Rally to the Valley Establishing Hydrogen Value Chains for the Nordics (Nord_H2ub)

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Nordic
Hydrogen Valleys
as Energy Hubs

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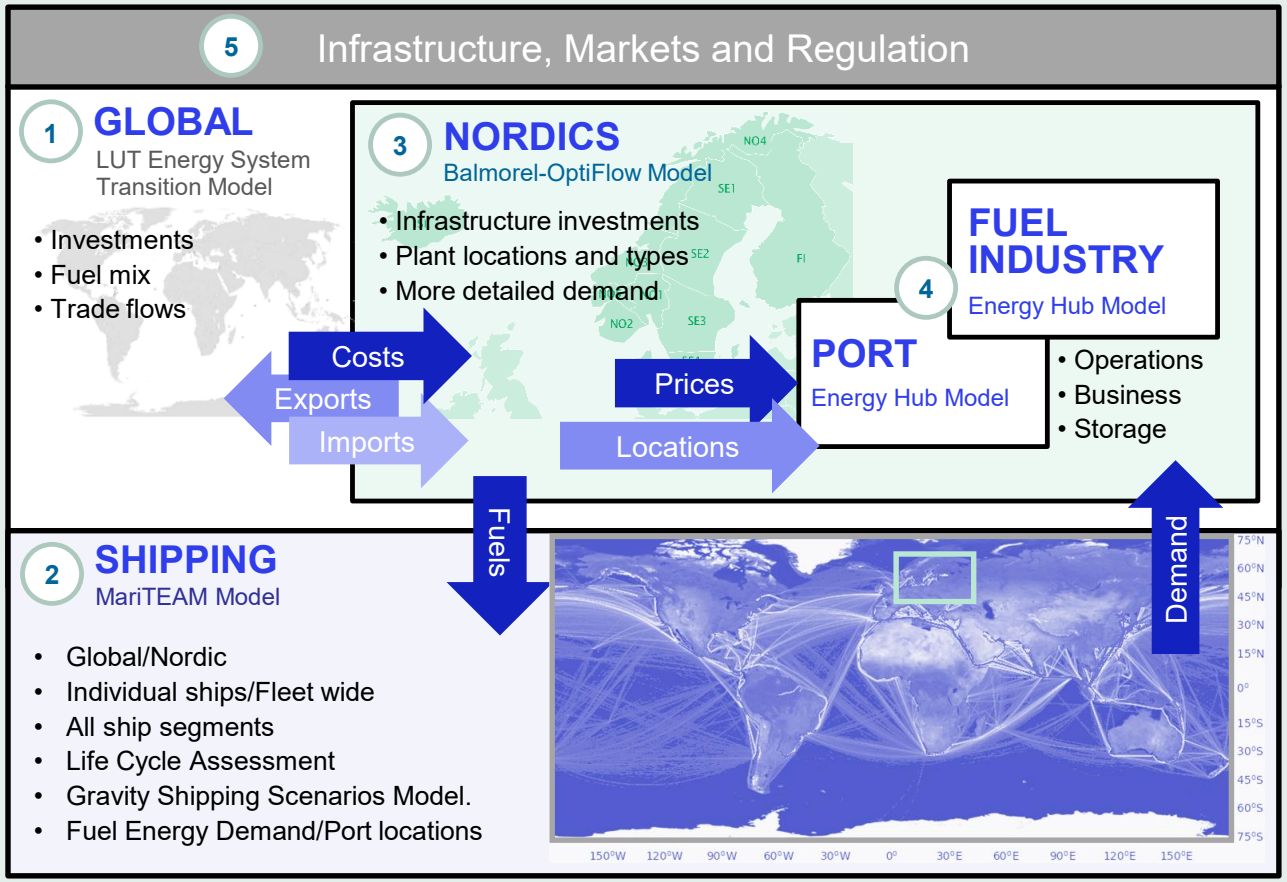
Recommendations & Takeaways

Green fuels require coordinated system transformation

- System Perspective:
  - **PV becomes cost-competitive in the Nordics,** reducing storage needs and fuel costs.
  - Electricity supply, carbon availability, and pricing determine outcomes.
  - Strong demand growth in **maritime & aviation increases decarbonisation challenge.**
  - **European energy security ambitions** create export potential for Nordic synthetic fuels.
  - **Carbon-based fuels outperform pipeline** transport of hydrogen (except for hydrogen from Denmark).
- Maritime & Transport Perspective:
  - **Emission pricing drives fuel choice**: electrification for short, synthetic fuels for long distances.
  - Aligned maritime **regulation should prioritise defossilisation** over offsetting and CCS.
  - E-Kerosene becomes competitive by 2040–50 (with pricing); e-H_2 remains costly.
- Infrastructure and Economic Regulation
  - Green fuels not yet cost-competitive → require policy support.
  - Defossilisation requires **coordinated scale-up** of fuels, infrastructure, and propulsion technologies.
  - Policies should **prioritise low-cost renewables, clean power supply, and carbon sourcing.**

Hydrogen value chains focusing on the maritime sector



1. The **current use of hydrogen** must become renewable.
2. The (long-haul) **maritime sector** is a potential application area due to the lack of better alternatives. Currently, it remains unclear which fuels will prevail for this.

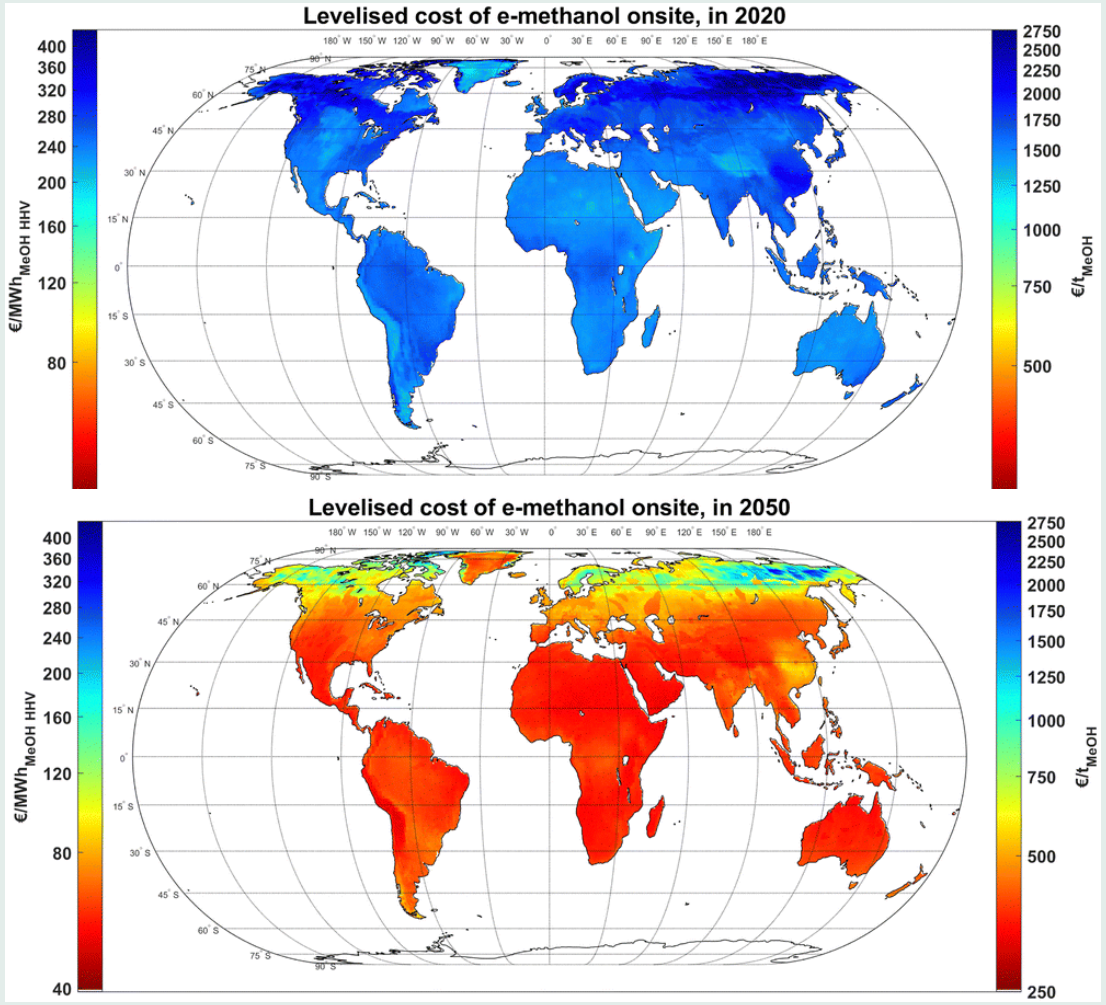
WP 1: LUT University, stl
WP 2: NTNU, stl
WP 3: DTU, LUT University, NTNU, CBS, Port of Roenne
WP 4: CBS, DTU, Port of Roenne
WP 5: NTNU, NHH, CBS, stl

Nordics with Export Potential

European energy security and system design enable Nordic fuel exports

- Long-term competitiveness of green fuels
  - **PV-dominated** power supply drives cost reduction.
    - PV becomes a viable part in the Nordics.
    - Counterbalancing the seasonality of wind.
  - Green fuel production scales with **low-cost CO_2 and CO_2 pricing.**
  - The **Nordics can become a supplier of derivatives for Europe** in case of a focus on Energy Security.
    - Finnish and Swedish sustainable carbon sources.
    - Transport of carbon-based fuels outcompetes pipeline transport to central Europe.

- The analysis addresses:
  - **Trade flows** for hydrogen-based green fuels and green chemicals using the LUT-ESTM model,
  - **Supply costs** in the Nordics, Europe, and the global level,
  - **Competition for resources** such as biomass between regions and sectors.

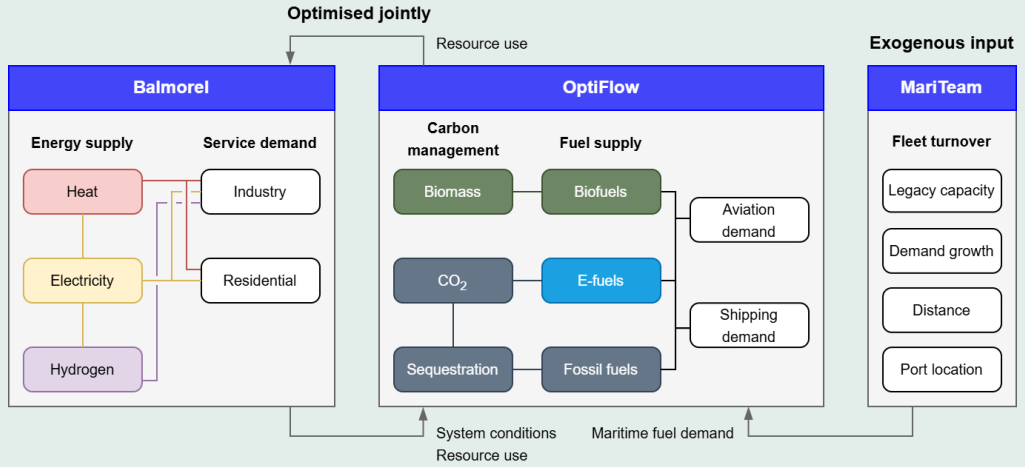


Transition Requires Alignment

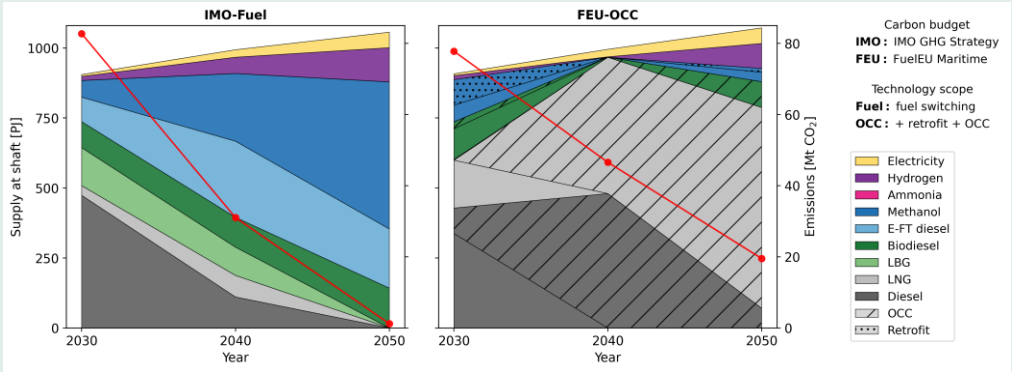
Maritime regulation requires consistent national, European and global approaches

- IMO- and FuelEU Maritime-inspired transition pathways represent contrasting approaches
  - **Shipping remains largely fossil, as offsetting or onboard CCS are more attractive.**
  - Strict shipping mandates are necessary for early and widespread renewable fuel switching
- Infrastructure planning must account for the long-term shipping transition.
  - Decarbonising the sector entails **large, irreversible investments** impacting the energy system.
  - **Lower deployment** in shipping results in approximately **50% less hydrogen production and 30% less hydrogen transmission** in the Nordic region.
- Fuel and technology mix remains diverse across different ship segments.
  - **Electrification** of short-distance routes.
  - **Synthetic or bio-fuels** for long-distance vessels.
  - Shipping segments and distances in between show scenario-dependent fuel shares.

Integrated modelling setup



Nordic maritime fuel mix across pathways

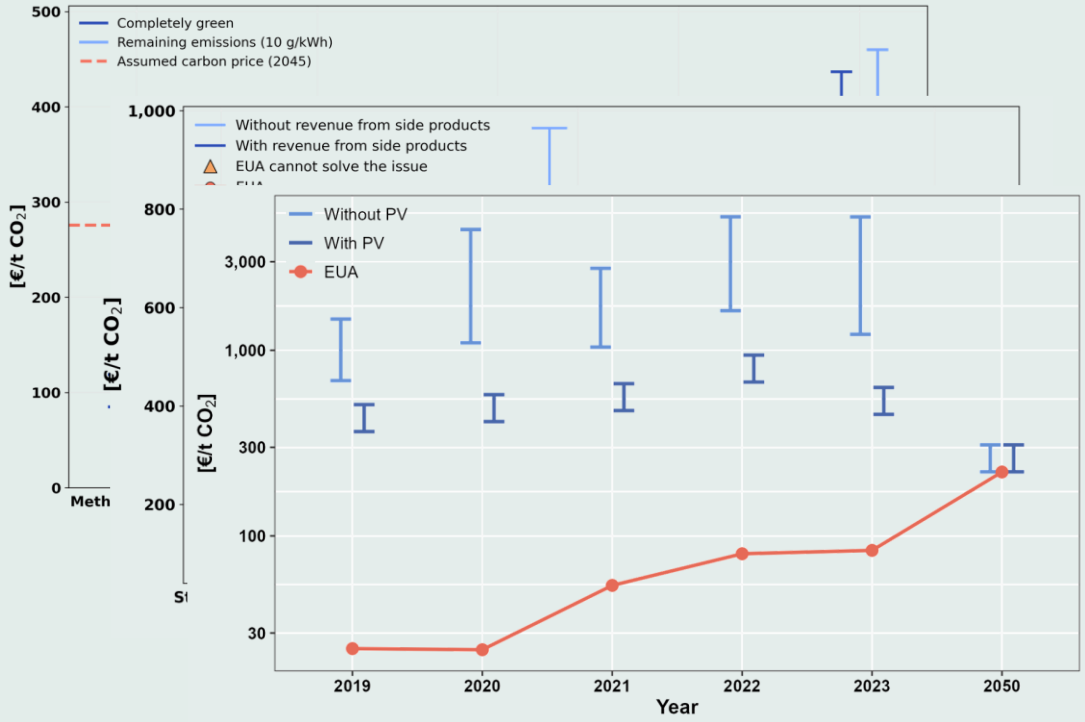


Cost Reduction Alone Won't Deliver

Results highlight trade-offs between flexibility, grid use, and renewable supply

- **Carbon Pricing Alone is Insufficient**
  - Cost-optimal operation can exceed fossil emission levels
  - Required carbon prices (~300–450 €/t CO_2) exceed projected levels.
  - **Need for additional mechanisms** such as fuel mandates, quotas.
- **Electricity, Carbon Intensity & CO_2 Access are Critical**
  - Policies should **prioritise low-cost renewables, clean power supply, and carbon sourcing,** leveraging regional advantages in the Nordic region.
  - Renewable-only systems ensure low emissions but significantly increase costs
- **Integrated Energy Hubs Enable Scale**
  - **Flexibility lowers costs but increases grid reliance,** limiting emission reductions
  - System integration reduces costs and improve performance. Supporting energy hubs, infrastructure, and cross-sector coupling is key to scaling hydrogen-based fuels.

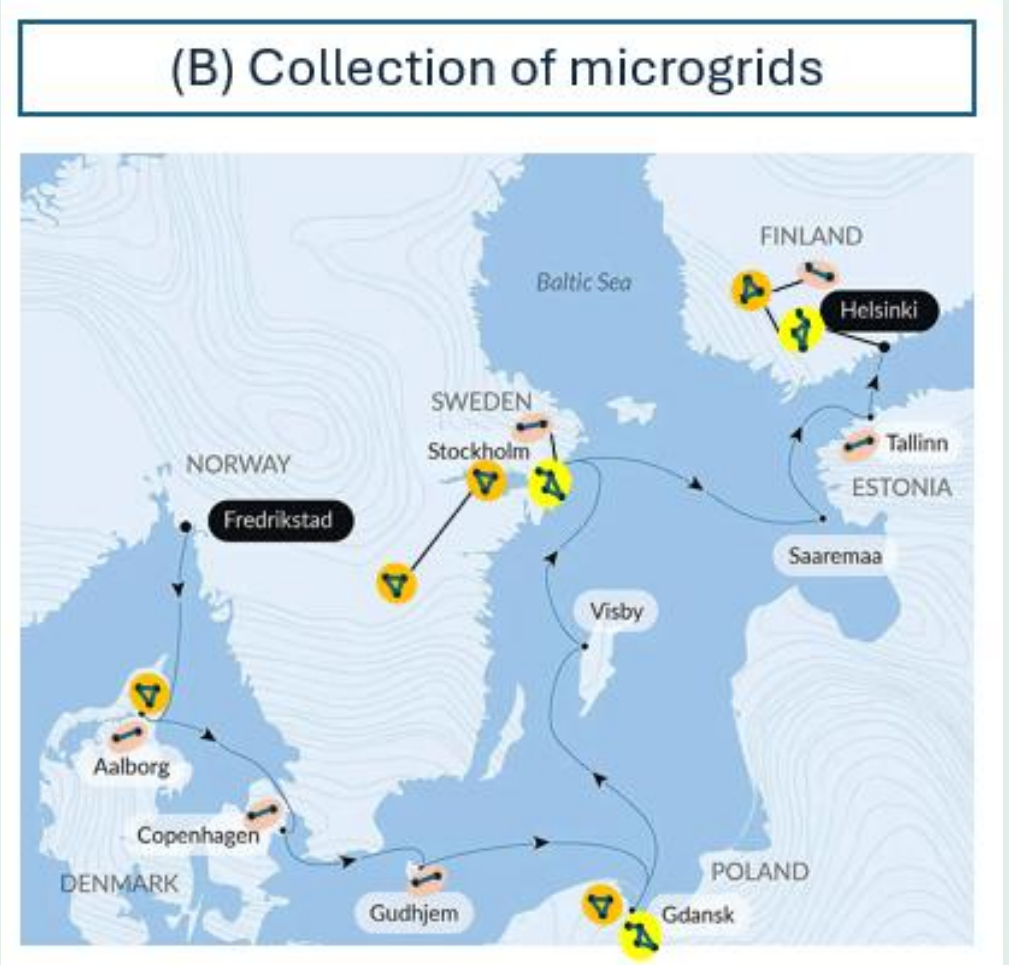
- **Green fuel production is currently not viable**
  - Costs remain high but decline over time
  - Renewable fuel production needs **financial support** and technological advancements to become economically viable.
  - **Renewable fuel quotas** can help make green fuels competitive.
- Carbon pricing and power mix impact the sustainability



Markets Don’t Emerge

Regulation shapes the development, structure, and competitiveness of fuel markets

- Fuel characteristics (H_2, NH_3, e-methanol) drive costs, infrastructure, and market structure
- Lessons from natural gas highlight the importance of early and consistent market design
- The structure of the market depends on which fuels are predominant and how and where they are produced, stored, and transported
- Regulatory instruments are critical to enable market development
  - Contracts,
  - Third-party access to infrastructure,
  - Taxonomy, etc.
- Implement fuel-agnostic rules now; delay fuel-specific regulation



Thank you.

nordhub2

Scientific Partners

Industrial Partners

Observers

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This project is part of the

Nordic Hydrogen Valleys as Energy Hubs Programme

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