markus academy

Developing a global Hydrogen Market

Veronika Grimm
University of Erlangen-Nürnberg

14. July 2023

Poll

1. In **which sectors** will hydrogen be used on a scale **by 2030**? (more than one)
   a. Power generation b. Industry c. Mobility
2. … in the long term **by 2050**? (more than one)
   a. Power generation b. Industry c. Mobility
3. Will hydrogen economy be a **leveler** to bring prosperity/growth to the **Global South**?
   a. True b. Maybe c. False
4. Which regions will be **hydrogen exporters**? (more than one)
   a. Arabian Peninsula b. Australia c. North Africa
   d. South America e. USA f. Canada
5. Will bottlenecks in **raw minerals** slow down hydrogen?
   a. True b. Maybe c. False

Global Hydrogen Market

- Product market
  - Green, blue, grey, brown
  - Competitive price benchmark
    - Design of a price index
- Transport
  - Electricity, pipeline, ships
- Geoeconomics
  - Resilience
- Financing market
  - Project financing in Global South

Financing of Global South Projects

- "Solar plant" capital cost
  (high initial investment, minimal operation cost)
  - Developed country: 4% required return
  - Developing country: >10% (IEA.org)
- Risks and risk premium
  - Micro vs. macro risk
    - (Geo)political/expropriation risk
  - **Advanced Purchasing agreement** to reduce risk in
    - Quantity
    - Price / floor ⟷ H-price index (benchmark)
      - Currency risk *limit pricing power*
    - How to allocate agreements across countries?
      "Resilience principle" – Auction?

Financing of Global South Projects

- Currency risk
  - Solar for export in €-area
    - Finance in € and invoice **H** in €
      (plant abroad, but finance in €-area)
  - Solar for home consumption (e.g. Namibia)
    - Problem: finance is local currency is expensive
    - Currency risk subsidy (Presaud)
      - Local currency depreciates due to
        - **Negative supply** shock with stagflation
        - **Positive demand** shock, overheating, inflation
      - Why transfers in both? Currency is volatile for many reasons
- Alternative: Targeted insurance based on GDP

DEVELOPING A GLOBAL HYDROGEN MARKET

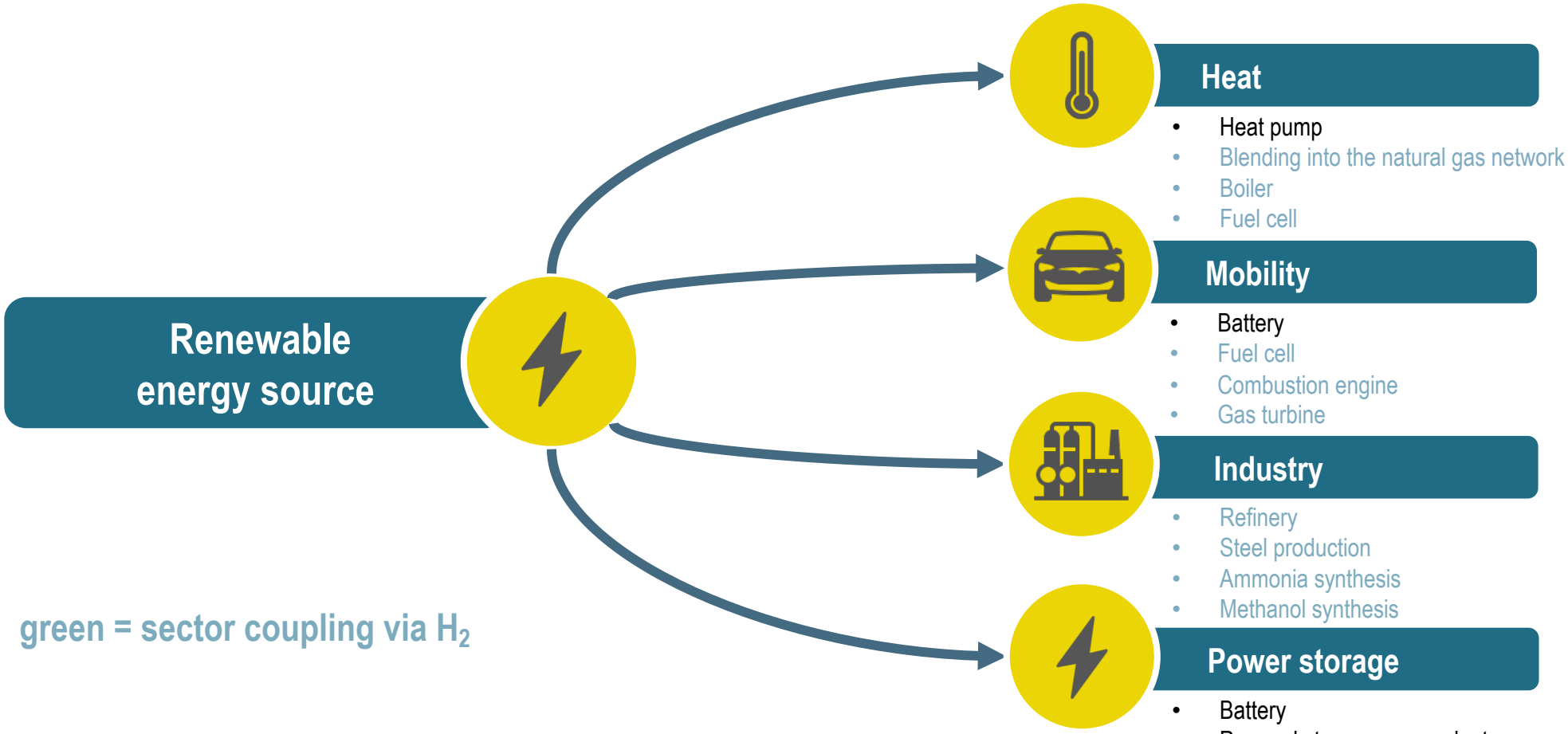
GERMAN COUNCIL
of Economic Experts

Veronika Grimm
FAU Erlangen-Nürnberg &
German Council of Economic Experts (GCEE)

Markus‘ Academy, July 14, 2023

HDYROGEN WILL PLAY A KEY ROLE IN THE ENERGY TRANSITION

GERMAN COUNCIL of Economic Experts

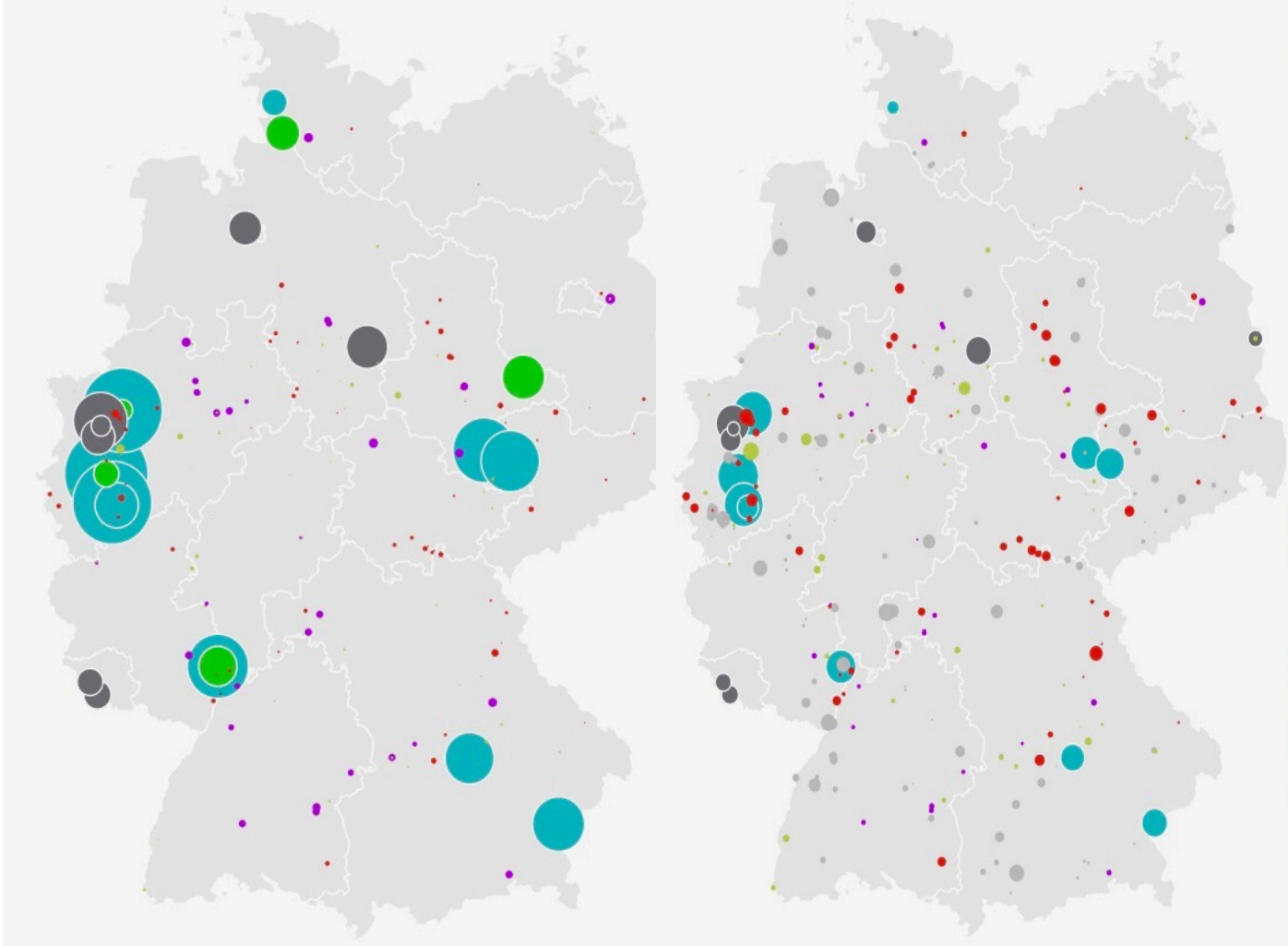


green = sector coupling via H_2

H2 DEMAND IN EUROPE WILL BE HIGH

(HERE: INDUSTRIAL H2 DEMAND IN GERMANY)

Egerer, J., V. Grimm, N. Farhang-Damghani und P. Runge (2023b), **The Industry Transformation from Fossil Fuels to Hydrogen will reorganize Value Chains: Big Picture and Case Studies for Germany,**



Lower bound scenario

Δ between higher and lower H2 demand scenarios

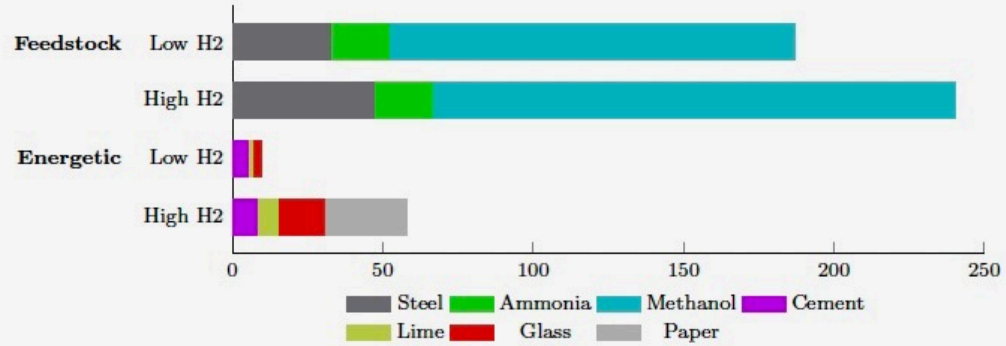


FIGURE 5. Projected industrial hydrogen demand for Germany in a carbon-neutral economy without relocation of energy intensive production abroad (in TWh/a)

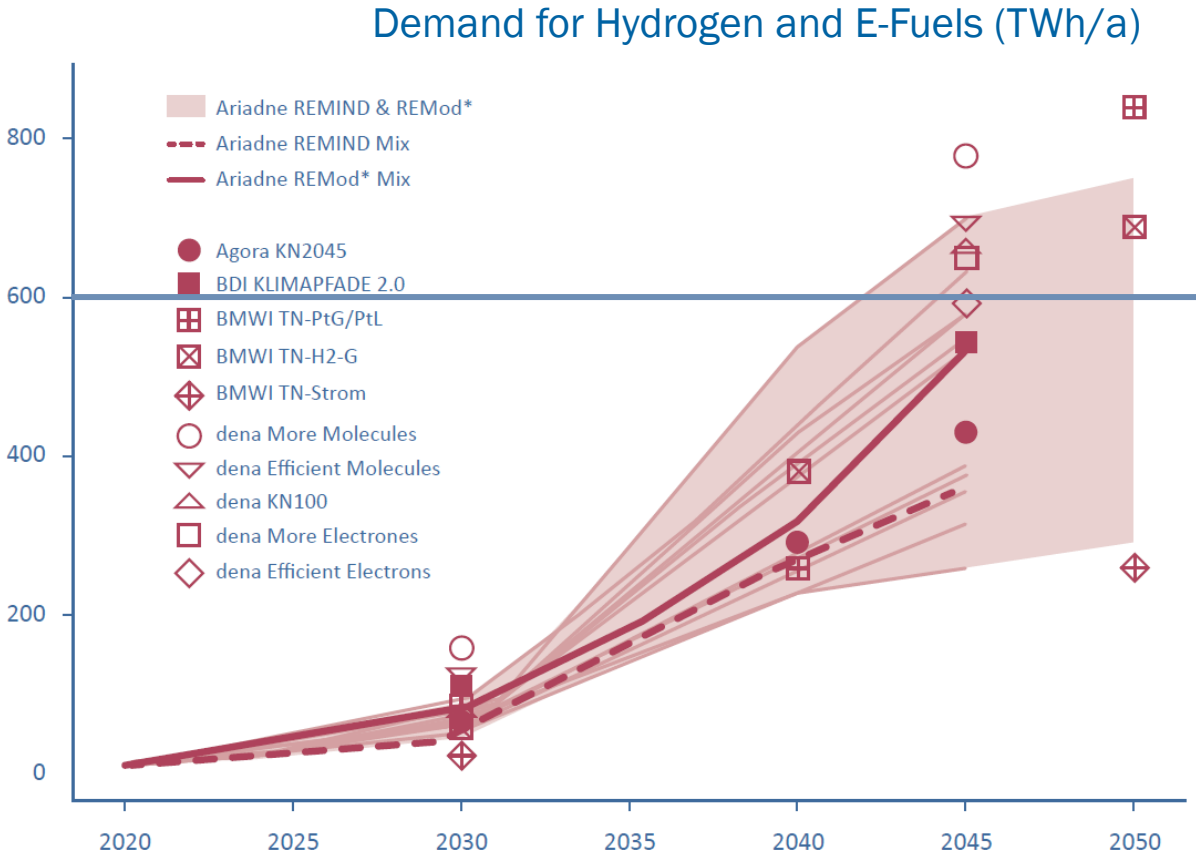
NWR* estimates (for 2040-50):

Process industries	298
Transport	73
Heat	125 - 500
Energy supply	288
Total	964 – 1364

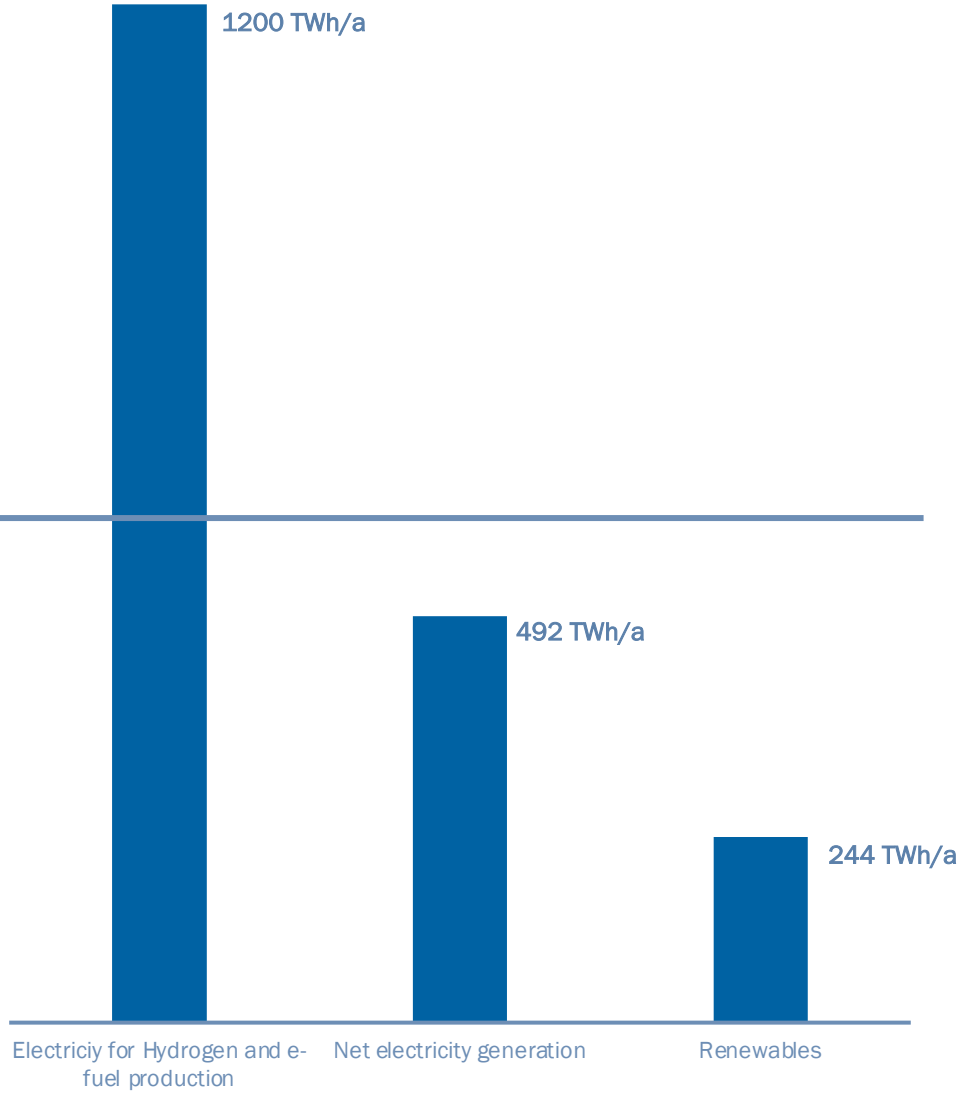
*NWR: German National Hydrogen Counil, 2023

GERMANY (AND EUROPE) WILL NEED TO IMPORT HYDROGEN AND DERIVATIVES

GERMAN COUNCIL of Economic Experts



Source: Staiß, F. et al. 2022

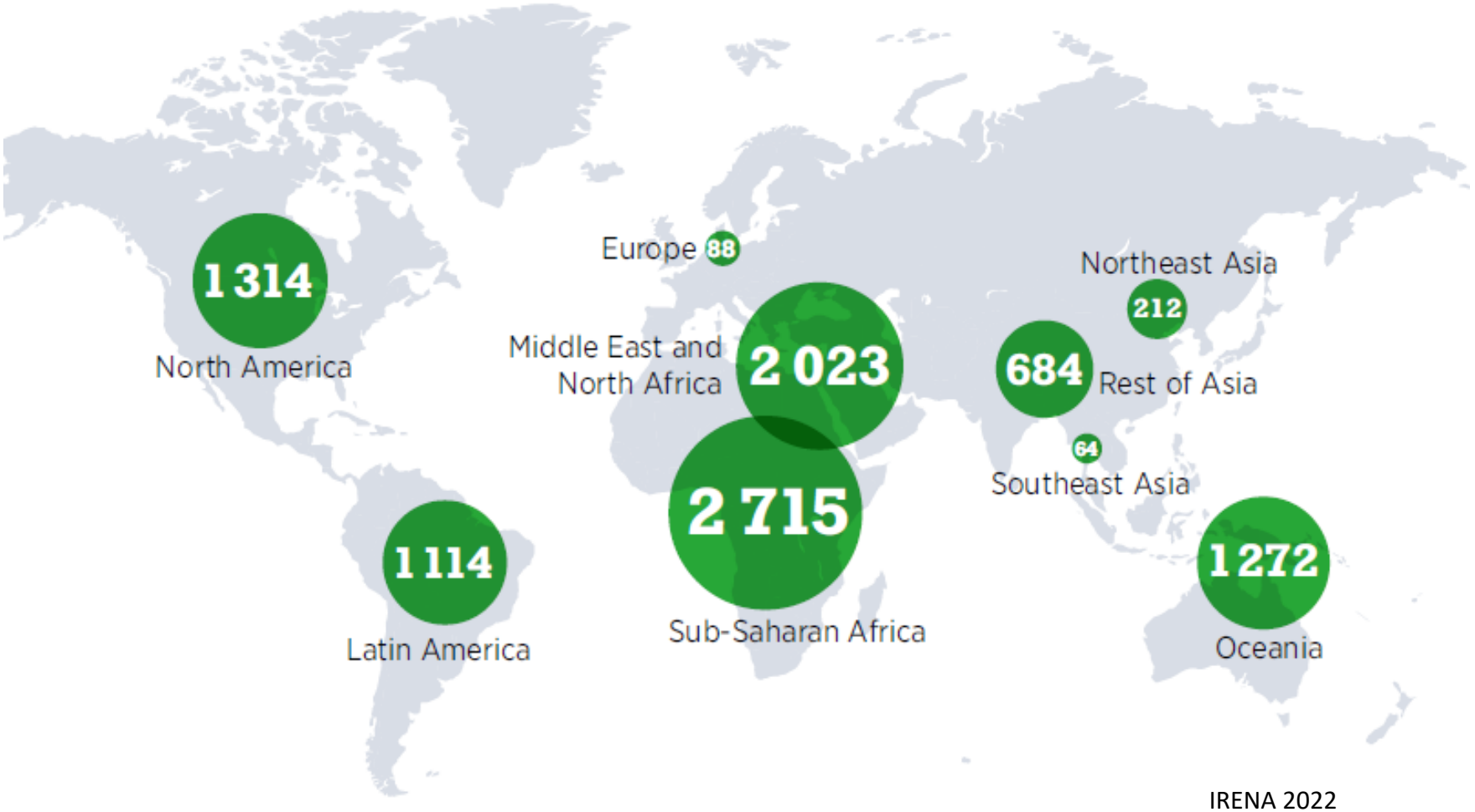


Source: Fraunhofer ISE 2022

POTENTIAL FOR H2 PRODUCTION IN EUROPE IS LOW

GERMAN COUNCIL of Economic Experts

Figure 3.4 **Technical potential for producing green hydrogen under USD 1.5/kg by 2050, in EJ**



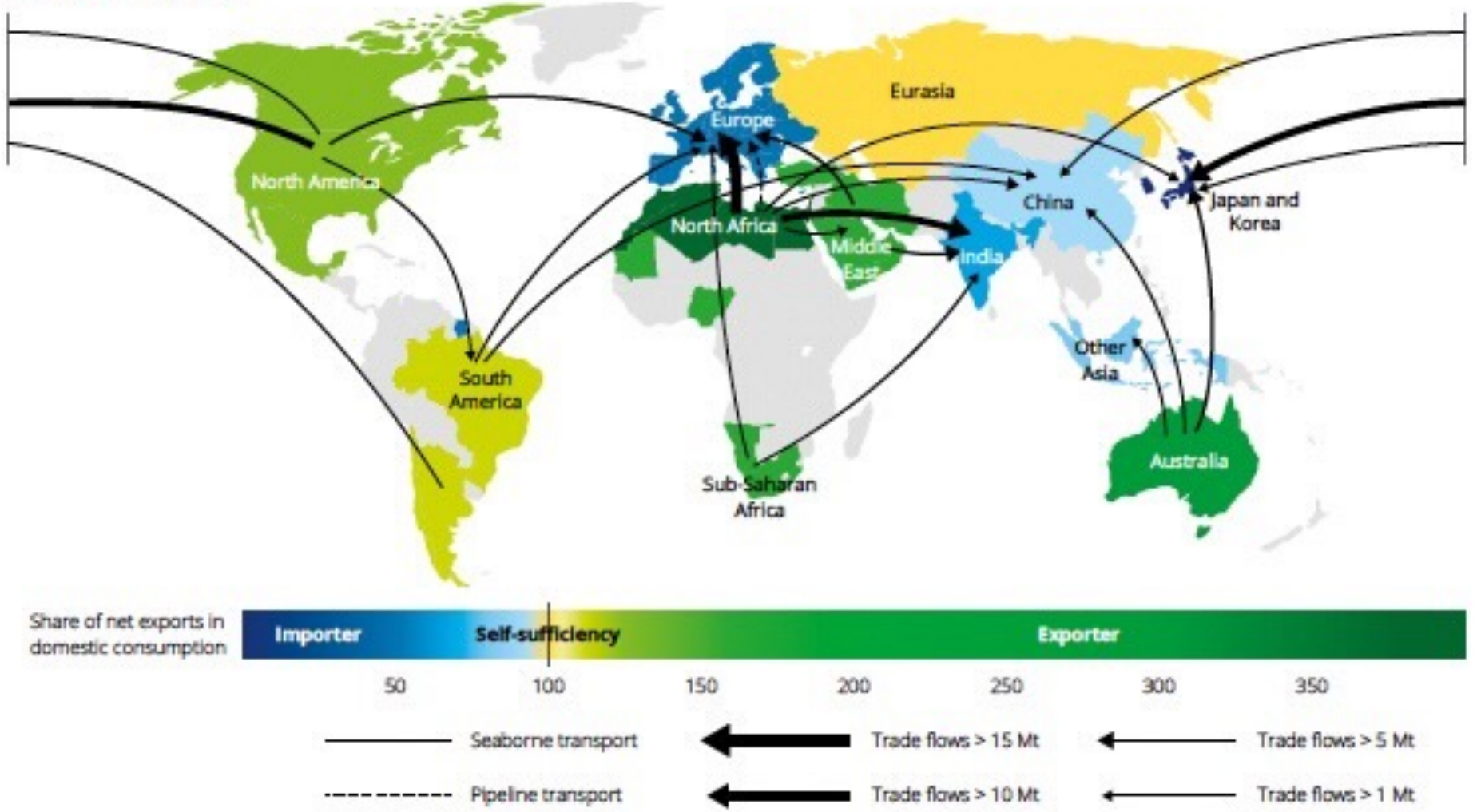
IRENA 2022

H2 & DERIVATIVES PRODUCTION AND TRADE 2050

GERMAN COUNCIL of Economic Experts

Figure 16. Global hydrogen trade among the key regions, 2050

a) World map of trade



Source: Deloitte 2023

<u>The US:</u>

self-sustained in 2030 and a net exporter in the long run.

<u>Europe:</u>

net importer. Goal should be early diversification of imports.

STRATEGIES TO DEVELOP H2 MARKETS

GERMAN COUNCIL of Economic Experts

US:

- IRA tax credits for clean H2,
- domestic production and consumption,
- focus on CO2 footprint, not „color“ of H2:

The subsidy differentiates according to the CO2 emissions of hydrogen production over the entire life cycle and, assuming that the requirements for labour standards and training places are met, amounts to

- 60 ct per kg for hydrogen with a CO2 footprint between 4 and 2, 5 kg of CO2 per kg of hydrogen,
- 75 ct per kg for a CO2 footprint between 2.5 and 1.5 kg, US$1 for a CO2 footprint between 1.5 and 0.45 kg, and
- US$3 for a CO2 footprint of less than 0.45 kg (Internal Revenue Code Title 26 Section 45V).

Europe:

- Import strategy necessary
- current debate on „color“ of H2
- certification decisions still pending
- point-to-point contracts bear the risk of lock-in with few suppliers (dependencies and market power)
- H2Global double auction instrument as an attractive option.

THE COLORS OF HYDROGEN

GERMAN COUNCIL of Economic Experts

Steam Reforming

$+ \; = H_2 + CO_2$

Steam Reforming + CCS o. CCU

$+ \; = H_2 + CO_2$ } **Store, use**

Pyrolysis

$= H_2 + C$ } **Store, use**

Biomass Conversion

$+ \; = H_2 + CO_2$

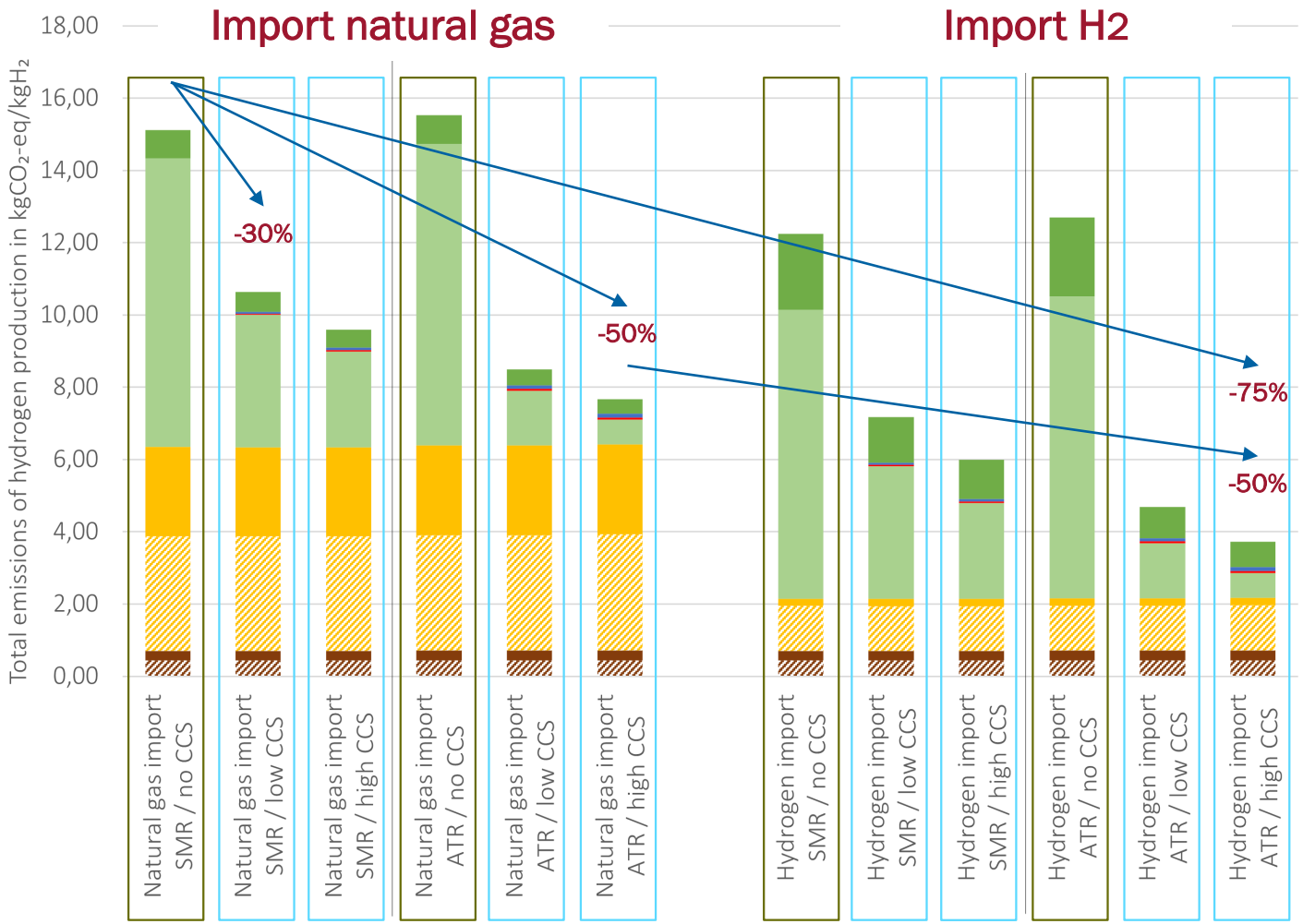
Electrolysis

$+ \; = H_2 + O_2$

Schippert, J., N. Farhang-Damghani, V. Grimm, P. Runge (2022). GHG potential of blue hydrogen given different technologies and logistics options, Working Paper.

CERTIFICATION IS PARTICULARLY AN ISSUE FOR BLUE HYDROGEN

Schippert, J., N. Farhang-Damghani, V. Grimm, P. Runge (2022). GHG potential of blue hydrogen given different technologies and logistics options, Working Paper.



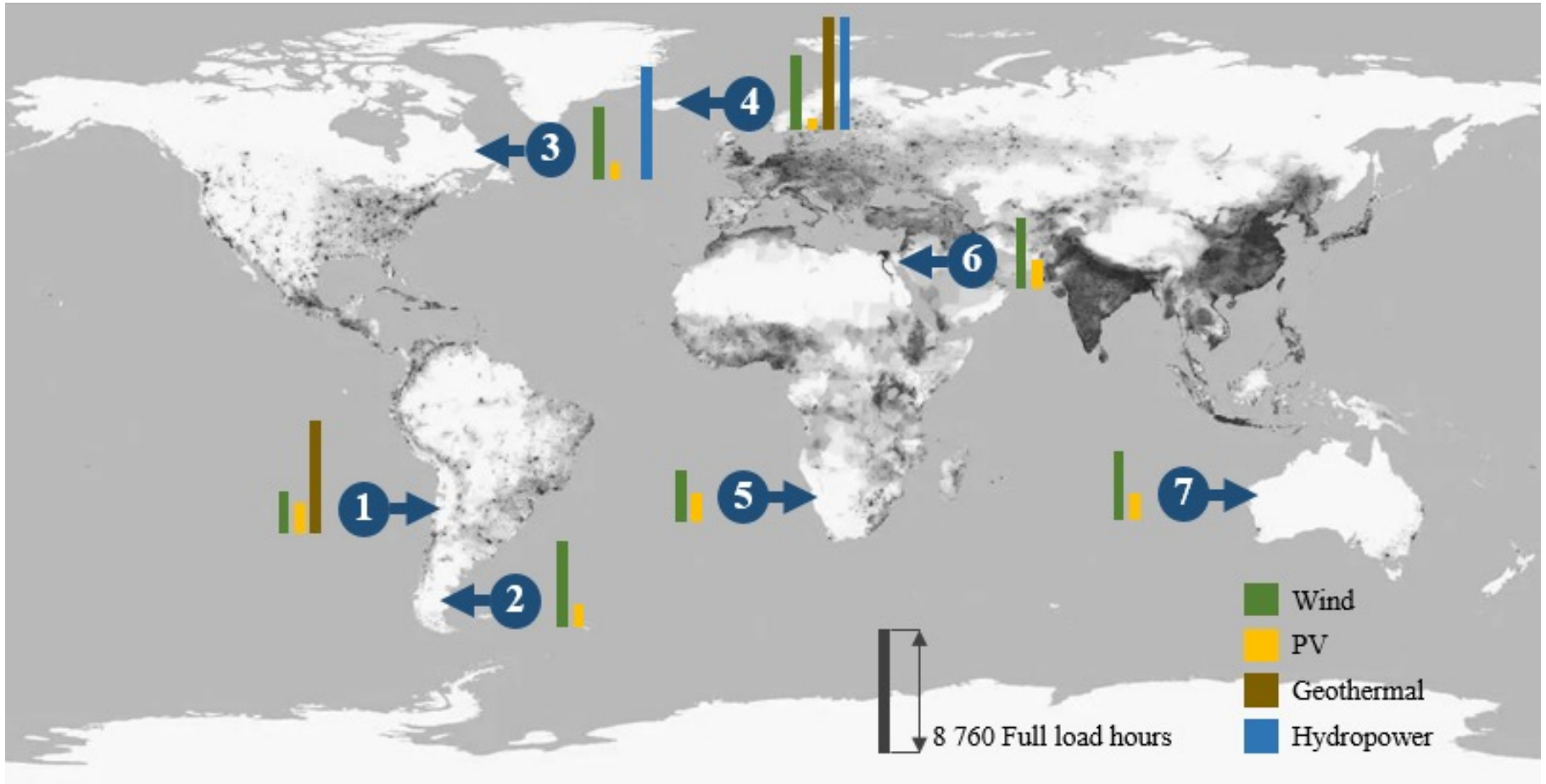
Blue hydrogen emissions differ significantly between different production technologies.

Methane emissions in the upstream chain have a significant impact on the footprint of blue hydrogen.

- Methane emissions from natural gas production
- Methane emissions from natural gas transport
- Emissions from H_2 production
- Emissions from CO_2 storage
- Other emissions from natural gas production
- Other emissions from natural gas transport
- Emissions from CO_2 transport
- Emissions from H_2 transport

MORE COUNTRIES WORLDWIDE CAN EXPORT GREEN ENERGY THAN FOSSIL FUELS … BUT

GERMAN COUNCIL of Economic Experts



Locations

1. Atacama Desert in Chile
2. Patagonia in Argentina
3. Labrador in Canada
4. Iceland
5. Karas in Namibia
6. Gulf of Suez in Egypt
7. West Australia

Fuels

FTD - Fischer Tropsch Diesel
MeOH - Methanol
H18-DBT – Perhydrodibenzyl-toluene (LOHC)
LH2 - Liquid Hydrogen

LOCATIONS DIFFER IN LEVELIZED COST, GEOPOLITICAL RISK, FINANCIAL CAPACITIES

GERMAN COUNCIL of Economic Experts

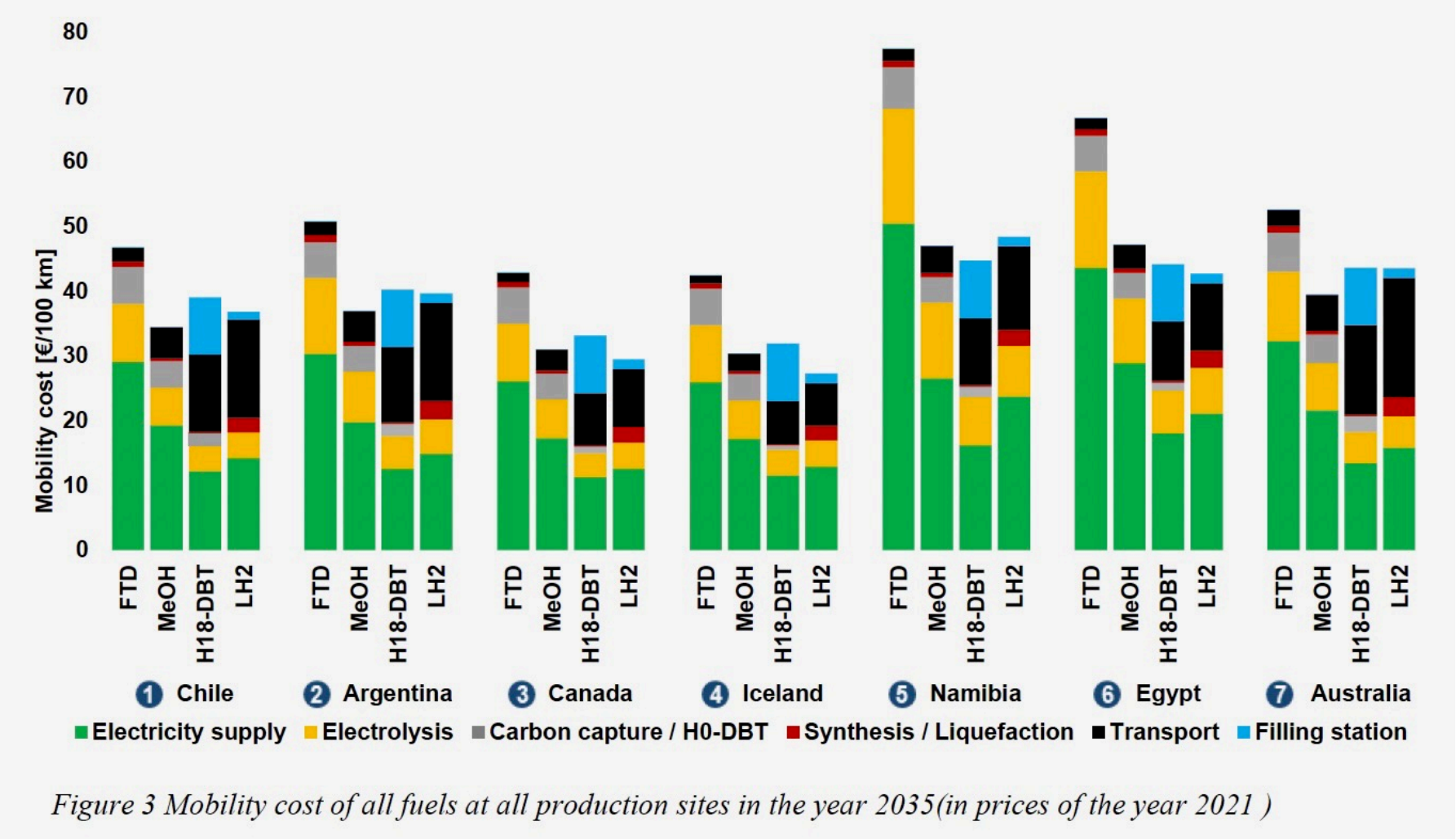


Figure 3 Mobility cost of all fuels at all production sites in the year 2035(in prices of the year 2021)

- Diversification does not happen by itself
- Concentration on a few partners leads to dependencies
- Ship more flexible than pipeline
- Transport costs moderate in the long term

Runge, P, C. Sölch, J. Albert, Jakob, P. Wasserscheid,, G. Zöttl, V. Grimm, **Economic Comparison of Electric Fuels Produced at Excellent Locations for Renewable Energies: A Scenario for 2035**

ATTRACTIVENESS OF DIFFERENT ENERGY CARRIERS TODAY

(THE FUTURE MAY LOOK DIFFERENT)

GERMAN COUNCIL of Economic Experts

	Liquid Hydrogen	LOHC	Green Ammonia	Green Methanol
Volumetric hydrogen content				
Boil-off Losses (Storage)				
Conversion- Energy demand				
Dehydrogenation- Energy demand				
Conversion TRL				
Dehydrogenation TRL				
Logistic Infrastructure availability (Medium scale)				
Direct utilization/ Fuel cell				
Flammability				
Toxicity				

 Best

 Medium

 Worst

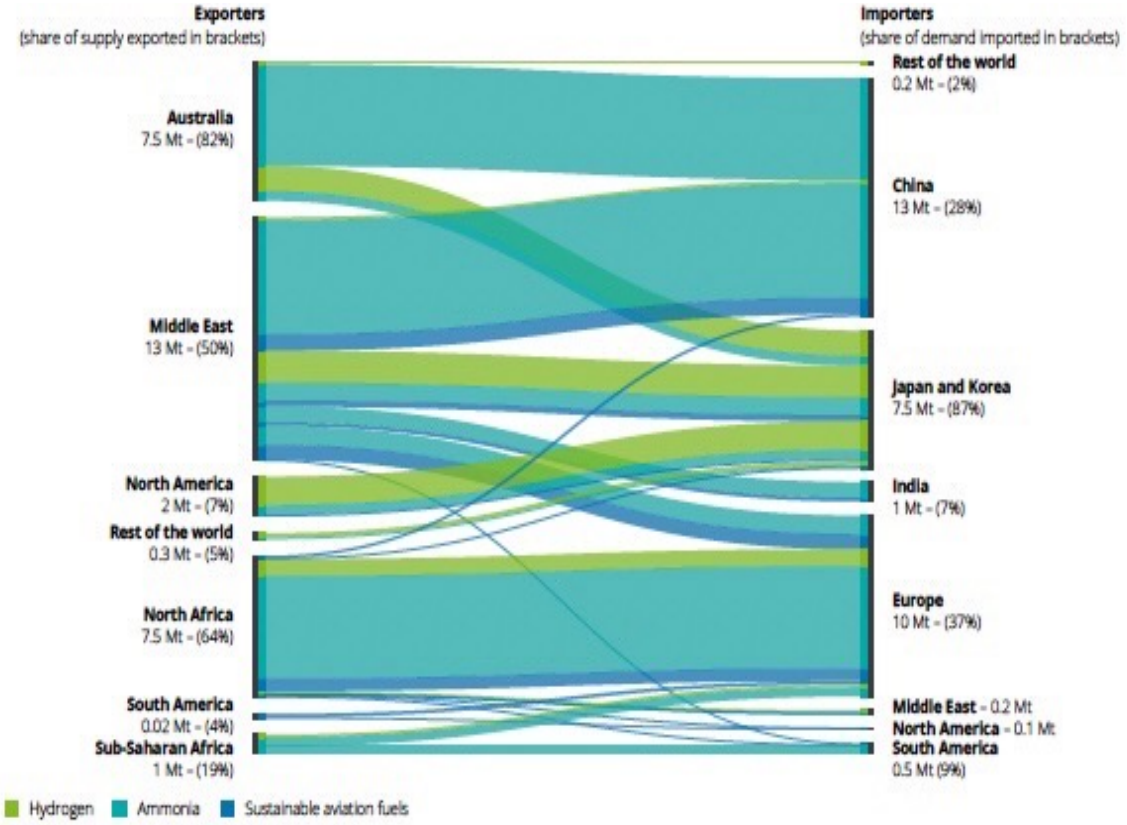
Ref: Runge, et al.(2020), Aziz, et al. (2019), Valera-Medina, A., & Banares-Alcantara, R. (2020)

FROM AMMONIA TO OTHER DERIVATIVES

GERMAN COUNCIL of Economic Experts

2030

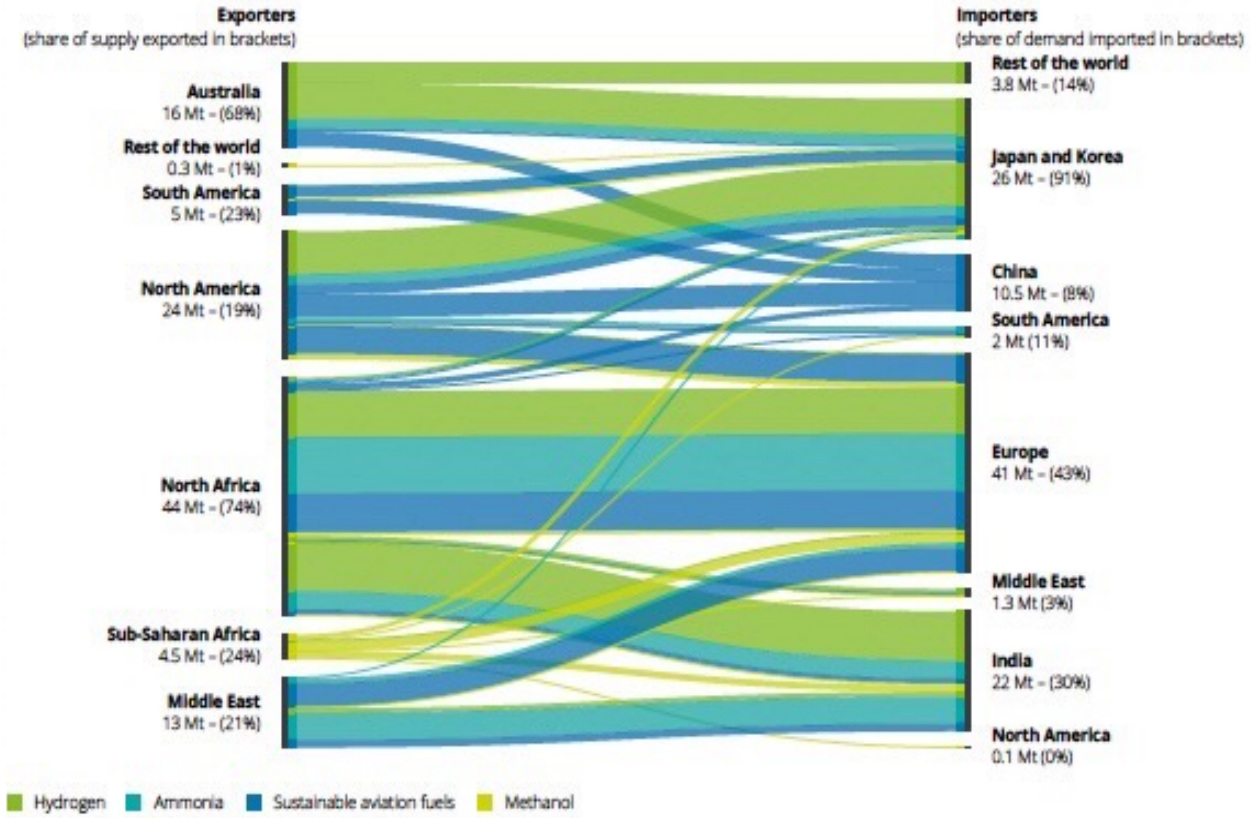
Mainly ammonia, less H2 and SAFs



Source: Deloitte analysis based on the HyPE model.

2050

Mainly H2, SAFs & Methanol, less ammonia



Source: Deloitte analysis based on the HyPE model.

GLOBAL AMMONIA TRADE FLOWS

GERMAN COUNCIL of Economic Experts

Ammonia is the first available option to trade H2 at a large scale

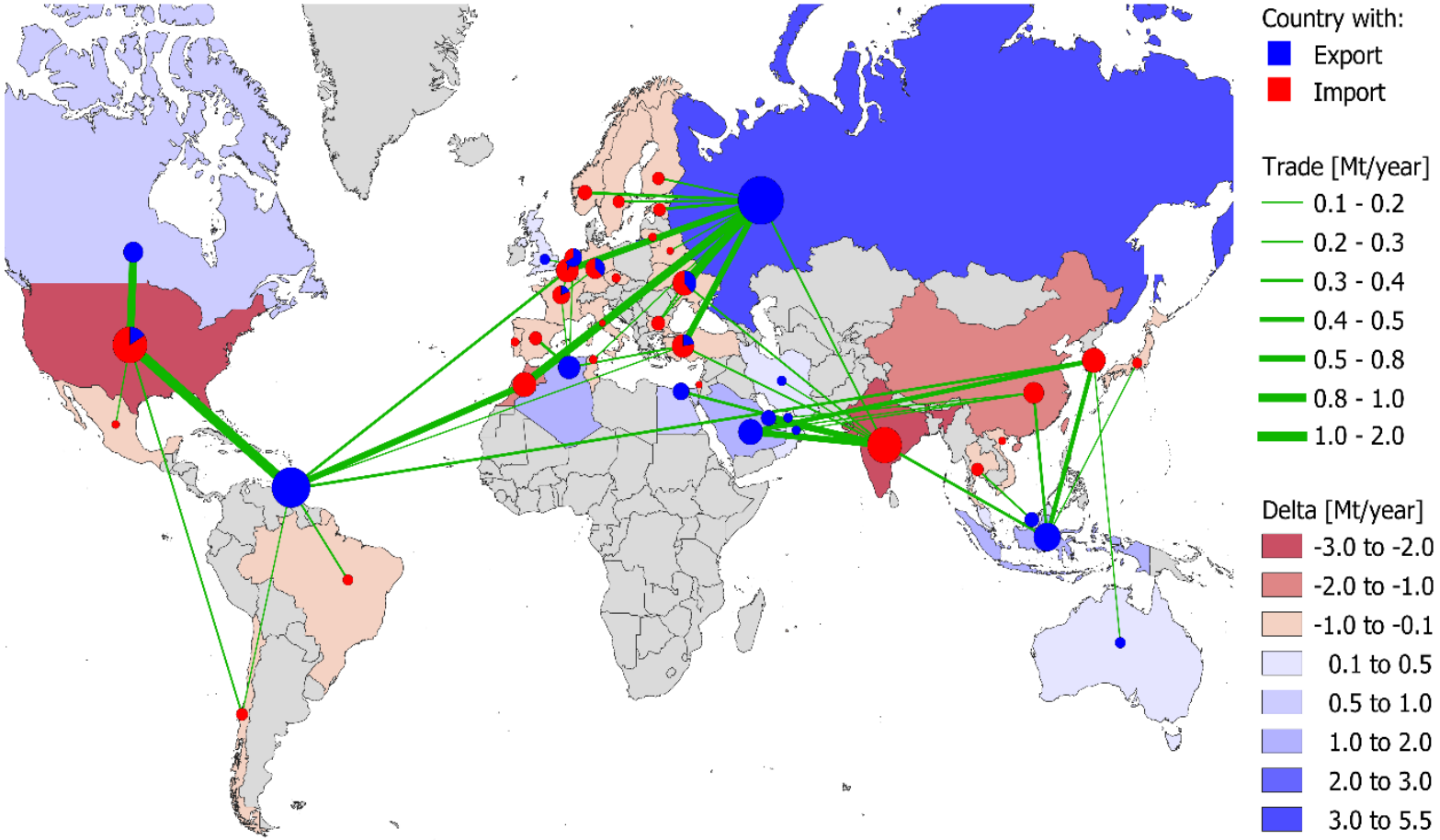


Figure: Global ammonia trade flows and balances larger 0.1 Mt per year in 2019

Today

- 20.6 Mt (12 %) of global production is traded between countries.
- Today, large exporters are gas producing countries, concentrated market.

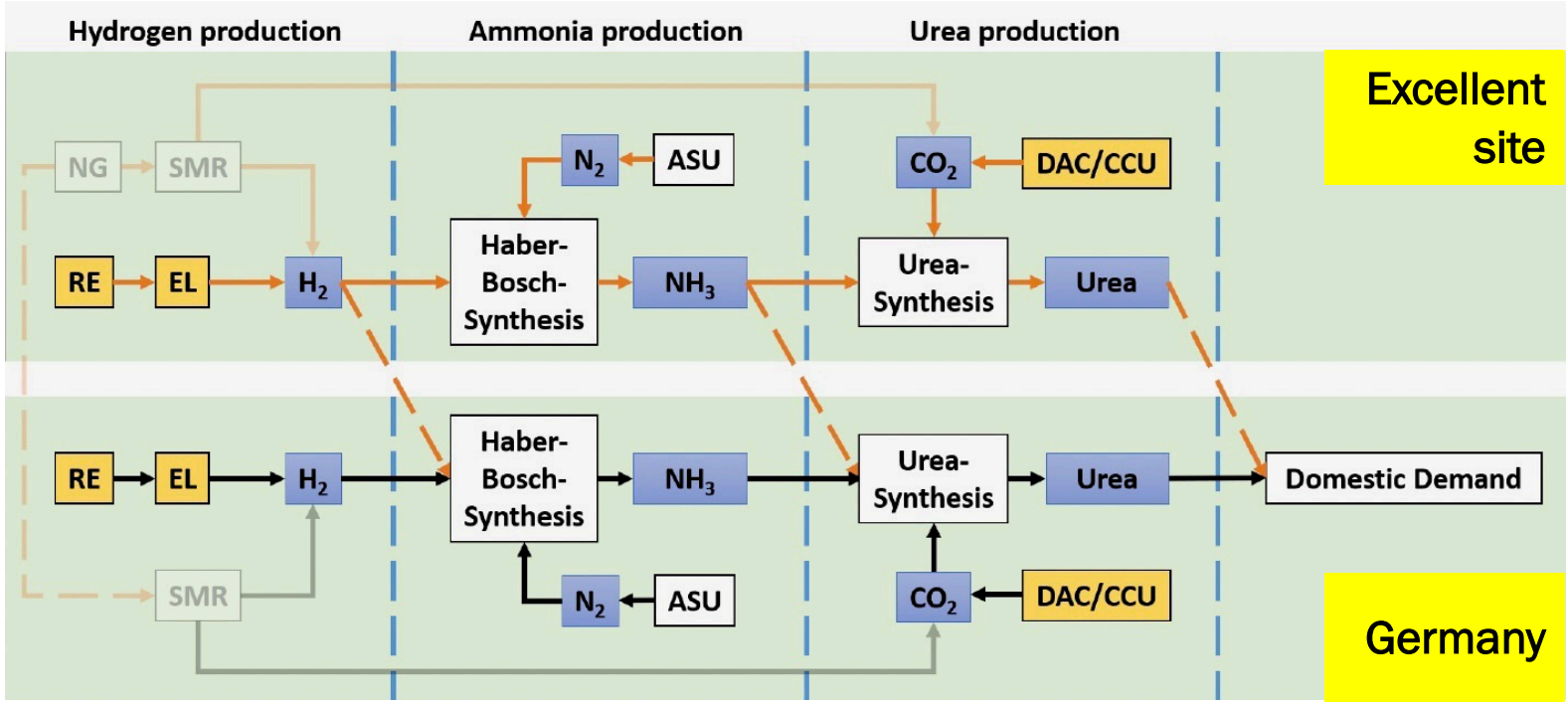
Tomorrow

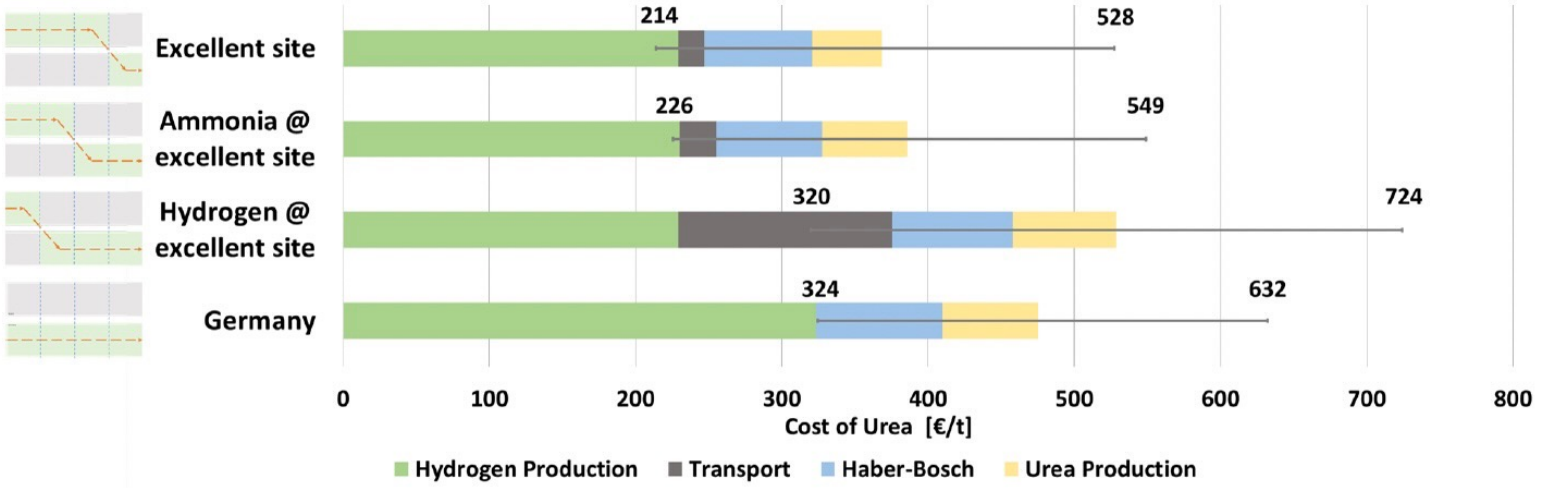
- **Green ammonia supply of 10 TWh (1.93 Mt) per year (equivalent to 7.86 TWh green hydrogen)**
- Initial investment of **10.69 bn €.**
- Annual operation costs of **0.33 bn €.**
- **Three large ship** (volume of 160,000 m^3) with 8 tours per vessel

Egerer, J., V. Grimm, K. Niazmand und P. Runge (2023a), **The economics of global green ammonia trade – "Shipping Australian wind and sunshine to Germany"** Applied Energy, 334 (2023), 120661

WHICH PRODUCTS TO IMPORT?

GERMAN COUNCIL of Economic Experts





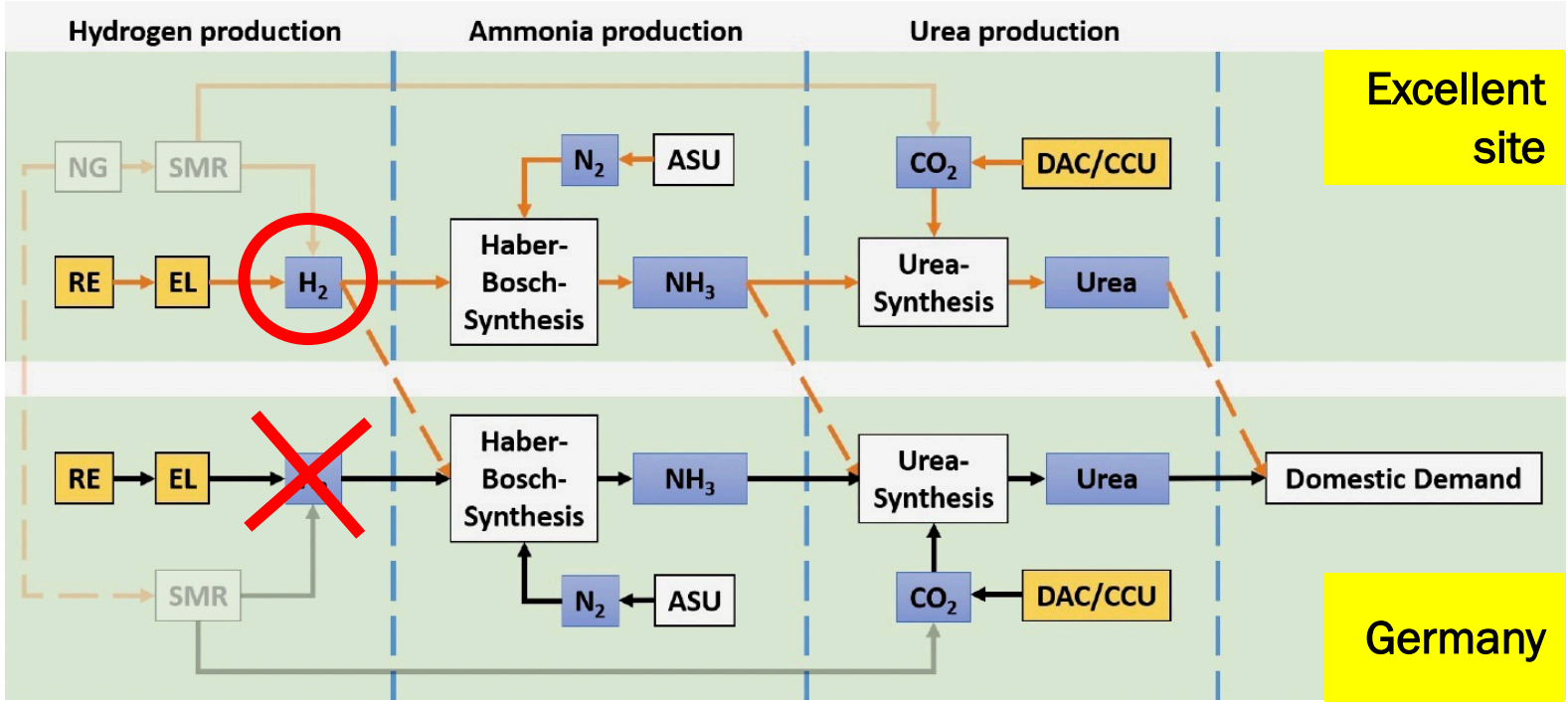
Import substitution very early in the value chain has advantages:

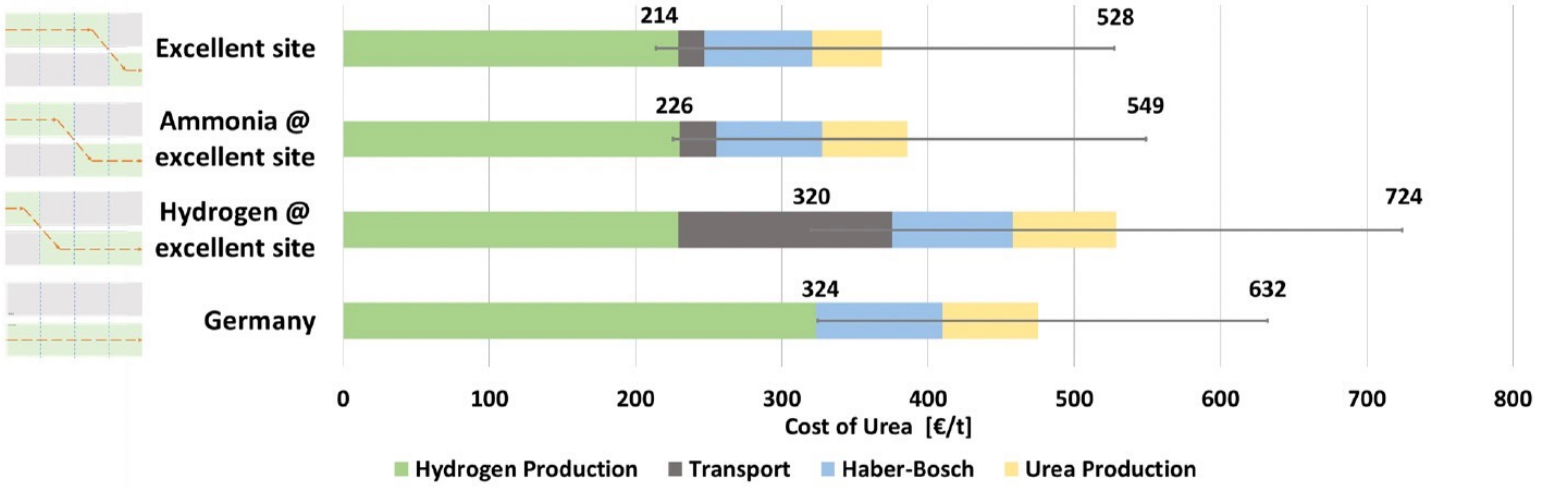
- No loss of by-products that are needed (e.g. for waiste-water treatment)
- More standardized products are traded, and thus, **liquid markets** foreseeable
- More diversification possible due to many possible suppliers
- Benefit from new comaparative advantages without loss of whole industries.

Egerer, J., V. Grimm, N. Farhang-Damghani und P. Runge (2023b), **The Industry Transformation from Fossil Fuels to Hydrogen will reorganize Value Chains: Big Picture and Case Studies for Germany.**

WHICH PRODUCTS TO IMPORT?

GERMAN COUNCIL of Economic Experts





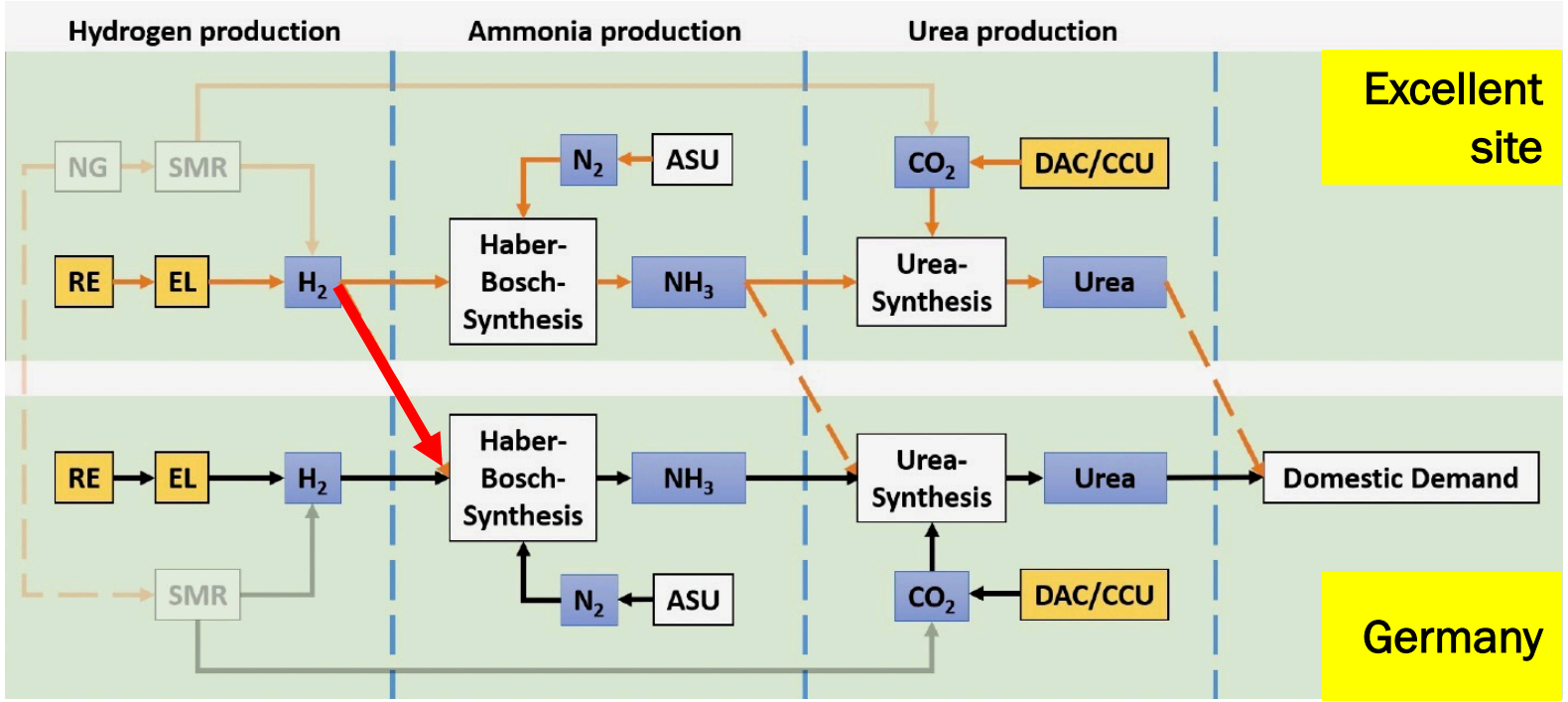
Import substitution very early in the value chain has advantages:

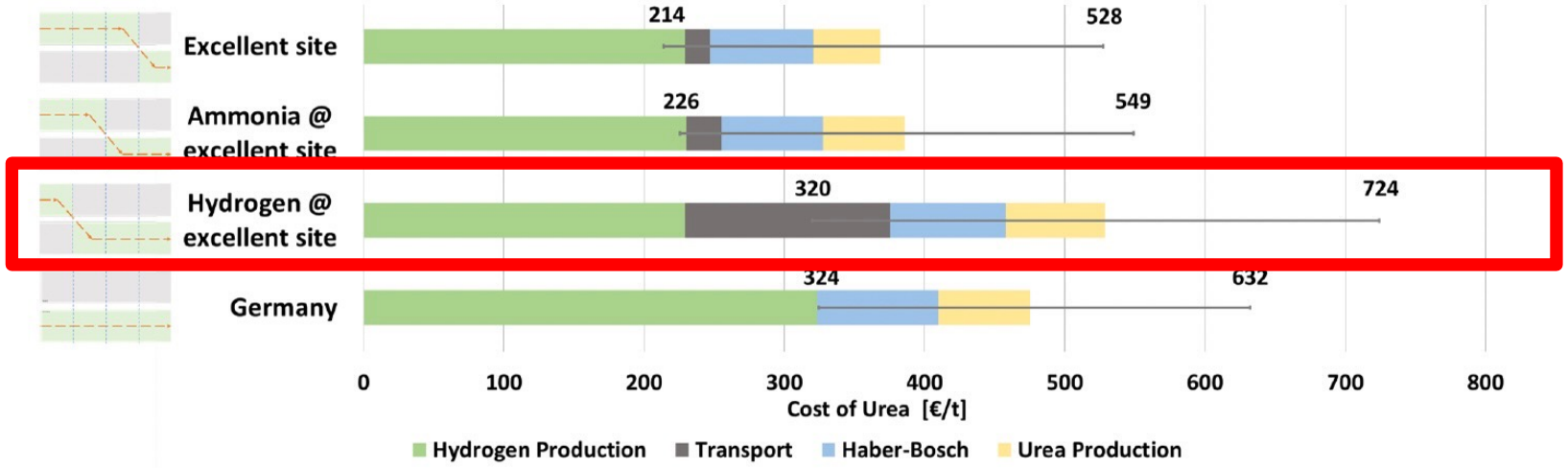
- No loss of by-products that are needed (e.g. for waiste-water treatment)
- More standardized products are traded, and thus, **liquid markets** foreseeable
- More diversification possible due to many possible suppliers
- Benefit from new comaparative advantages without loss of whole industries.

Egerer, J., V. Grimm, N. Farhang-Damghani und P. Runge (2023b), **The Industry Transformation from Fossil Fuels to Hydrogen will reorganize Value Chains: Big Picture and Case Studies for Germany.**

WHICH PRODUCTS TO IMPORT?

GERMAN COUNCIL of Economic Experts





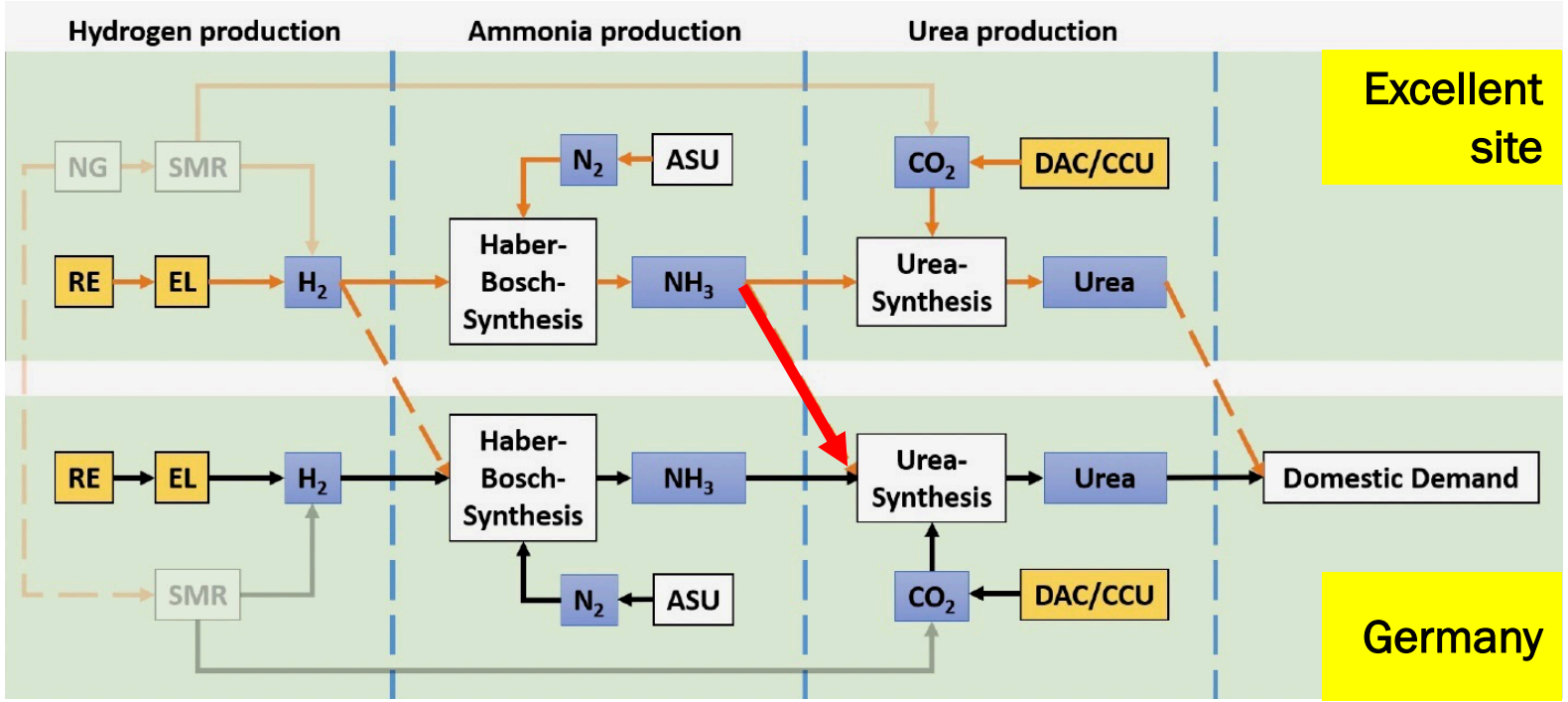
Import substitution very early in the value chain has advantages:

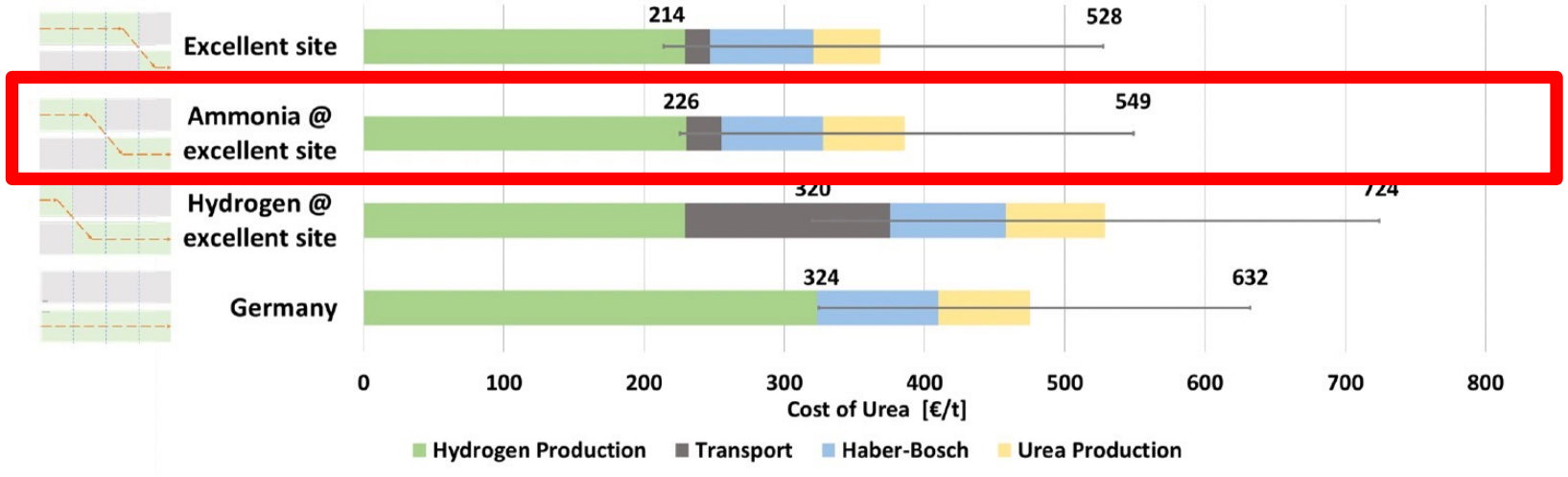
- No loss of by products that are needed
- More standardized products, and thus, liquid markets foreseeable
- More diversification possible due to many possible suppliers
- Benefit from comaparative advantage without loss of whole industries.

Egerer, J., V. Grimm, N. Farhang-Damghani und P. Runge (2023b), **The Industry Transformation from Fossil Fuels to Hydrogen will reorganize Value Chains: Big Picture and Case Studies for Germany,**

WHICH PRODUCTS TO IMPORT?

GERMAN COUNCIL of Economic Experts





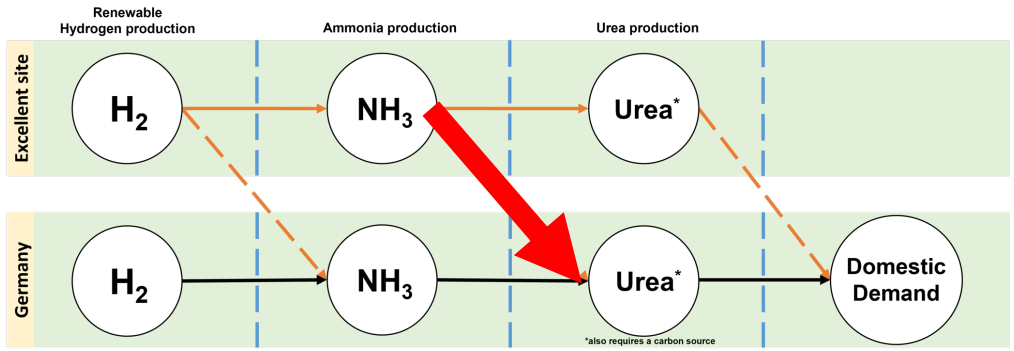
Import substitution very early in the value chain has advantages:

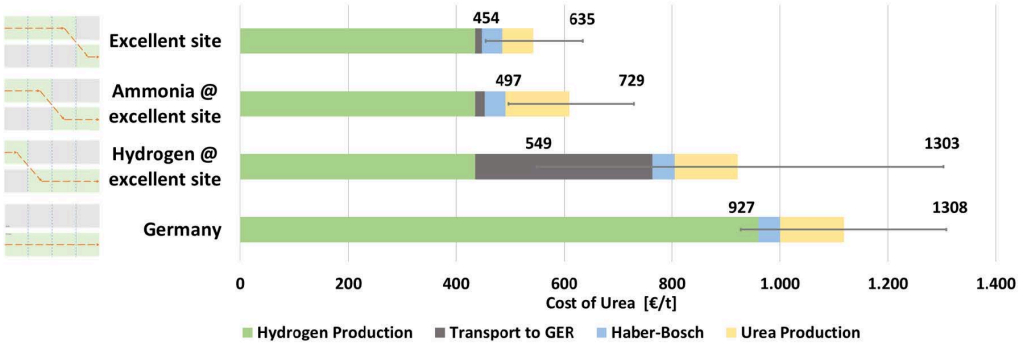
- No loss of by products that are needed
- More standardized products, and thus, liquid markets foreseeable
- More diversification possible due to many possible suppliers
- Benefit from comaparative advantage without loss of whole industries.

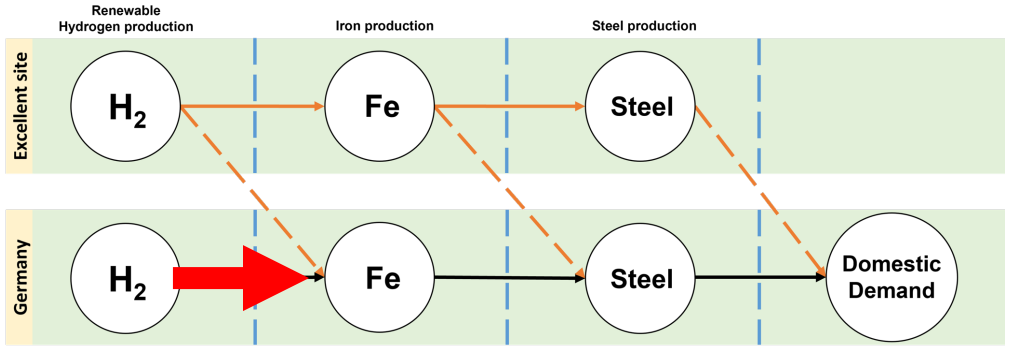
Egerer, J., V. Grimm, N. Farhang-Damghani und P. Runge (2023b), **The Industry Transformation from Fossil Fuels to Hydrogen will reorganize Value Chains: Big Picture and Case Studies for Germany,**

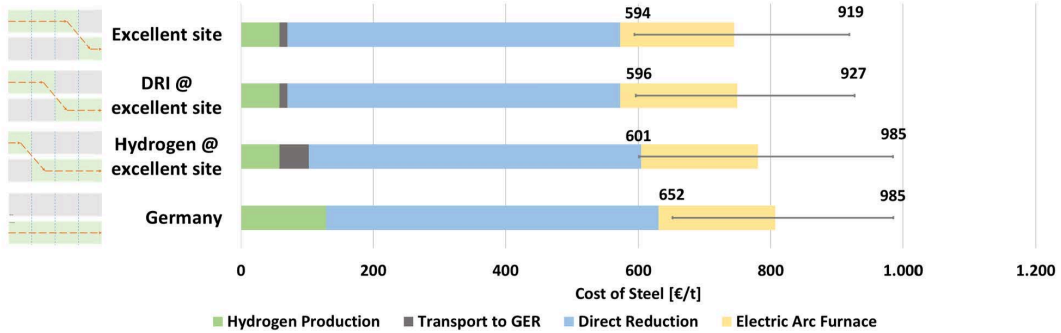
BUT: ENERGY INTENSIVE INDUSTRIES ARE HETEROGENOUS

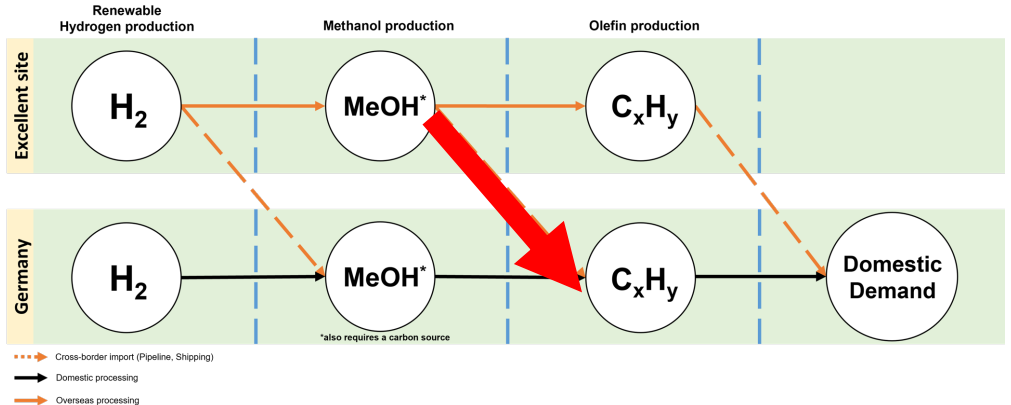
Egerer, J., V. Grimm, N. Farhang-Damghani und P. Runge (2023b), **The Industry Transformation from Fossil Fuels to Hydrogen will reorganize Value Chains: Big Picture and Case Studies for Germany,**

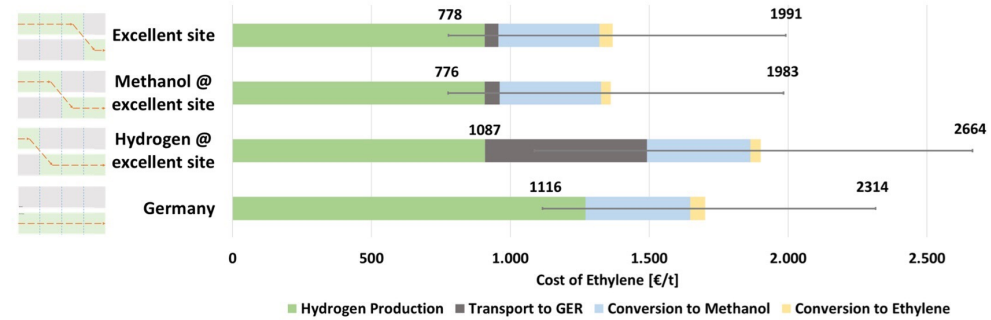












WHERE WE STAND

GERMAN COUNCIL of Economic Experts

Current situation

- **Chicken-Egg-Problem** (Simultaneous ramp-up of supply/logistics/demand)
- **Certification** unclear and internationally not harmonized
- Various **new players** with interesting RES potential but not enough access to capital
- **Big players** (may) attempt early deterrence
- Market power on related markets for fossile commodities
- No natural commoditycurrently traded to link the prices to

Questions to tackle

- **Which products** to import?
- **Geopolitical risk** (how to deal with it)?
- How to **avoid the relocation** of entire production sites?
- **Pipeline vs Ship**, supply security issues (particularly with pipelines)?
- should Europe accept (cover) higher financing costs due to country risks in some cases in order to **reduce own supply risk through diversification**?
- How to **avoid windfall profits from subsidies** (i.e. for point-2-point contracts)

DEVELOPING A MARKET FOR CLEAN HYDROGEN

GERMAN COUNCIL of Economic Experts

Markets, Trading and Price Signals

Standardized and transparent trade reduces windfall profits from subsidies in the medium term.

Emission Trading Scheme, CO2 Price and CBAM

A strong CO2 price signal is important to reduce emissions and encourages investment in renewable hydrogen production.

Standardization and certification

Clear and precise sustainability criteria for renewable hydrogen and its derivatives are key for private investment.

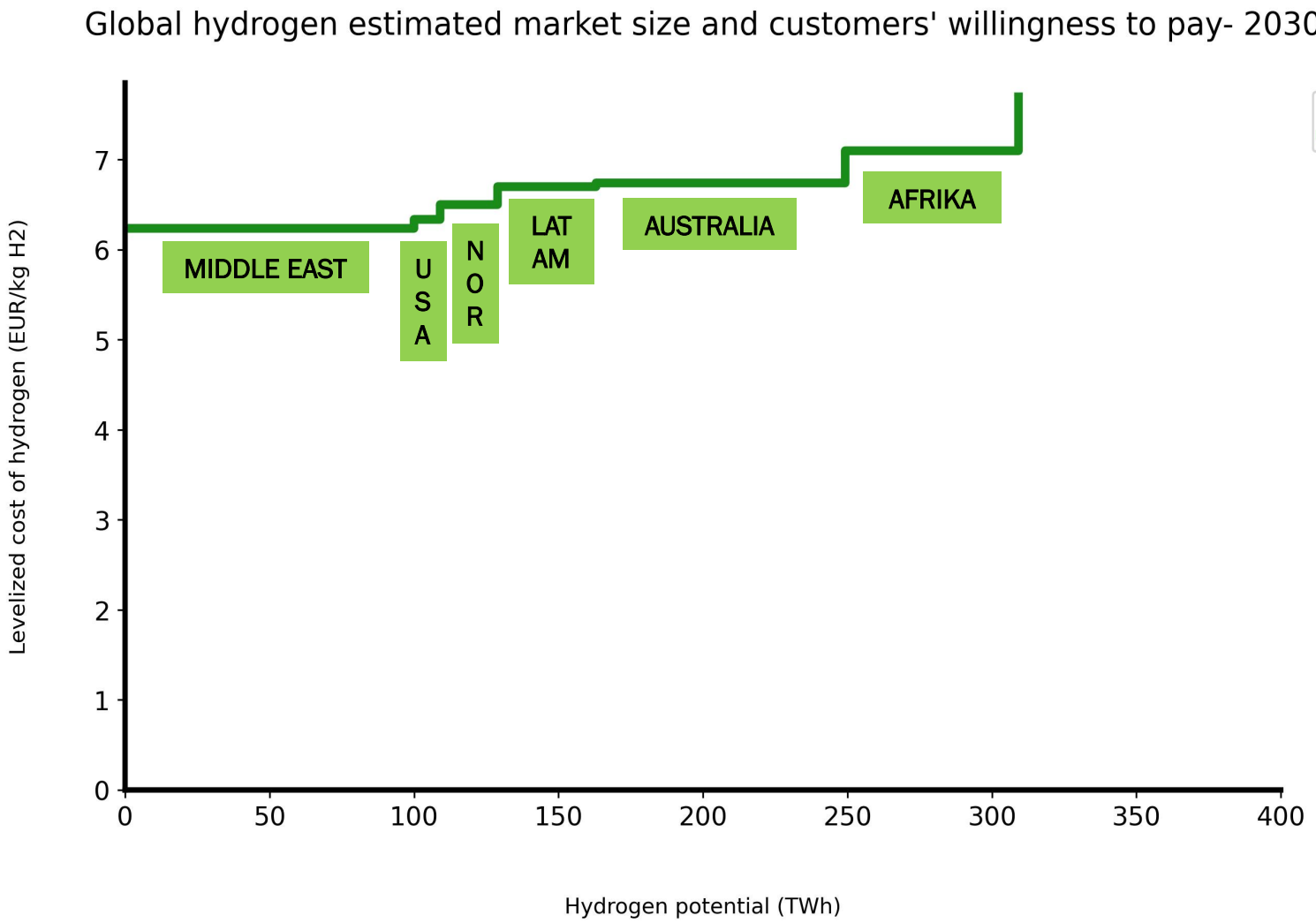
Lessons learned from gas markets

Long-term point-to-point contracts were often rigid and inflexible, making market entry and adaptation to changing market conditions difficult.

H2 GLOBAL TWO SIDED AUCTIONS

HOW MARKETS COULD BE INITIATED

GERMAN COUNCIL of Economic Experts



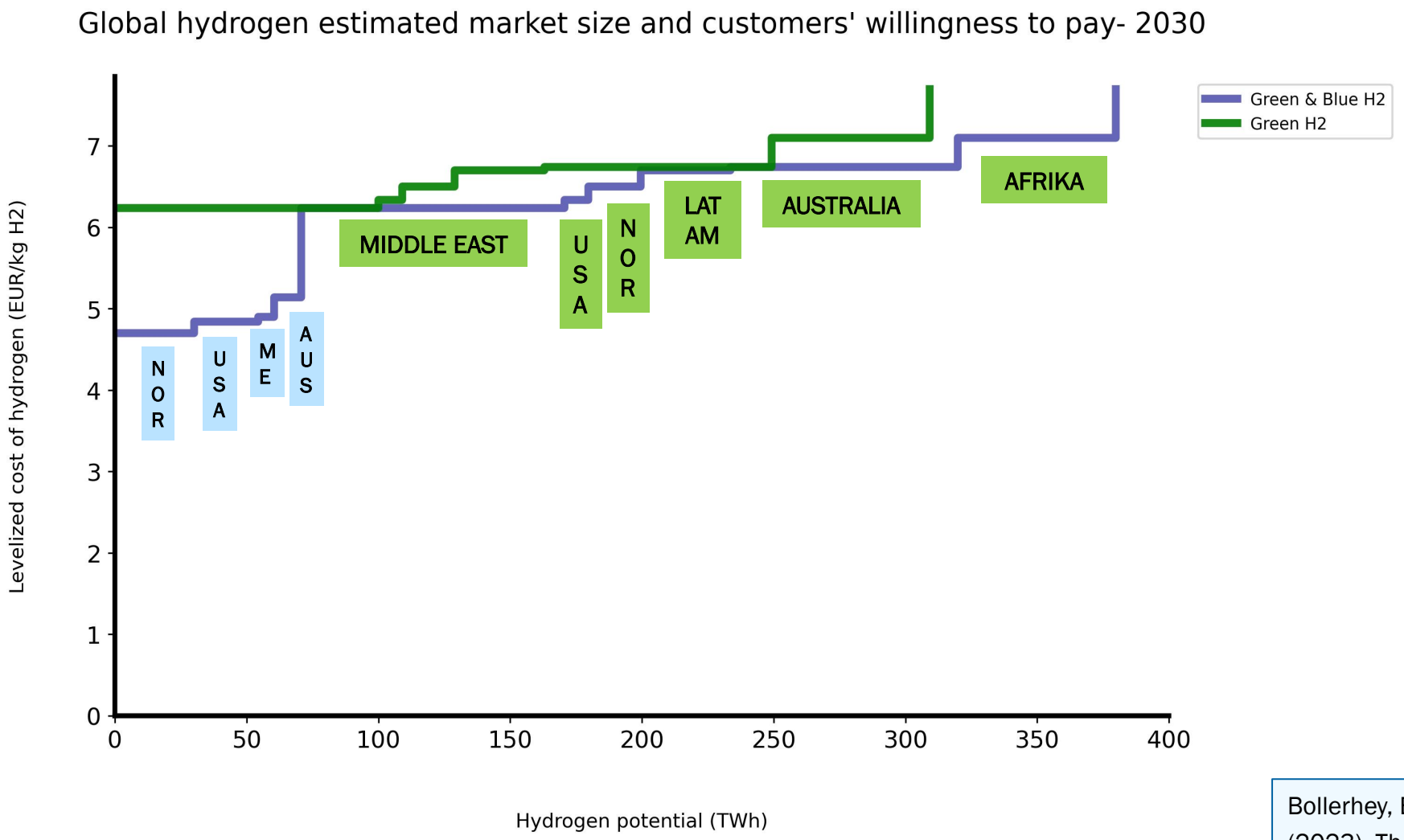
- Worldwide countries prepare to supply **green H2** or derivatives
- **Long-term contracts** are needed to mobilise private capital
- There is very **different access to capital** in different countries.

Bollerhey, Exenberger, Grimm, Sterner, Wragge et al. (2023). The Market Ramp-Up of Renewable Hydrogen and its Derivatives - the Role of H2Global.

H2 GLOBAL TWO SIDED AUCTIONS

HOW MARKETS COULD BE INITIATED

GERMAN COUNCIL of Economic Experts



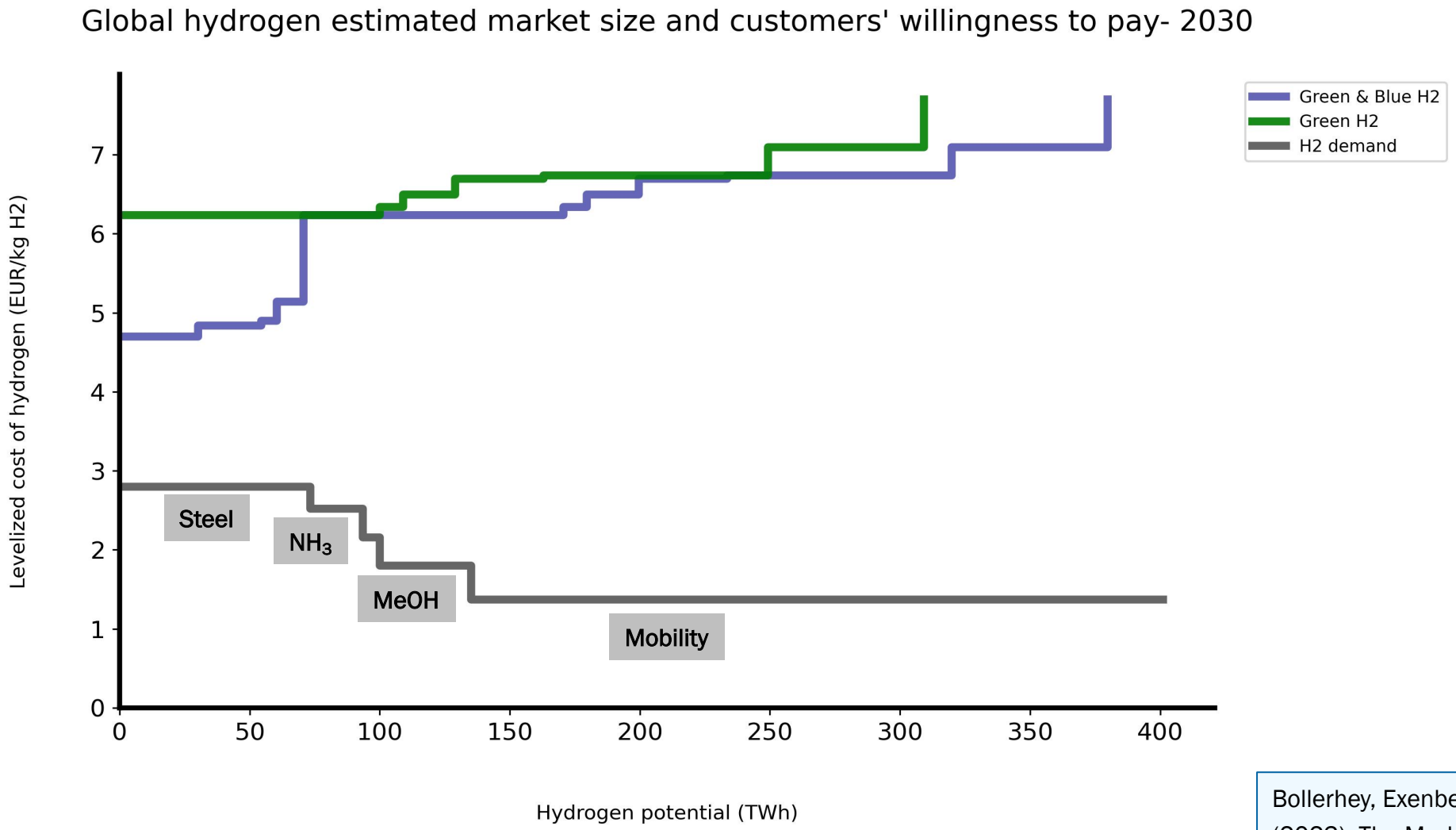
- Worldwide countries prepare to supply **green H2** or derivatives
- **Long-term contracts** are needed to mobilise private capital
- There is very **different access to capital** in different countries.
- Including **blue H2** could increase supply / lower the cost (certification issue!)

Bollerhey, Exenberger, Grimm, Sterner, Wragge et al. (2023). The Market Ramp-Up of Renewable Hydrogen and its Derivatives - the Role of H2Global.

H2 GLOBAL TWO SIDED AUCTIONS

HOW MARKETS COULD BE INITIATED

GERMAN COUNCIL of Economic Experts



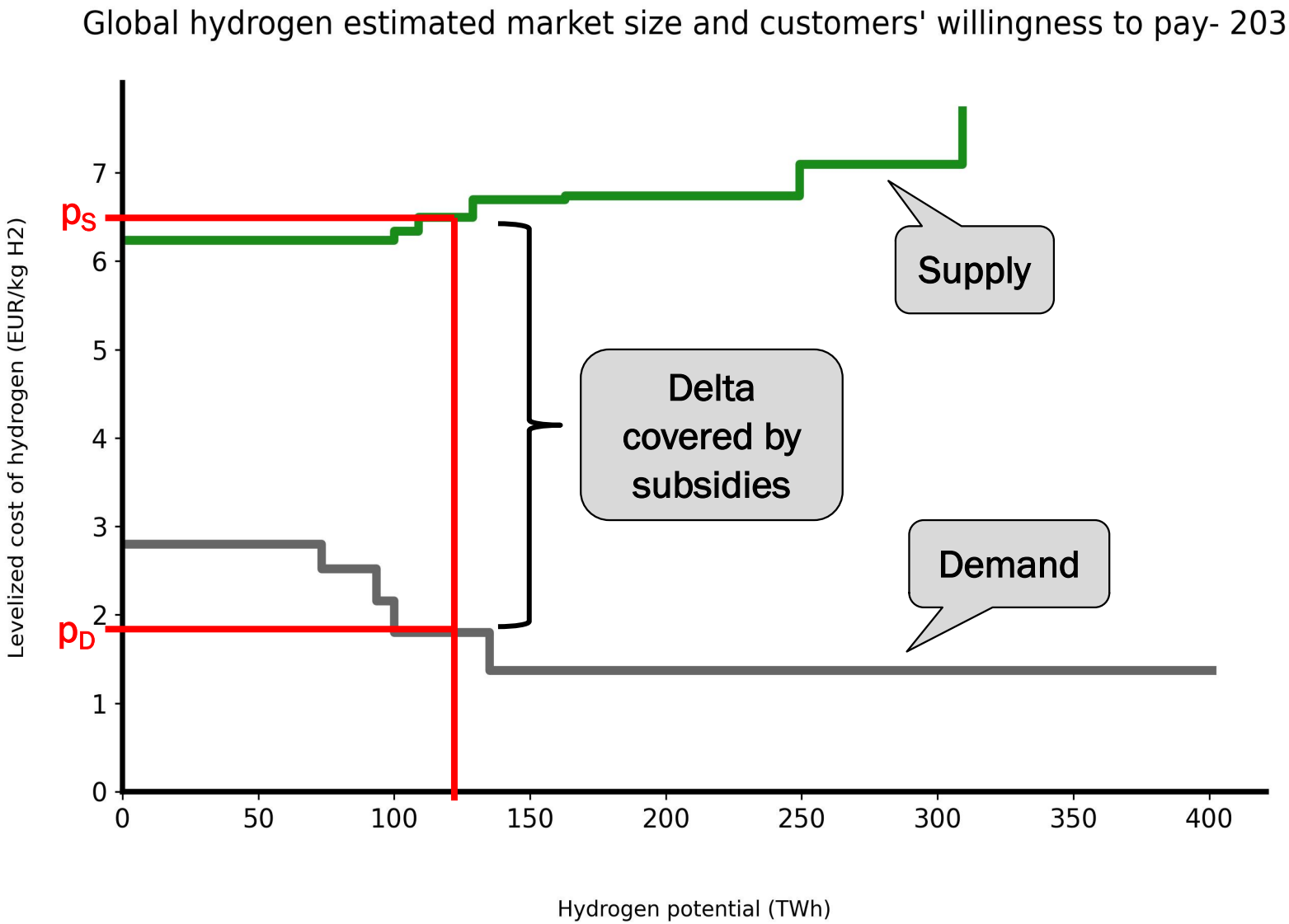
- Today: WTP below cost
- no intersection of supply & demand
- **Subsidies needed** to „close the gap“
- Diversification of imports via **quotas**
- Trading blue and green jointly leads to **windfall profits** for blue H2
- **Maturity transformation** desirable: buy long term, sell short term (more WTP-signals)

Bollerhey, Exenberger, Grimm, Sterner, Wragge et al. (2023). The Market Ramp-Up of Renewable Hydrogen and its Derivatives - the Role of H2Global.

H2 GLOBAL TWO SIDED AUCTIONS

HOW MARKETS COULD BE INITIATED

GERMAN COUNCIL of Economic Experts

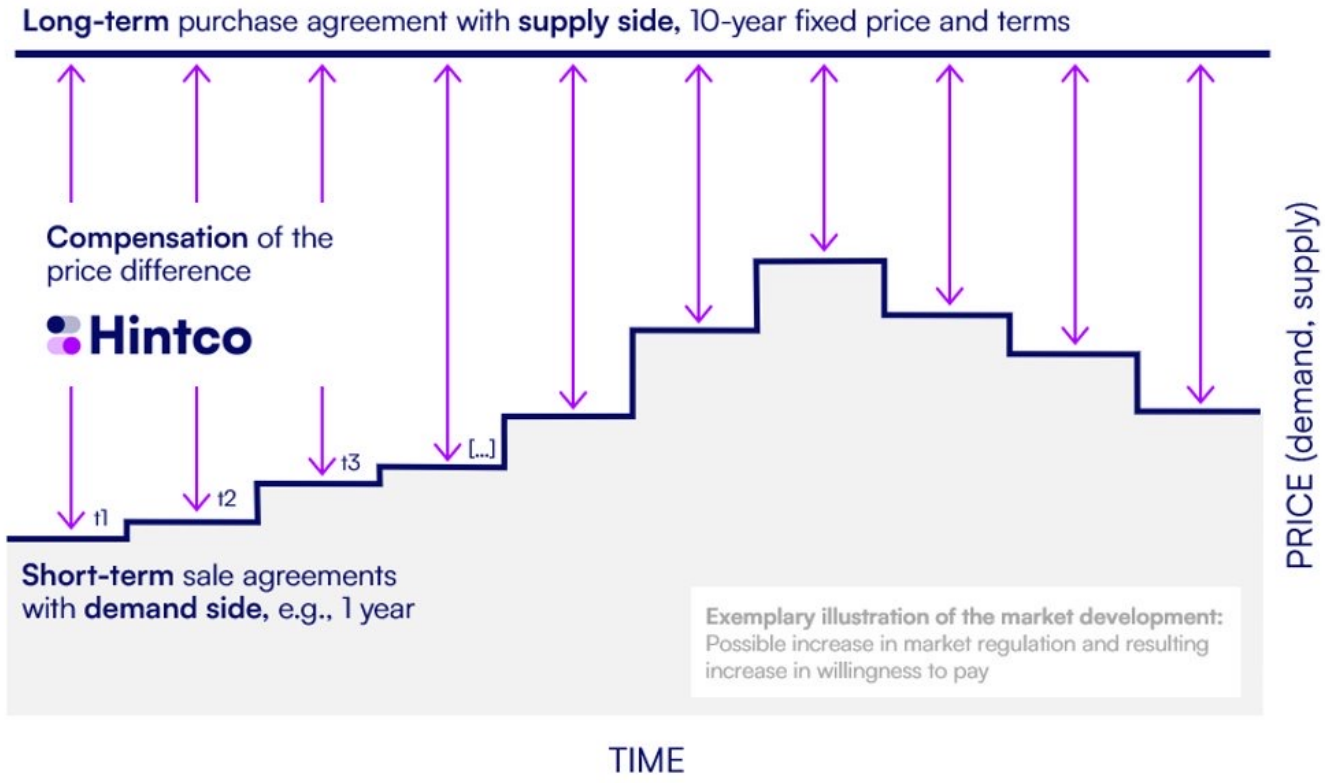


- Today: WTP below cost
- no intersection of supply & demand
- **Subsidies needed** to „close the gap“
- Diversification of imports via **quotas**
- Trading blue and green jointly leads to **windfall profits** for blue H2
- **Maturity transformation** desirable: buy long term, sell short term (more WTP-signals)

Bollerhey, Exenberger, Grimm, Sterner, Wragge et al. (2023). The Market Ramp-Up of Renewable Hydrogen and its Derivatives - the Role of H2Global.

H2 GLOBAL: TWO-SIDED AUCTION

Bollerhey, Exenberger, Grimm, Sterner, Wragge et al. (2023). The Market Ramp-Up of Renewable Hydrogen and its Derivatives - the Role of H2Global.



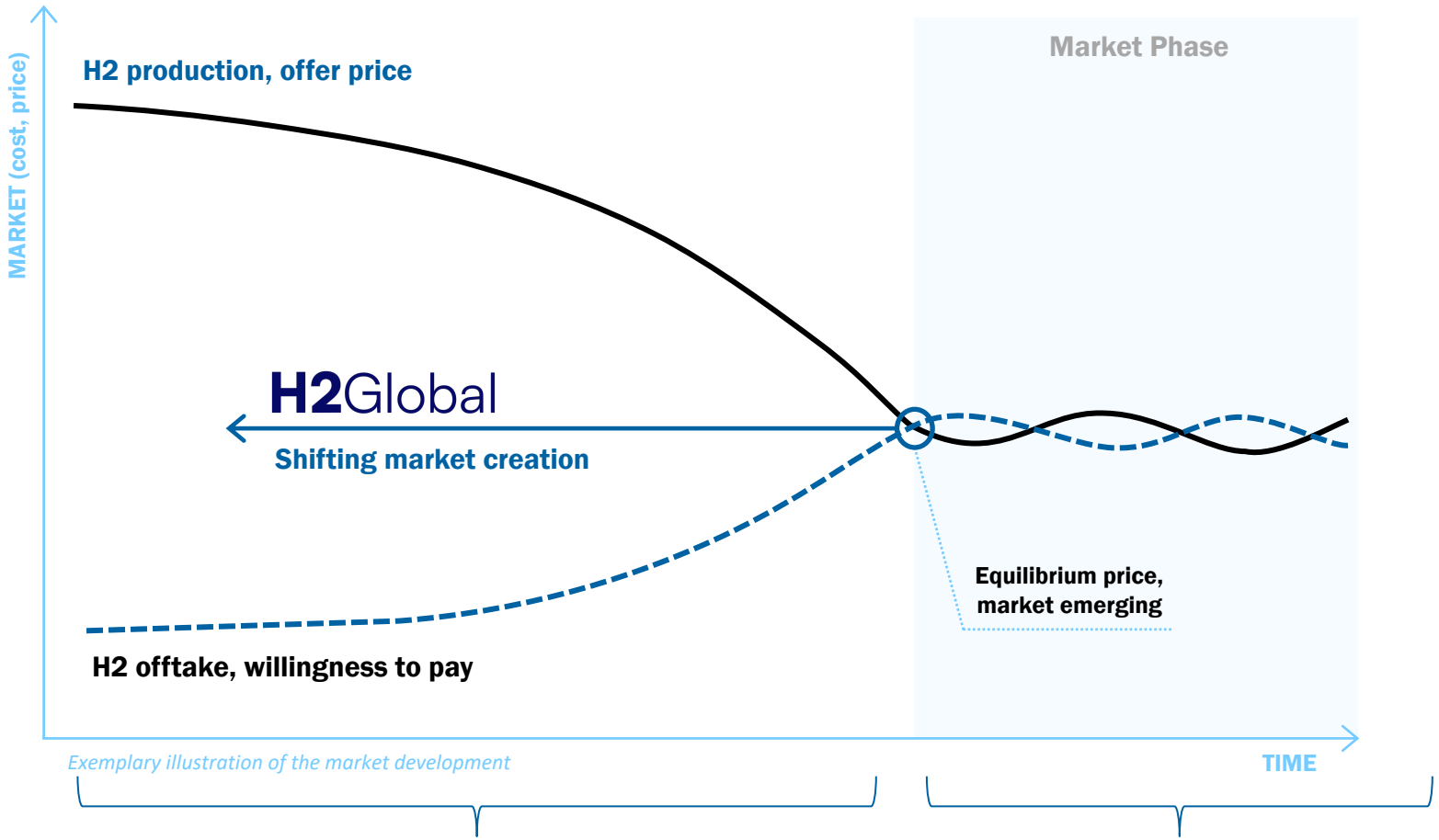
- ↘ Financial volume (€900 million + €3.5 billion) too low in view of the challenge.
- ↘ First tender round (€900 million for ammonia, methanol and sustainable aviation fuels) was launched in December 2022.

Two-sisded “H2Global” auction

- Competition-based instrument: overcoming the “chicken and egg” problem
- **Physical intermediary (Hintco) concludes long-term contracts and short-term offtake contracts via ‘double-sided auction scheme’**
- The cost of difference between production costs and offtakers’ willingness/ability to pay is compensated utilizing public funds
- Funding bodies can define their own criteria (products, geographical regions etc.)

H2GLOBAL'S CATALYTIC EFFECT SHIFTS MARKET CREATION FORWARD ALLOWING EARLY MARKET OPENING

GERMAN COUNCIL of Economic Experts



H2 Index established
- First long term contracts (also for derivatives) can be linked to H2 index
- Subsidies can be linked to index

H2 Indices traded
- Long term contracts for all derivatives can be linked to index

Acceleration transition to exchange based trading:

- Revealation of costs and WTP reduces windfall subsidies.
- H2Global **eliminates regulatory uncertainty** in transition
- Efficient allocation on the buyer side
- Instrument can be used by other donors (states) & for other technologies
- Price signals can be the basis for an **H2 index** …
- … which can also be the basis for **long-term contracts** on the buyer side.
- Global **H2 trade in Euros** as a long term opportunity

THANK YOU FOR YOUR ATTENTION.

GERMAN COUNCIL
of Economic Experts

Visit our websites:

www.sachverständigenrat-wirtschaft.de
www.wirtschaftstheorie.rw.fau.de

https://www.wirtschaftstheorie.rw.fau.de/en/

and follow us on Twitter

@SVR_Wirtschaft or @GCEE_en

@GrimmVeronika

SOME REFERENCES

GERMAN COUNCIL of Economic Experts

Reports

NWR (2022) Assessment of the Inflation Reduction Act. https://www.wasserstoffrat.de/fileadmin/wasserstoffrat/media/Dokumente/EN/2023/2022-12-09_NWR-Position-Paper_Inflation-Reduction-Act.pdf

SVR (2023). Der Inflation Reduction Act: Ist die neue US-Industriepolitik eine Gefahr für Europa? https://www.sachverstaendigenrat-wirtschaft.de/fileadmin/dateiablage/PolicyBrief/Policy_Brief_2023_01.pdf

Bauer, F., T. Bollerhey, J. Egerer, M. Erdmann, M. Exenberger, F. Geyer, V. Grimm, A. Hofrichter, M. Krieger, P. Runge, M. Sterner, J. Wirth und D. Wragge (2023). The Market Ramp-Up of Renewable Hydrogen and its Derivatives - the Role of H2Global. https://www.wirtschaftstheorie.rw.fau.de/files/2023/06/The-Market-Ramp-Up-of-Renewable-Hydrogen-and-its-Derivatives-the-Role-of-H2Global.pdf

Grimm, V. & C. von Rüden (2023). Europe‘s dependence on critical raw materials mus be put to test. https://table.media/europe/en/opinion/europes-dependence-on-critical-raw-materials-must-be-put-to-the-test/

Academic Papers

Runge P., C. Sölch, J. Albert, P. Wasserscheid, G. Zöttl, V. Grimm (2019). Economic comparison of different electric fuels for energy scenarios in 2035. Applied Energy, Bd. 233–234, S. 1078–1093. https://doi.org/10.1016/j.apenergy.2018.10.023

Egerer, J., V. Grimm, K. Niazmand und P. Runge (2023a), The economics of global green ammonia trade – “Shipping Australian wind and sunshine to Germany” Applied Energy, 334 (2023), 120661, https://ssrn.com/abstract=4153386

Schippert, J., P. Runge, N. Farhang-Damghani, and V. Grimm, Greenhouse Gas Footprint of Blue Hydrogen with Different Production Technologies and Logistics Options (July 4, 2022). Available at SSRN: https://ssrn.com/abstract=4153724

Runge, P., C. Sölch, J. Albert, P. Wasserscheid, G. Zöttl, and V. Grimm, Economic Comparison of Electric Fuels Produced at Excellent Locations for Renewable Energies: A Scenario for 2035 (June 10, 2020). Forthcoming, Applied Energy Available at SSRN: https://ssrn.com/abstract=3623514

Egerer, J., V. Grimm, K. Niazmand und P. Runge (2023b), The Industry Transformation from Fossil Fuels to Hydrogen will reorganize Value Chains: Big Picture and Case Studies for Germany, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4390325