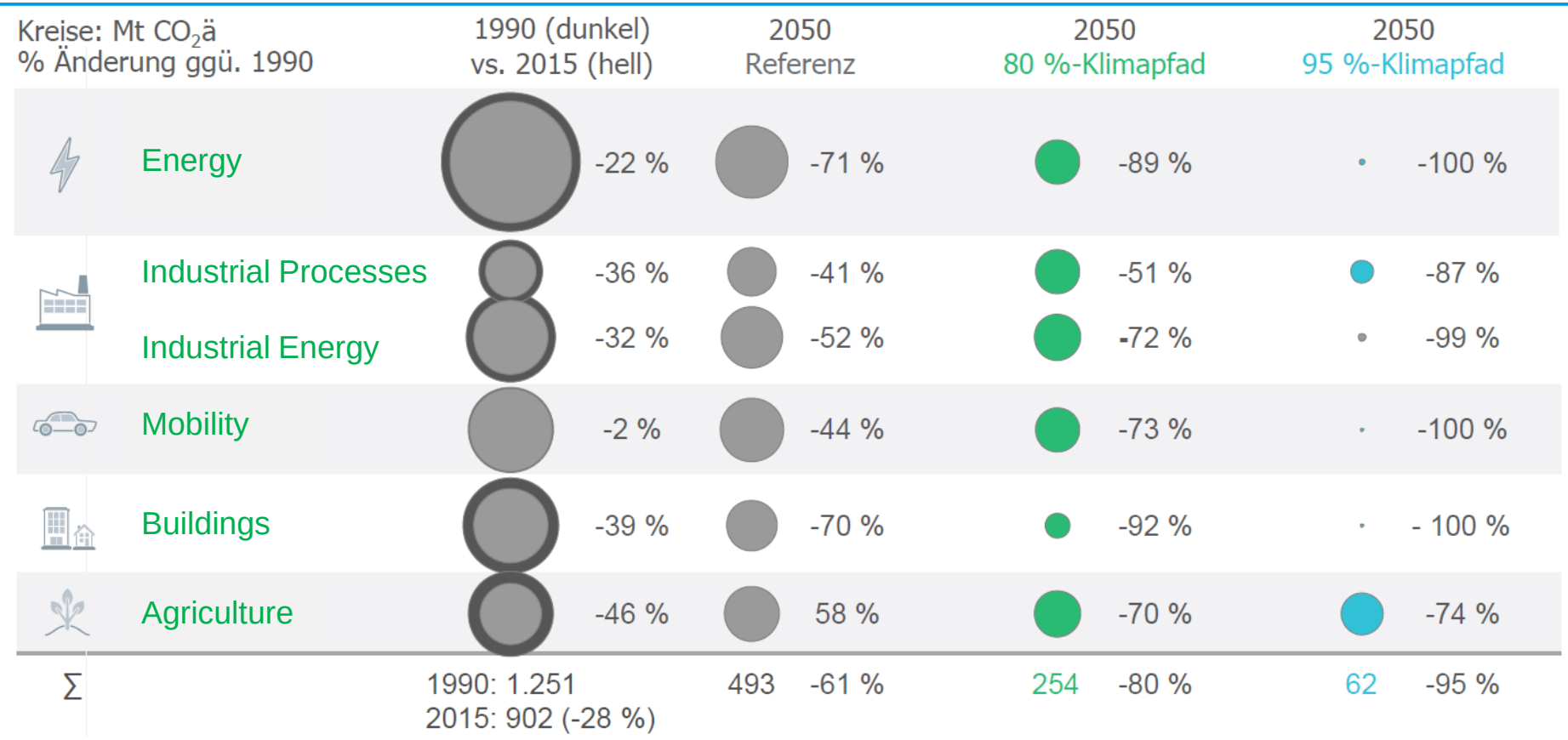
Excursion



Energy Transition – Role of Power-to-X?!

ENERGY EFFICIENCY

Re-adjusted energy efficiency strategy with systemic approach needed.

DIRECT RENEWABLE ENERGIES

Push RES power generation, define clear RES corridors, coordinate w/ grid expansion.

Green Synthetic Fuels

Establish a global market, design frameworks open to a range of technologies.

Source: dena 2019

Focus of this study

- We focus on synthetic fuels and hydrogen produced from renewable electricity (Power-to-X or PtX), analysing…
  - …the potential future role of PtX in the global energy transition
  - …potential PtX exporting countries (case studies)
  - …the main pillars of a potential roadmap towards a future global PtX market

17 Study supporters from different sectors

Member companies / organisations

- DVGW
- E.ON SE
- EnBW Energie Baden- Württemberg AG
- Mitsubishi Hitachi Power Systems Europe GmbH
- Robert Bosch GmbH
- RWE AG
- Siemens AG
- VCI Verband der Chemischen Industrie e. V.
- 50Hertz Transmission GmbH

External partners

- Bundesverband der Deutschen Luftverkehrswirtschaft (BDL)
- Innogy
- IWO Institut für Wärme und Oeltechnik e. V.
- MEW Mittelständische Energiewirtschaft Deutschland e. V.
- Mineralölwirtschaftsverband e. V. (MWV)
- Open Grid Europe GmbH
- UNITI Bundesverband mittelständischer Mineralölunternehmen e. V.
- Volkswagen AG

The roadmap towards a global PtX industry is based on the requirements and opportunities of the global energy transition

1. PtX is a necessary element of the energy transition

2. Imports of green synthetic fuels and the development of a global PtX market support the energy transition

3. A global market for PtX can be huge in size – driving substantial investments

4. There is a large number of PtX producing countries – each with individual motivations

5. Roadmap towards a global PtX market is based on 3 core pillars:
   - Technologies
   - Demand/Markets
   - Supply/Investments

6. Timing and complex interdependencies require a coordinated approach to develop an international PtX market

The roadmap towards a global PtX industry is based on the requirements and opportunities of the global energy transition

1 PtX is a necessary element of the energy transition

PtX will be a key element for the transition of energy systems towards carbon-neutrality

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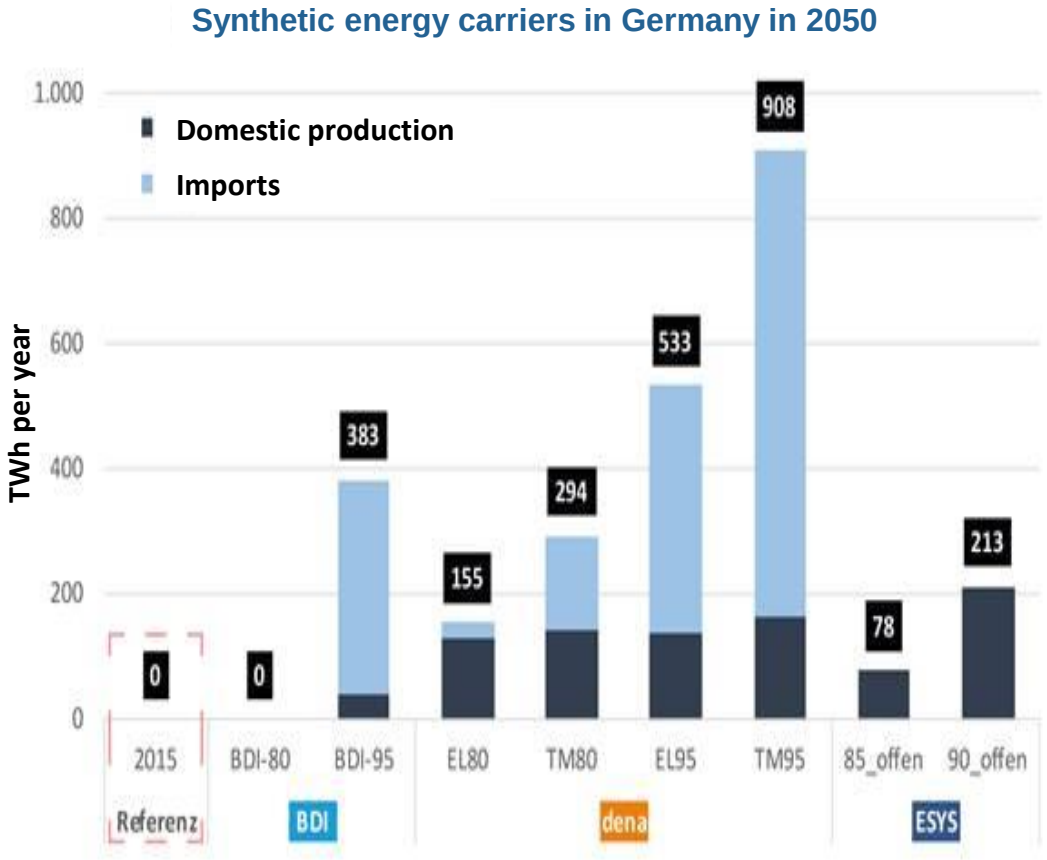
PtX provides essential benefits for the transition towards a carbon-neutral energy system

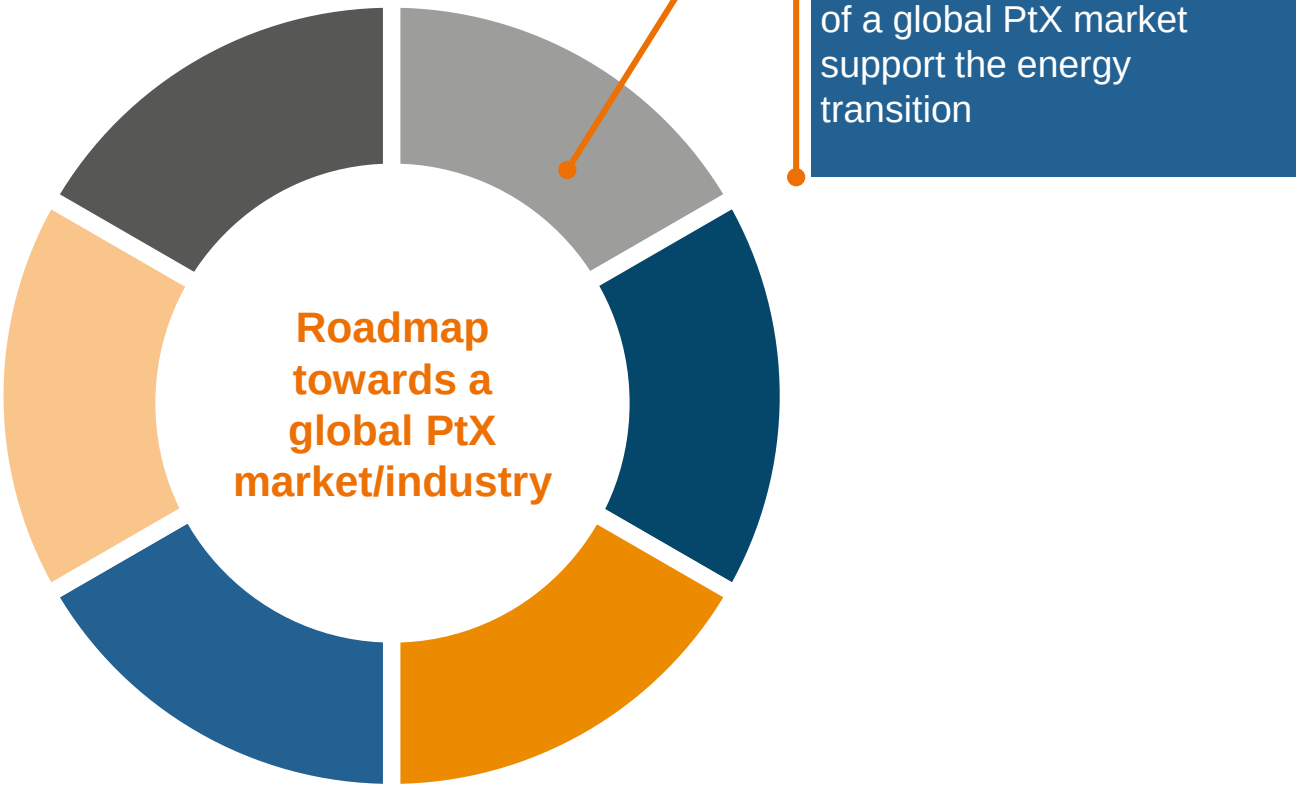
- Some sectors will inevitably require green synthetic fuels for decarbonisation
- An electricity system based solely on renewables will need massive storing of energy – this requires chemical fuels

- Use of existing infrastructure and applications – with positive implications on
  - System costs
  - Acceptance
  - Acceleration of the speed of the energy transformation



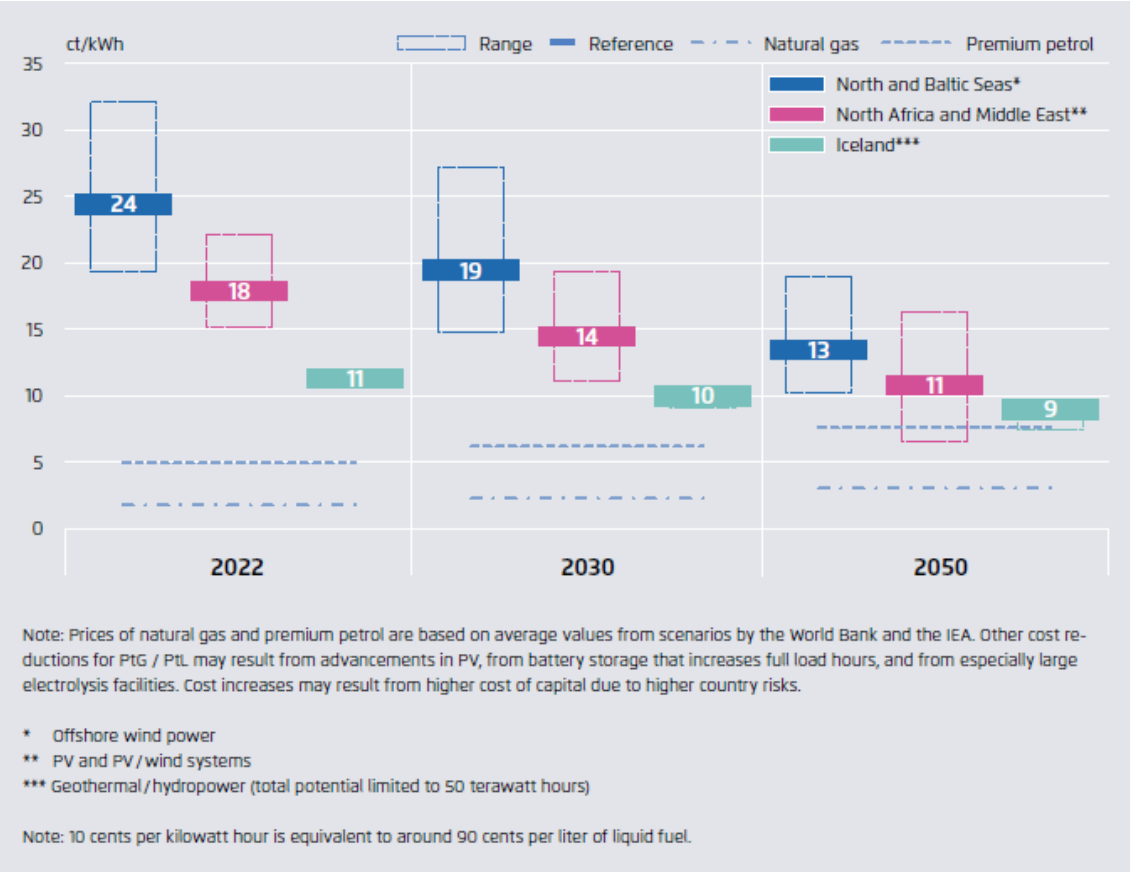
Source: BDI, dena, ESYS 2019

The roadmap towards a global PtX industry is based on the requirements and opportunities of the global energy transition



A global market for PtX makes sense – due to the availability of sites for RES-E and cost optimisation

Cost of synthetic fuels / methane



Note: Prices of natural gas and premium petrol are based on average values from scenarios by the World Bank and the IEA. Other cost reductions for PtG / PtL may result from advancements in PV, from battery storage that increases full load hours, and from especially large electrolysis facilities. Cost increases may result from higher cost of capital due to higher country risks.

* Offshore wind power
** PV and PV / wind systems
*** Geothermal / hydropower (total potential limited to 50 terawatt hours)

Note: 10 cents per kilowatt hour is equivalent to around 90 cents per liter of liquid fuel.

Source: Frontier Economics in: Agora Verkehrswende und Agora Energiewende (2018)

THESIS 1

Renewable energy will have to be imported (to DE/EU) in order to accommodate accelerating demand

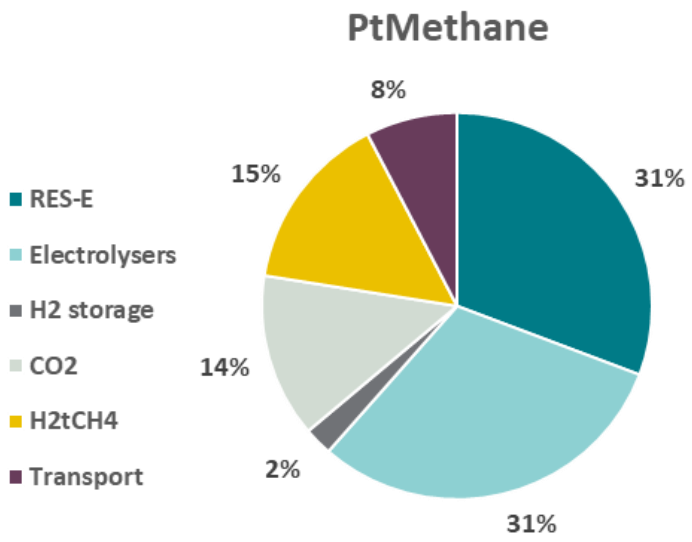
THESIS 2

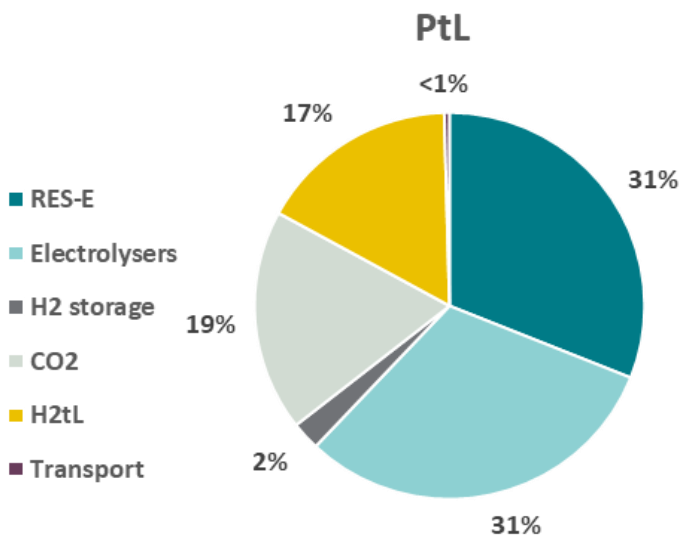
Boosting the scale of renewable energy imports will require chemical energy carriers, including PtX

THESIS 3

International PtX trade will help to accommodate the costs of the energy transition and can diversify the import portfolio

Electricity costs as main driver of synthetic fuel costs (opex)





Note: All cost shares (in%) and absolute figures (ct/kWh) are rounded and associated with the following scenario: North Africa, reference scenario 2030, PV-Wind-combination, CO2 from DAC, 6% WACC.

Source: Frontier Economics in: Agora Verkehrswende und Agora Energiewende (2018)

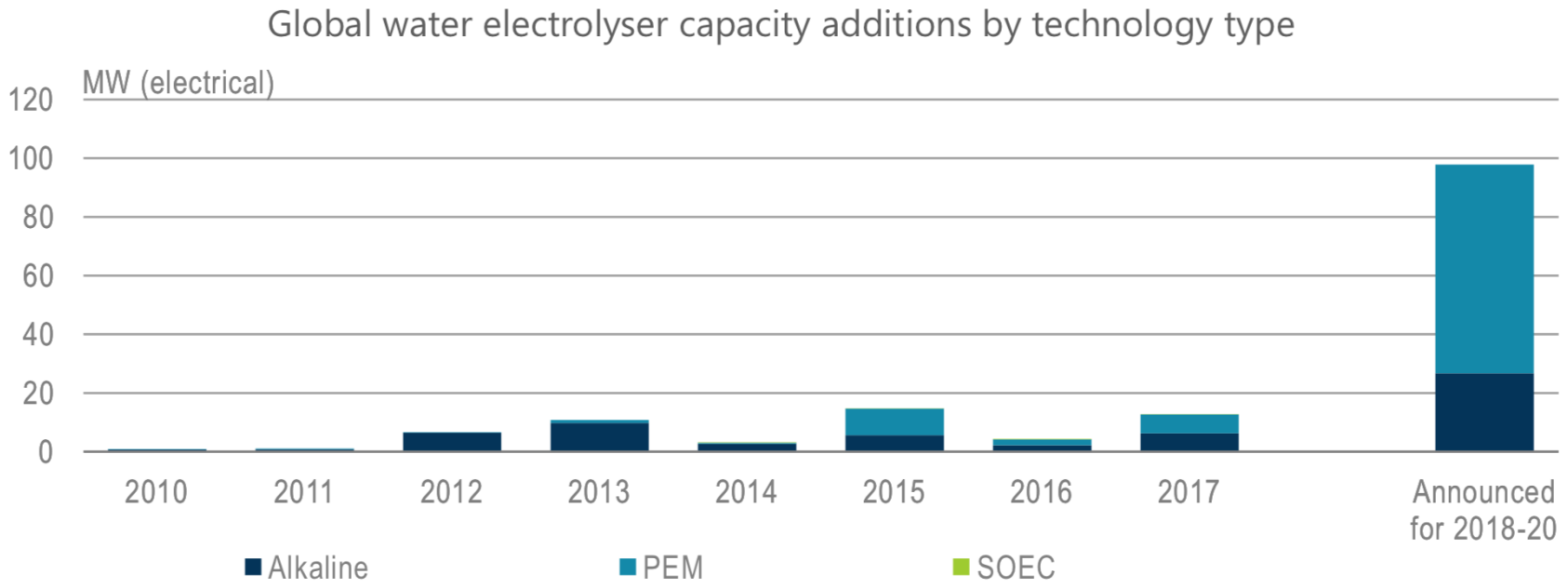
The roadmap towards a global PtX industry is based on the requirements and opportunities of the global energy transition

3

A global market for PtX can be huge in size – driving substantial investments

PTX-Technologies are at the very early stage

Electrolysers for hydrogen for clean energy are set to grow



While only around 13 MW of clean energy electrolyser projects came online in 2017, many more were announced for 2020, mostly backed by governments and increasingly for power-to-gas and storage.

Future global PtX market will rise to a significant size

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Corresponds to electrolyser capacity of 3,000-6,000 GW

PtX market	Low Case	Reference Case	High case
	Ca. 10,000 TWh	Ca. 20,000 TWh	Ca. 41,000 TWh

PtX final demand share

Road – passenger | Road – freight | Marine | Aviation | Rail | HH | GHD | Industry | Other

Scenarios based on assumed Market shares

Low Case | Reference Case | High Case

Division into sectors

Division into geographies

Final energy demand by sector and geography *(WEO, IEA)*

Source: Frontier Economics based on IEA, World Energy Outlook 2016, New Policies Scenario

Variety of PtX producing countries

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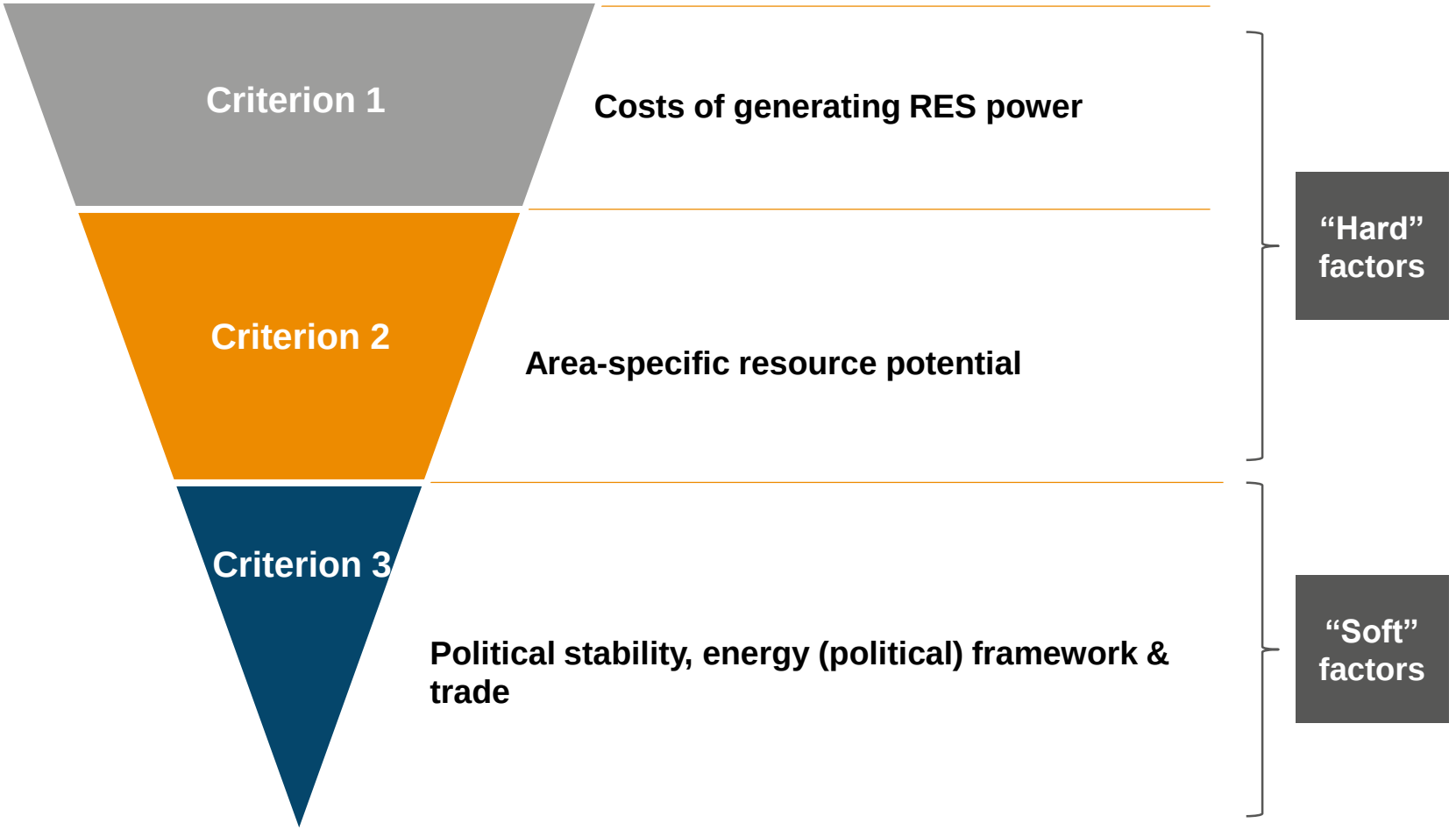
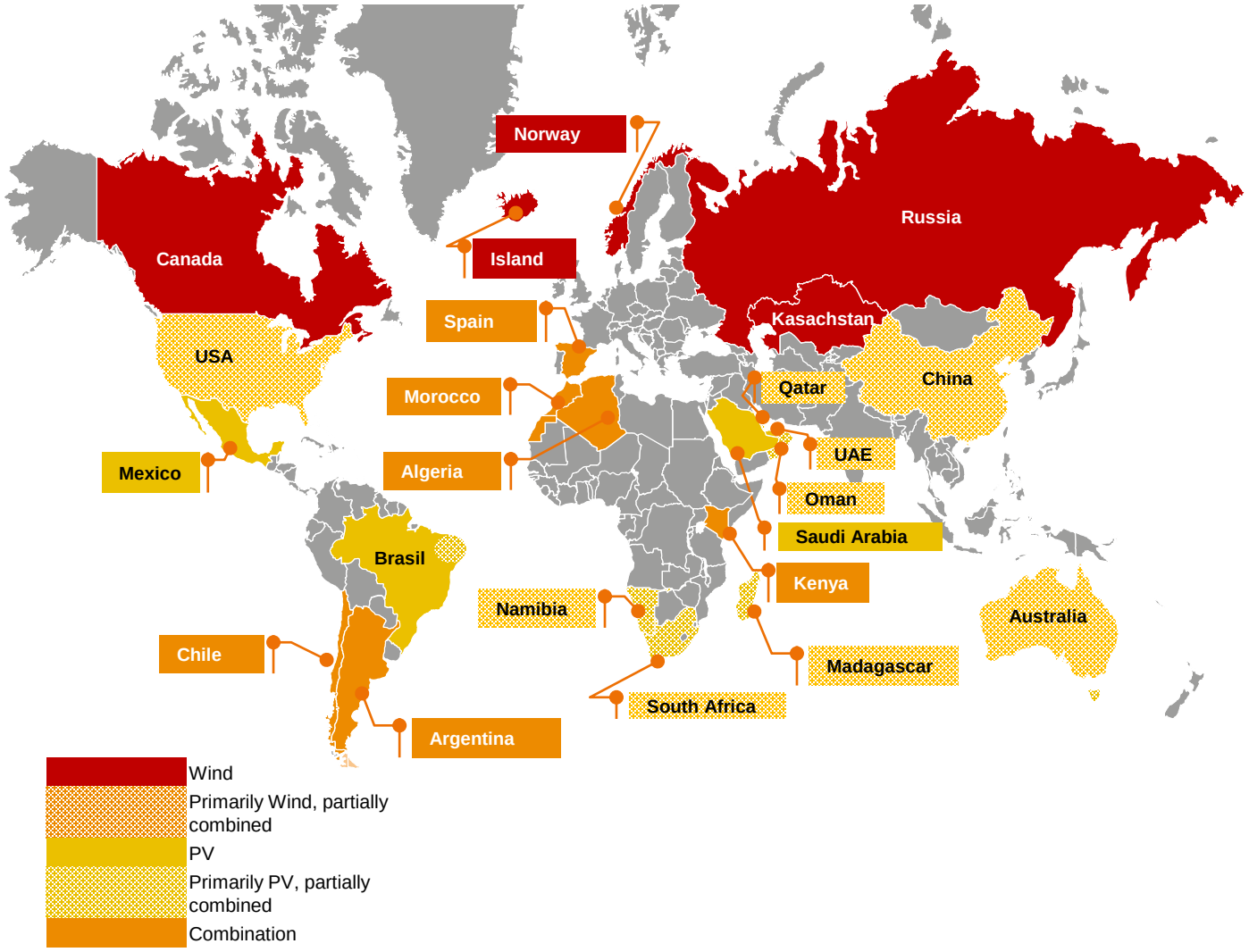
There is a large number of PtX producing countries – each with individual motivations

Potential PtX producing countries require a combination of various factors



Various countries demonstrate strong potential for PtX production / exports …



…however, potential PtX suppliers vary in terms of incentives and readiness to adjust

Type	PtX motivation and readiness	Examples
Frontrunners	• Especially favorable in early stages of market penetration	Norway
Hidden Champions	• PtX could readily become a serious topic if facilitated appropriately	Chile
Giants	• Provide order of PtX magnitudes demanded in mature market	Australia
Hyped Potentials	• Potential to lead technology development; may depend strongly on solid political facilitation	Morocco
Converters	• Strong motivation for PtX export technology development; may require political facilitation	Saudi Arabia
Uncertain Candidates	• May drive PtX technology development, export uncertain	China

3 pillars of the Roadmap

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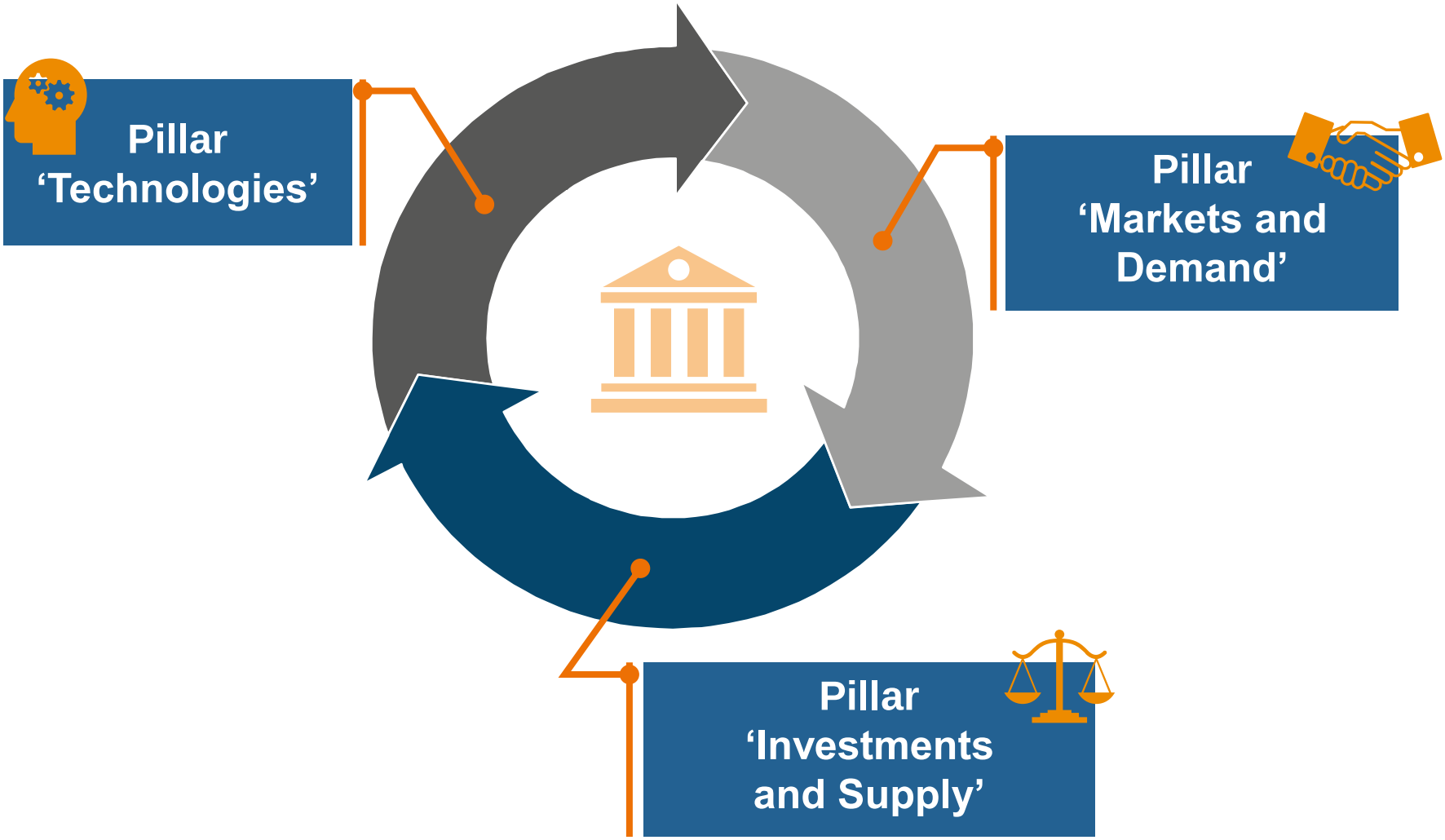
Roadmap towards a global PtX market is based on 3 core pillars:

- Technologies
- Demand/Markets
- Supply/Investments

A PtX roadmap towards an international market requires a sustainable framework



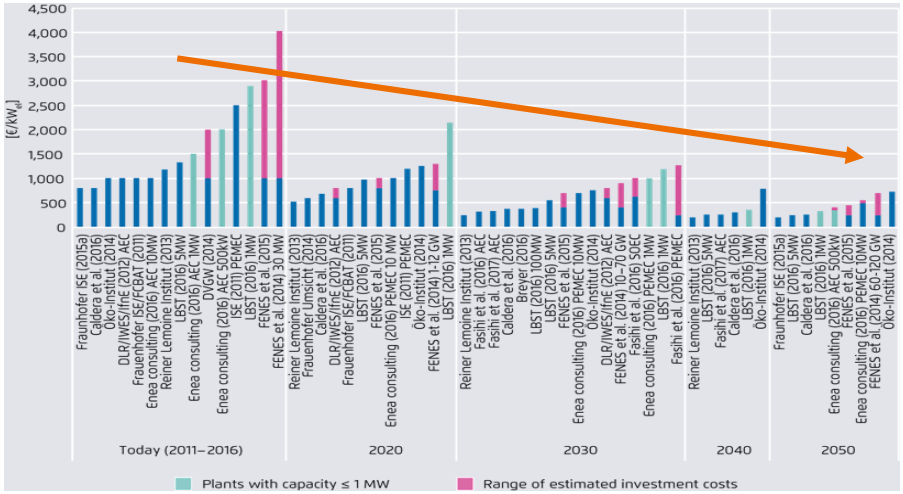
Pillar ‘Technologies’: Development of a PtX industry requires further technological progress

Source: Siemens

Key drivers to achieve cost savings…

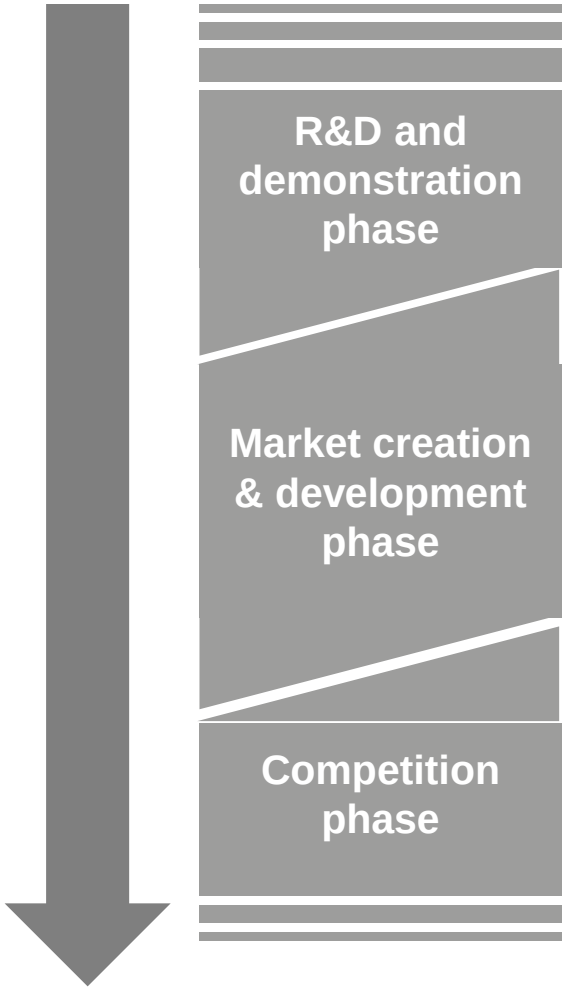
- Scaling up of plant sizes
- Standardisation of components / modules and of processes to build installations

… lead to investment cost reductions for the construction of electrolysers



Source: Agora Verkehrswende, Agora Energiewende and Frontier Economics (2018)

Pillar ‘Markets and Demand’: Regulation and political facilitation is needed to create PtX markets and demand



R&D support

- Support of technology development
- E.g. **direct subsidies**, pilot support
- “Clean up“ of existing regulatory framework to remove barriers for R&D investments, e.g. relieve from specific taxes / levies

Support market growth through targeted policy measures

- Establish growing niche markets (niche), for example by
  - Crediting of PtX from RES-E on **renewable targets**
  - Crediting of PtX from RES-E on **CO_2 reduction targets**
  - **Quotas / obligations** for specific markets, e.g. heat / transport
- Sector specific **adjustment of financial incentives** for the use of PtX products (e.g. regarding taxes/levies)

Ensure competitiveness through more technology neutral approaches

- Release PtX technology in competition to other CO_2-avoidance technologies across different sectors
- E.g. through pan-sectoral global CO_2 ETS / Carbon-tax

Pillar ‘Investments and Supply’: Politicians can help to reduce risks for investors

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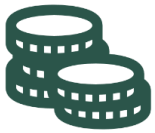
Place PtX on the **international climate policy and renewable agenda**



Financial instruments to mitigate the impact of country risks for investors

Promoting **bilateral co-operations and collaboration** such as energy partnerships

Backing of investments by multilateral **energy treaties and agreements**

Establishing **criteria for sustainability assessment**

Establishing **a green certification system**

Timing is key – complex interdependencies require coordination

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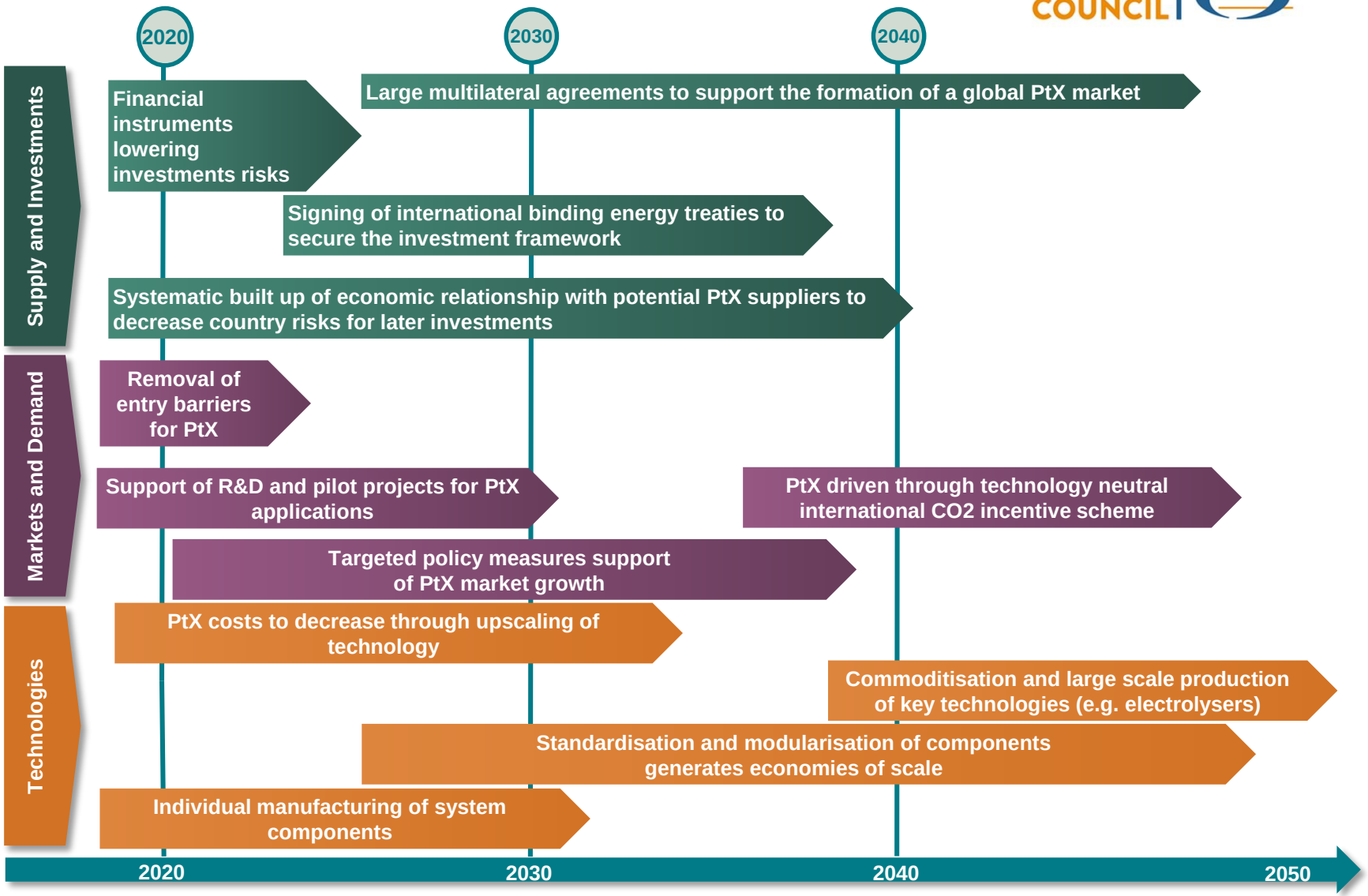
Timing and complex interdependencies require a coordinated approach to develop an international PtX market

The interaction of the 3 pillars



Thank You for your Attention!

Dowload Study here:

https://www.weltenergierat.de/ptxstudie/

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