GLOBAL H_2-POTENTIAL ATLAS

Sustainable Locations in the World for the Green Hydrogen Economy of Tomorrow: Technical, Economic and Social Assessment of Green Hydrogen Potential

HYPAT

H_2 Potential

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

Ukrainian Hydrogen Export Potential: Opportunities and Challenges in the Light of the Ongoing War

- Agenda:

	TOP	Speaker	Duration
1	Introduction • HYPAT – Who we are and what we do • Current developments in Ukraine	Natalia Sukurova	5 min
2	Ukraine – Socio political assessment on a hydrogen economy	Natalia Sukurova	10 min
3	Ukraine – Techno economic assessment for hydrogen exports	Viktor P. Müller	10 min
4	Conclusions	Viktor P. Müller	5 min

1. The hydrogen economy in Ukraine – Current trends and developments

1.1 Introduction

1.2 Hydrogen Roadmap and Hydrogen Strategy

1.3 Socio-political assessment

HYPAT: Basic Information

- Project duration: March 2021 – February 2024
- Sponsored by Federal Ministry of Education
- 5 Mio. € total budget
- 8 partners from science and institutions :
  - Fraunhofer ISE, Fraunhofer IEG, IDOS, RUB, ESA2, RIFS, GIZ, dena
  - Highly interdisciplinary team
- 75 scientific employees
- 15 advisory board members from politics, industry, science and international organizations
- Project Lead: Prof. Dr. Martin Wietschel, Fraunhofer ISI
  - Vice Project Lead: Dr. Andrea Herbst, Fraunhofer ISI
  - Project Management: Josephine Adam, Fraunhofer ISI
- Further information: www.hypat.de

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HYPAT: Key Research Questions

How can the global potential of importing green hydrogen and synthesis products be economically measured and evaluated?

What environmental aspects and sustainability criteria must be taken into account in a global, green hydrogen economy?

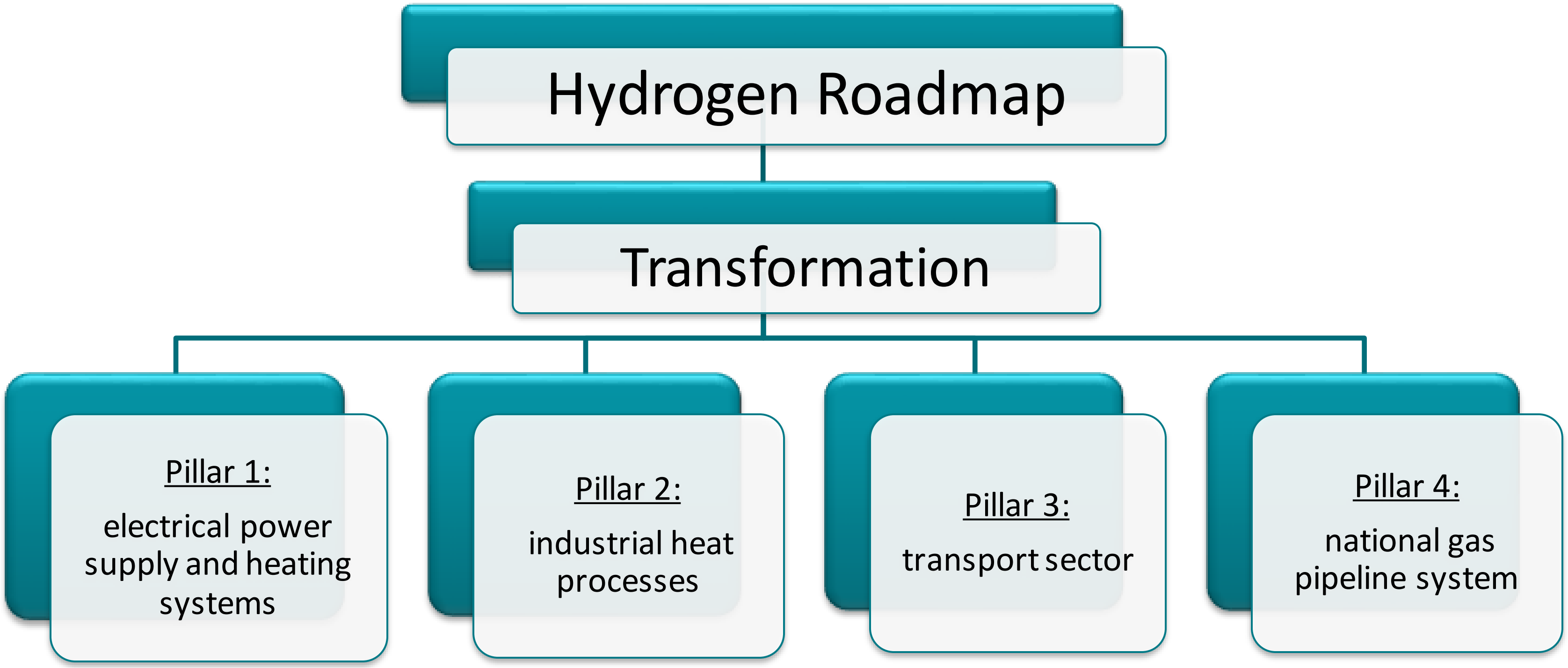
What potentials arise in a globally networked hydrogen economy for the production countries to generate added value, jobs and co-benefits locally?

1.1 Introduction

- For more details on the techno-economic modelling see [HYPAT Working Paper 02/2023]

1.2 Current developments in Ukraine
Hydrogen Roadmap

- **The Roadmap** outlines a path for Ukraine to integrate hydrogen as a new energy subsector.
- It identifies **four pillars** for introducing hydrogen in Ukraine:



- **The Hydrogen Strategy** of Ukraine comprises several key goals, including:

1.3 Socio-political assessment*

Opportunities:

- Driving economic sector
- Key tool for Ukrainian and European energy independence
- Potential hydrogen supplier to Europe

Challenges:

- Regulatory framework
- Potential land-use conflicts
- Fresh water availability
- Social acceptance

**Source:* The results of interviews conducted by Fraunhofer ISI as part of the research activities of the Global Hydrogen Potential Atlas Project (HyPat) with Ukrainian industry stakeholders regarding social acceptance of the production and export of hydrogen by key political, economic and social stakeholders.

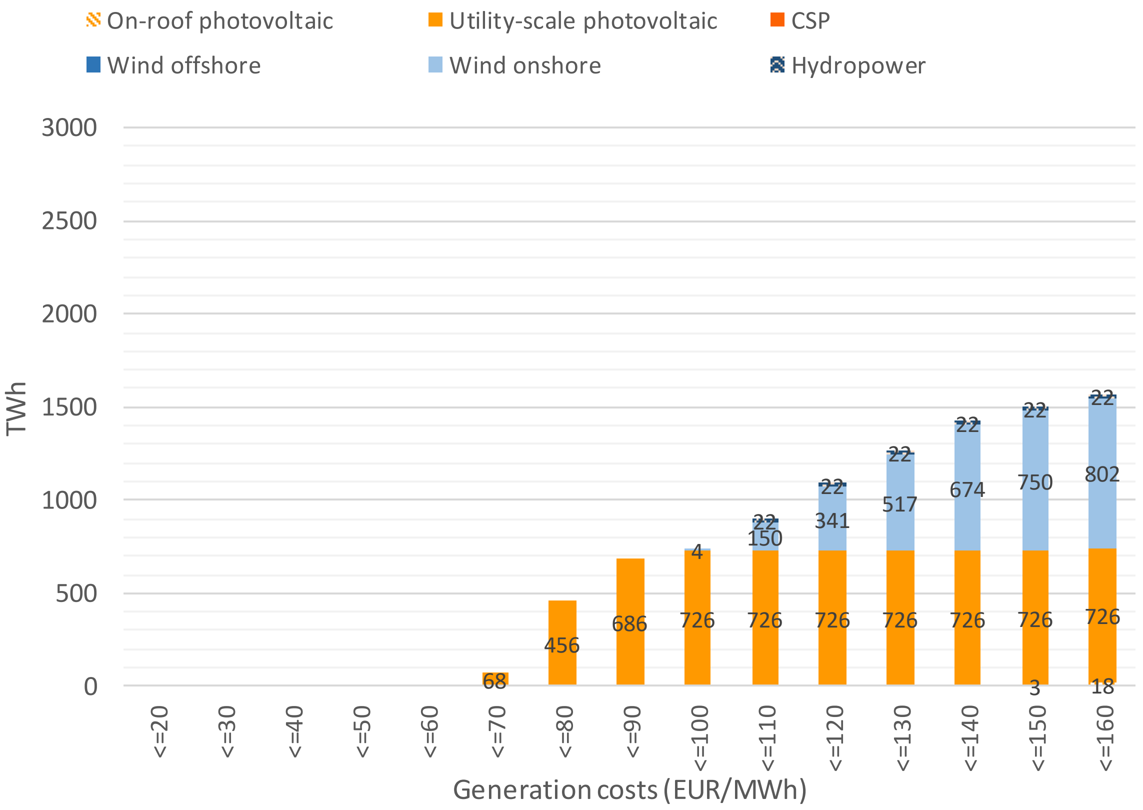
2. Hydrogen export potential of Ukraine – Techno economic assessment

2.1 RE potentials

2.2 Energy demand projections

2.3 Export infrastructure

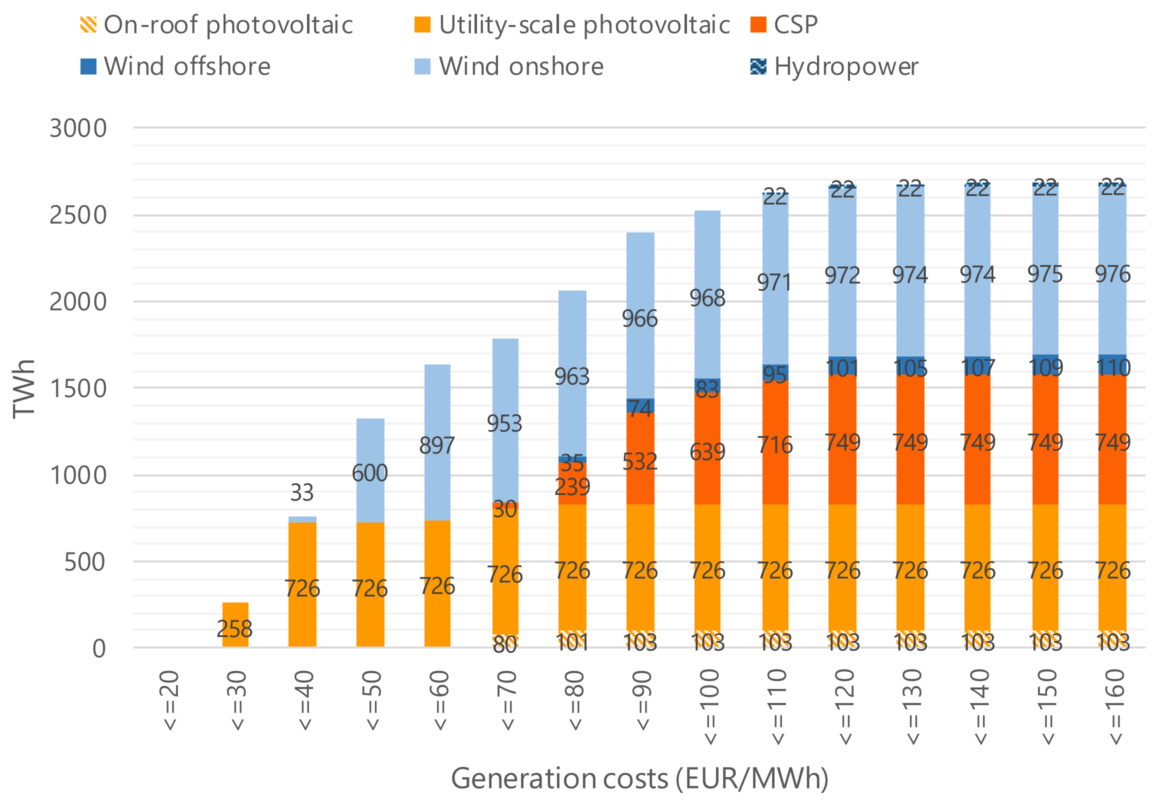
2.1 RE potentials 2050
Cost potential curve - WACC=21.9% (worst case)



- **RE Potential**
  - In contrast, a WACC of 21.9% is the worst-case scenario, assuming both high equity and country risks
  - With such high WACC, there would be no remaining potential at costs below 60 EUR/MWh
  - Only 730 TWh are available at costs below 100 EUR/MWh, mainly solar PV
  - WACC have strong impact on the techno-economic RE potential, especially for more capital intensive technologies like wind turbines
  - --> Keeping WACC low is crucial to guarantee low cost of electricity/hydrogen

1. Damodaran, A., (2016): Country Risk: Determinants, Measures and Implications The 2016 Edition. SSRN Journal. https://doi.org/10.2139/ssrn.2812261.
2. Breitschopf, B.; Thomann, J.; Fragoso Garcia, J.; Kleinschmitt, C.; Hettesheimer, T.; Neuner, F.; Wittmann, F.; Roth, F.; Pieton, N.; Lenivova, V.; Thiel, Z.; Strohmaier, R.; Stamm, A.; Lorych, L. (2022): Import von Wasserstoff und Wasserstoffderivaten: Exportländer. HYPAT Working Paper 02/2022. Karlsruhe: Fraunhofer ISI (Hrsg.).

2.1 RE potentials 2050
Cost potential curve - WACC=4.5% (best case)



- **RE Potential**
  - Utility-scale PV offers the most cost-effective potential for electricity generation, followed by wind onshore.
  - Wind offshore potential is limited and only available at higher cost.
  - Given assumed low WACC of 4.5 %, there is a potential of over 1600 TWh available at costs below 60 EUR/MWh.
  - --> Such low WACCs represent the most optimistic scenario and would require significant improvements in the regulatory framework and investment conditions

1. Damodaran, A., (2016): Country Risk: Determinants, Measures and Implications The 2016 Edition. SSRN Journal. https://doi.org/10.2139/ssrn.2812261.
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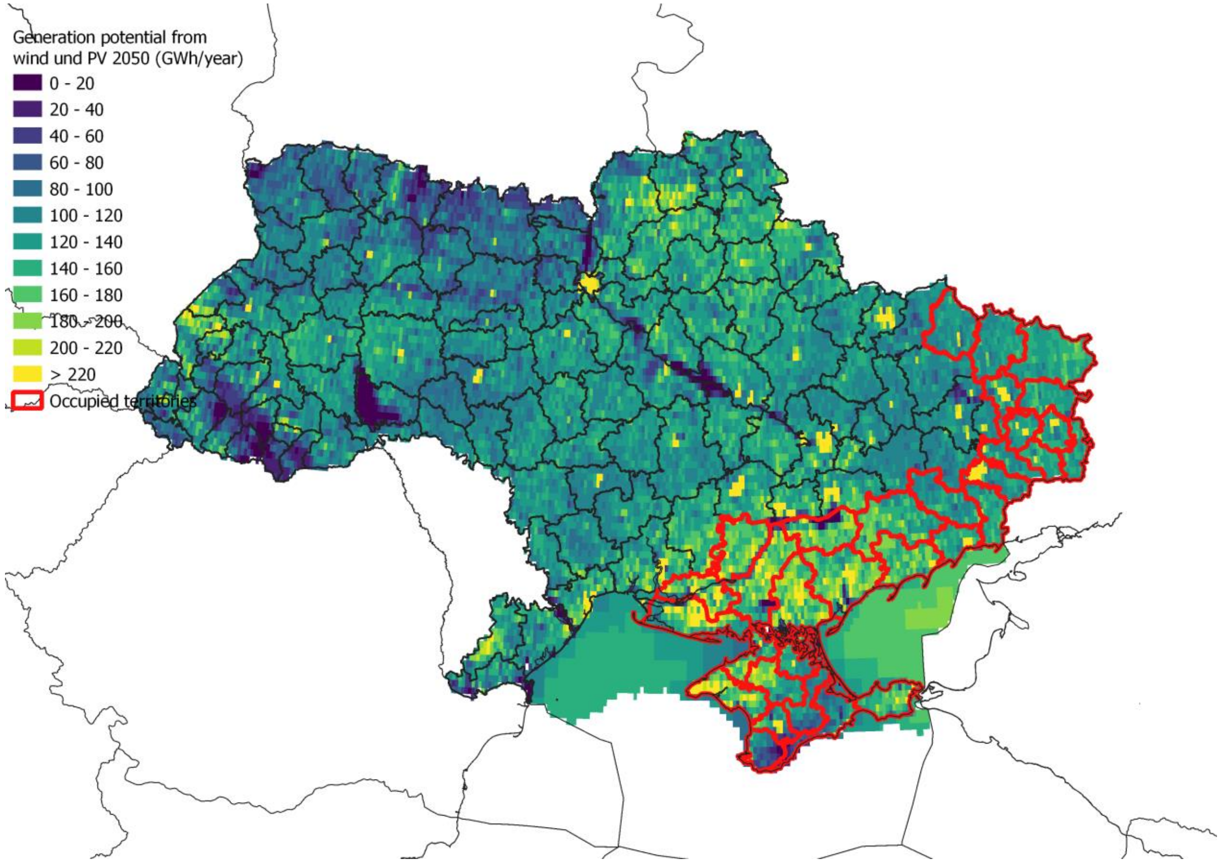
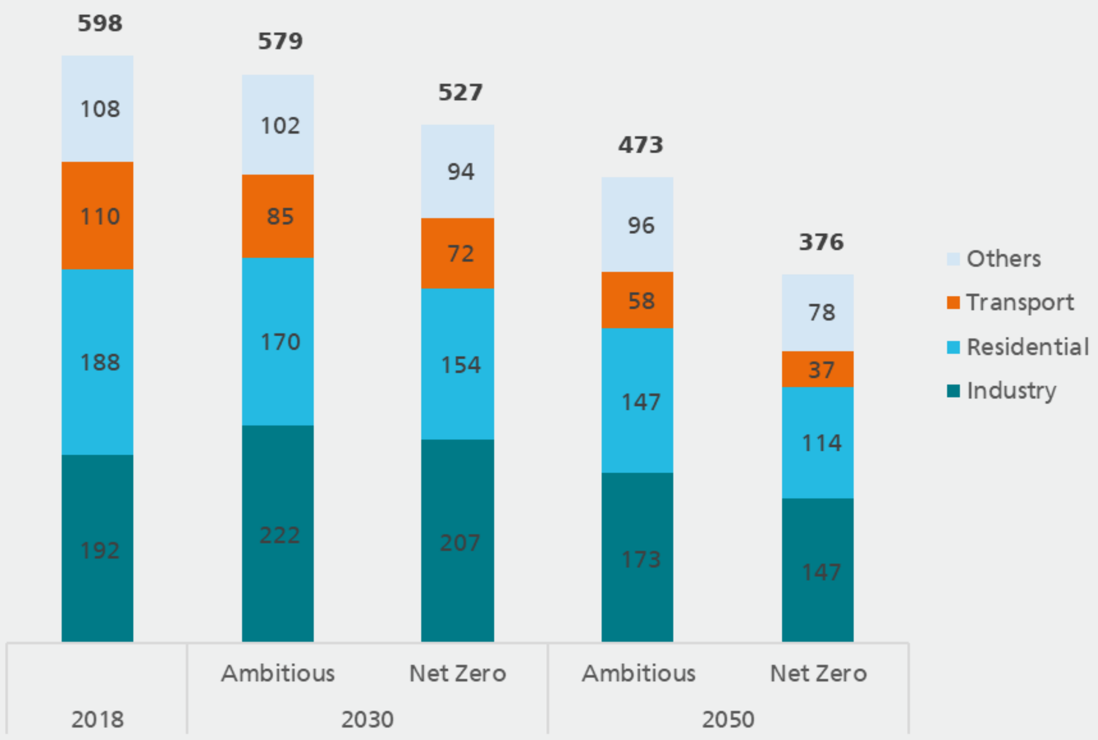
2.1 RE potentials
Geographical distribution



- **Geographical distribution**
  - The southeast region of the country, highlighted in yellow, boasts the best RE potential
  - Nearly 30% of the potential with LCOE under 80 EUR/MWh (WACC = 4.5%) is concentrated in the areas most affected by the war.
  - Notable high-potential areas are also situated in the western and northern parts of the country.

2.2 Energy demand projections
Total final consumption (TFC) by sector

Ukraine 2018, 2030 & 2050: Total final consumption (TFC) [TWh] [1, 2]

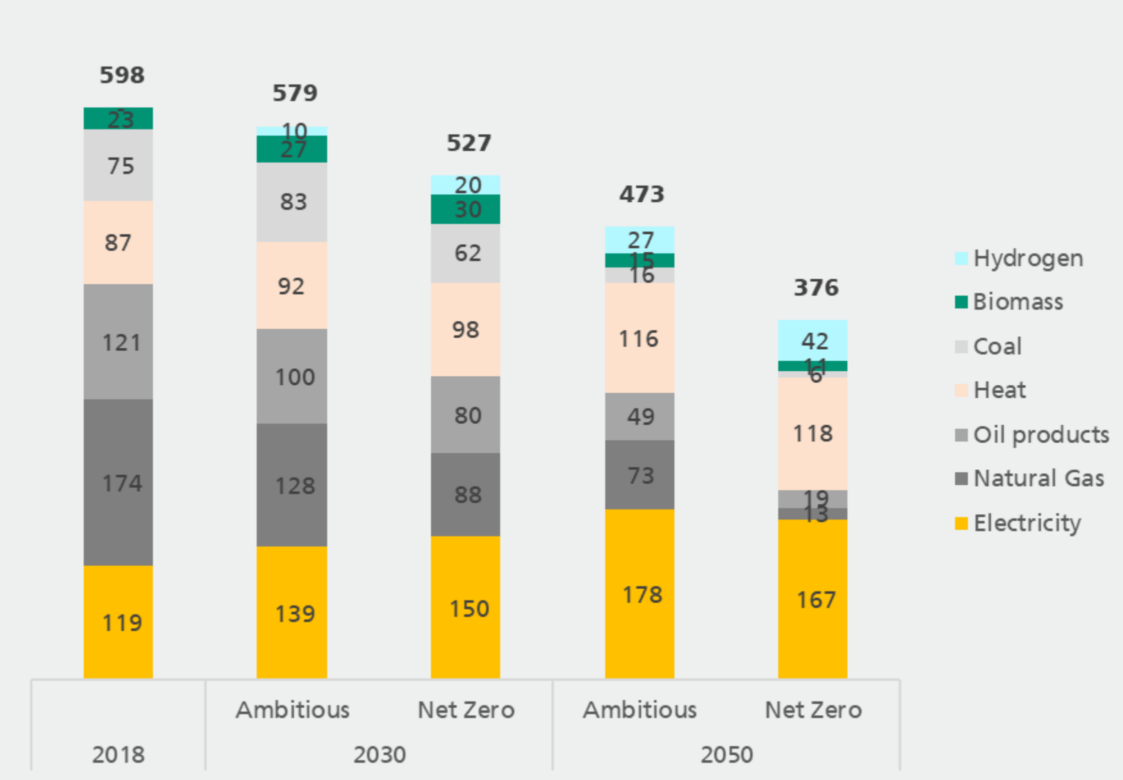


- **Energy demand by sector**
  - Overall energy demand is expected to decrease due to a declining population and energy efficiency measures
  - Industry remains the main consumer, followed by the residential sector
  - Highest energy decline is seen in transportation due to electrification
- **Role of steel production in Ukraine**
  - Steel industry is a major energy consumer (141 TWh in 2019 - 23% of total TFC – 60% of industrial TFC)
  - Strong export orientation (15.1 Mt in 2018)
  - Investments in hydrogen direct reduction plants are an important lever for decarbonization and represent an opportunity for Ukraine to become an exporter of green products

1. FhG Rechnungen (IEG, ISI) basierend auf Enerdata (2022): Global Energy & CO2 Data. A service from Enerdata. Online verfügbar unter Link, zuletzt geprüft am 29.06.2022.
2. Kriegsauswirkungen sind unberücksichtigt Der stoffliche Einsatz von Energieträgern ist inbegriffen.

2.2 Energy demand projections
Total final consumption (TFC) by fuel

Ukraine 2018, 2030 & 2050: Total final consumption (TFC) [TWh] [1, 2]



- **Energy demand by fuel**
  - To reduce CO2 emissions and dependence on fossil fuels (especially natural gas) by 2050, direct electric solutions (BEVs, heat pumps, industrial processes) are preferred wherever possible due to higher efficiency
  - In addition, further expansion of the existing district heating network is assumed, especially for space heating in buildings
  - Where direct electrification and heat grids are not suitable (e.g., primary steel production, renewable ammonia for fertilizer), the use of hydrogen will also be required
  - In contrast, a broad application of hydrogen in road transport or in the building sector seems highly unlikely
  - --> Hydrogen is not the best choice for all applications

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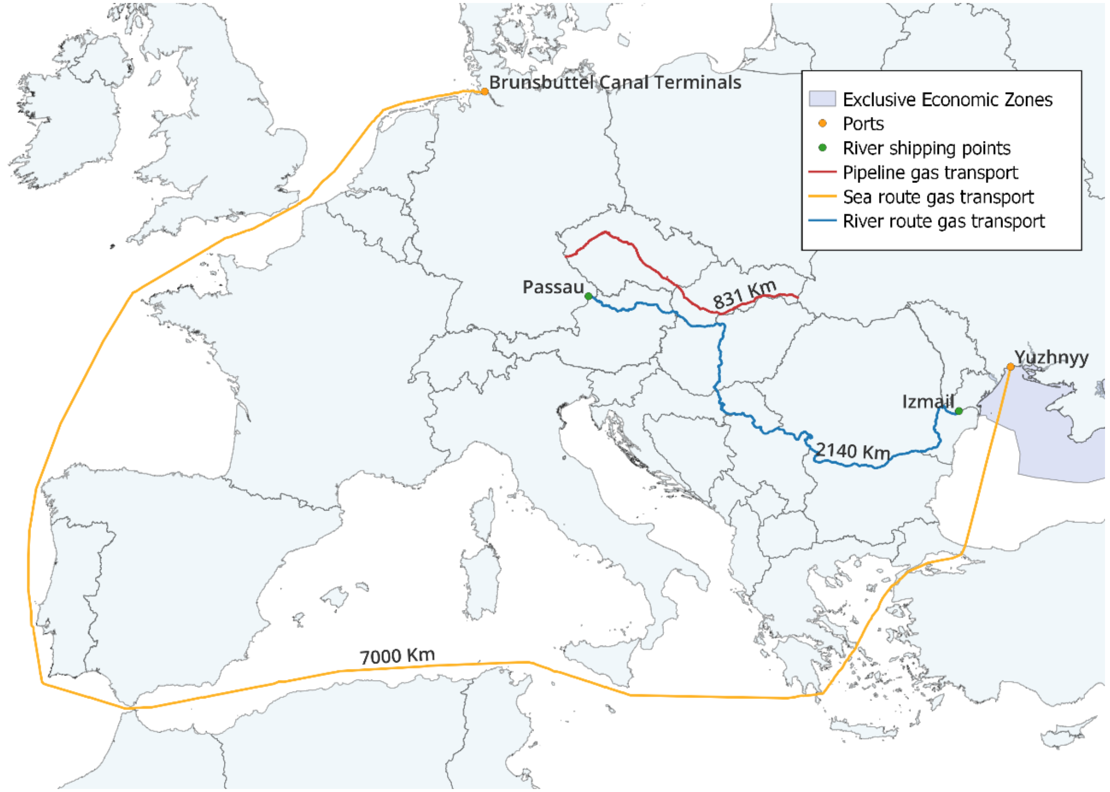
2.3 Export infrastructure
Transport options



1. Lahmann, F. (n.d.). Binnenschiffstypen. Schiff und Technik. Online available at http://www.schiffundtechnik.com/lexikon/b/binnenschiffstypen.html last acces June 30, 2022.

2. Bow Pioneer. Odfjell. Online available at https://www.odfjell.com/tankers/fleet/bow-pioneer/ last access June 30, 2022.

1) Pipeline transport

- Existing natural gas infrastructure as a competitive advantage for Ukraine's hydrogen exports (initial estimate assumes a transport capacity of 260 TWhH2/year via the 831 km transgas route)

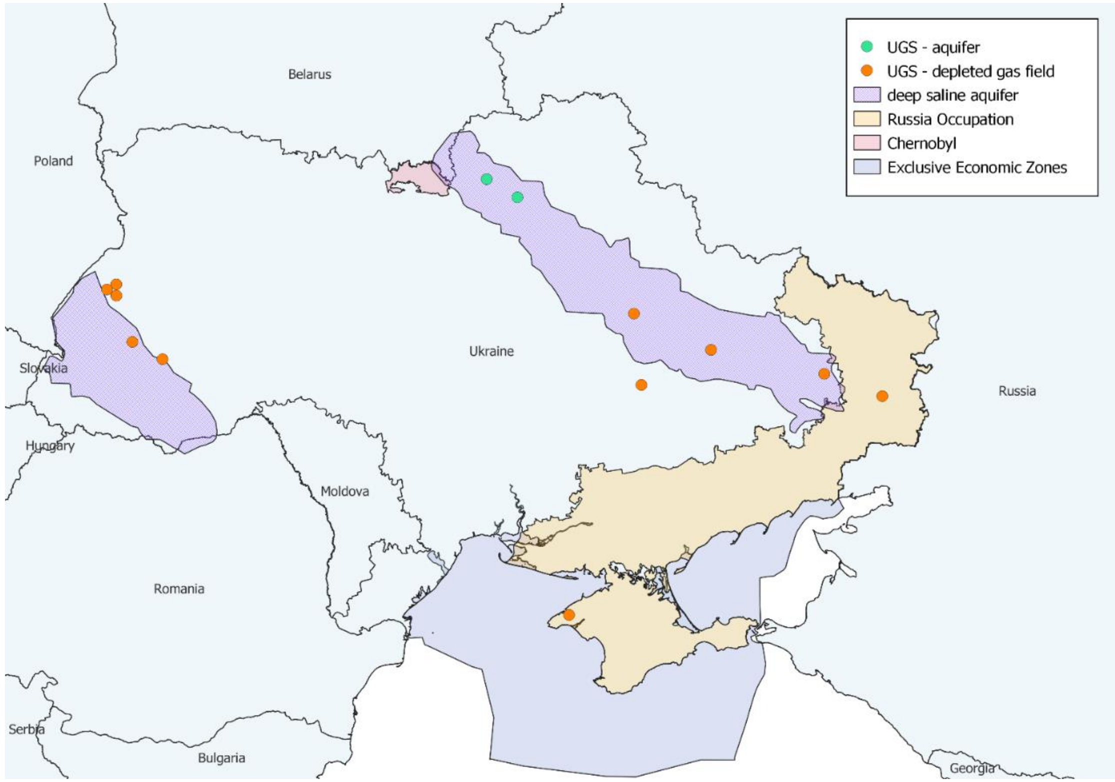
2) River shipping via Danube

- Might be interesting for initial smaller projects with different consumers along the route

3) Sea shipping

- Very unlikely for hydrogen due to the significantly longer distance and associated higher costs, but possible option for downstream products such as ammonia or green steel --> existing ammonia terminal in Yuzhne

2.3 Export infrastructure H2 storage potential



- **Existing natural gas storage**
  - Ukraine has the largest underground gas storage (UGS) capacity in Europe with about 327.9 TWh (natural gas) at thirteen storage sites connected to the existing pipeline infrastructure.
- **Repurposing for hydrogen use**
  - Converting all sites to hydrogen storage would result in a working gas capacity of about 109 TWh (hydrogen).
  - Locations in the north and west of the country align well with the potential for low-cost RE
  - However, natural gas and hydrogen compete with each other for storage and pipelines, as it is not possible to operate infrastructure for both gases in parallel
  - --> More detailed investigations needed on feasibility and timing

CONCLUSIONS

H2 Potential

Socio political assessment :

- The development of green hydrogen production capacities as well as exports could contribute to the revitalization of territories and overall socio economic growth
- Key instrument for Ukrainian and European independence from Russian energy suppliers
- Hydrogen Roadmap and Hydrogen Strategy of Ukraine lay the foundation for the partnership with EU
- Challenges: legislative framework, potential land-use conflicts, fresh water availability, social acceptance

Techno economic assessment:

- Ukraine has a high RE potential and existing gas infrastructure (pipelines and storage), which could be repurposed
- Besides hydrogen especially green steel and ammonia could be interesting downstream products due existing know-how and infrastructure
- Reliable investment conditions and resulting low WACC are a key factor to compete with potential suppliers with similar or better production and export conditions (e.g. Norway, Spain, MENA region)
- The state of the existing infrastructure and its potential for conversion to future hydrogen use need to be studied in more detail

CONTACT

Thank you for your attention!

Dr. Natalia Sukurova
Fraunhofer ISI
natalia.sukurova@isi.fraunhofer.de

Viktor Paul Müller
Fraunhofer ISI
viktor.paul.mueller@isi.fraunhofer.de