McKinsey & Company

Flexible, competitive new demand to unlock the RES pipeline in Finland

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Key messages

1

There is a significant RES pipeline in Finland…

… but it requires (PaP) PPAs to avoid capture price issues and to help secure the financing

2

The demand, mainly PtX, needs to have significant flexibility…

… to reach affordable energy on the system level (SCOE)

3

Energy-intensive projects have often global markets…

…hence also Finnish industrial projects need to understand their global competitiveness

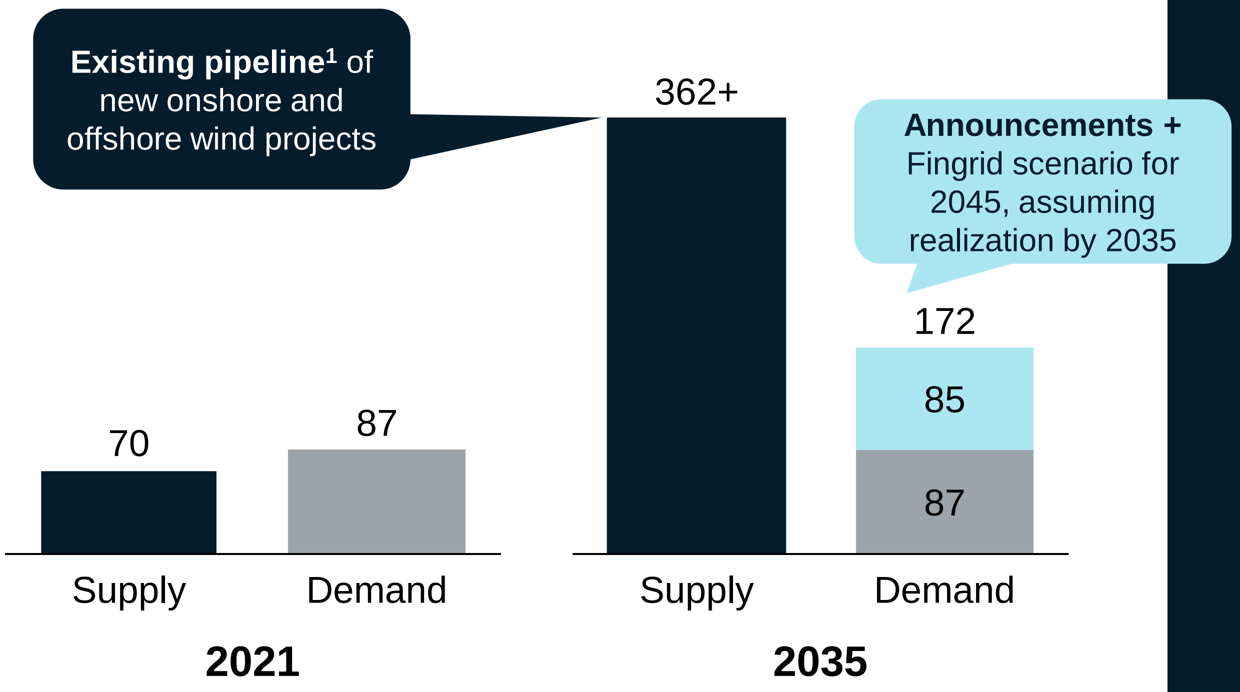
4

Finland has many strengths to build on for RES+industrial growth…

… but the country needs still a step-up on the ambition, execution and coordination to realize the potential

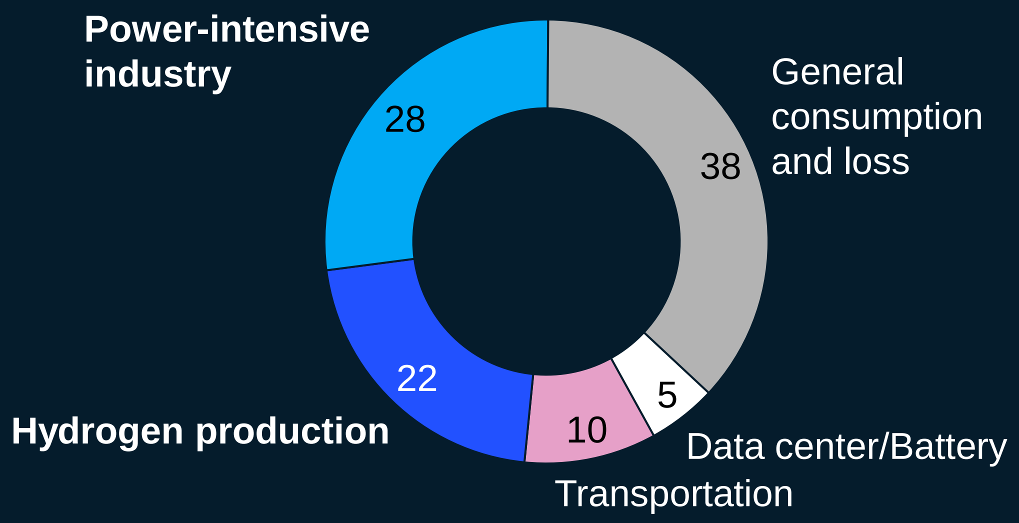
There is a strong, early pipeline of RES supply and demand…

Supply and demand of electricity in Finland, TWh



… new demand being predominantly hydrogen-related

Statnett 2040 Nordic demand scenario, TWh



1. Assuming 63.1 GW onshore and 57.6 GW offshore and 3000 full-load hours

Source: Fingrid's electricity system vision 2023, Svenska Kraftnät, Energiforsk, Sitra, Confederation of Swedish Enterprise, expert interviews, press search, project announcements, company websites, TEM, S&P Global, Suomen Tuulivoimayhdistys

Nordic LCOE expectations look attractive for industrials

LCOE expectations towards 2035, €/MWh

Preliminary

Low-end estimate ● High-end estimate

Source for LCOE	Solar	Onshore wind	Offshore wind[1], bottom fixed	Offshore wind[1], floating
LCOE expectations towards 2035, €/MWh	25-43	20-44	31-55	50-74
Fit for Nordics	**Seasonal solar irradiation levels during the long summer days provide opportunity**	**Low cost compared to other wind alternative**	**Low rock bed but also onshore potential – for giga projects**	**Limited benefit**

1. Assumed no cable connection to coast; 2. Timeline for nuclear more likely towards 2040; 3. Expert input and LCOE model comparing Sweden, Finland, Norway and Denmark: lowest and highest country specific LCOEs selected for analysis 2. Statnett report discusses EPRs instead, including Olkiluoto 3 with LSRs 3. Small Modular Reactor 4. Including opex and capex for nuclear

Source: BloombergNEF, WoodMac, Statnett, Fingrid, McKinsey experts and LCOE model, expert interviews

Finland has many benefits from industrial company viewpoint

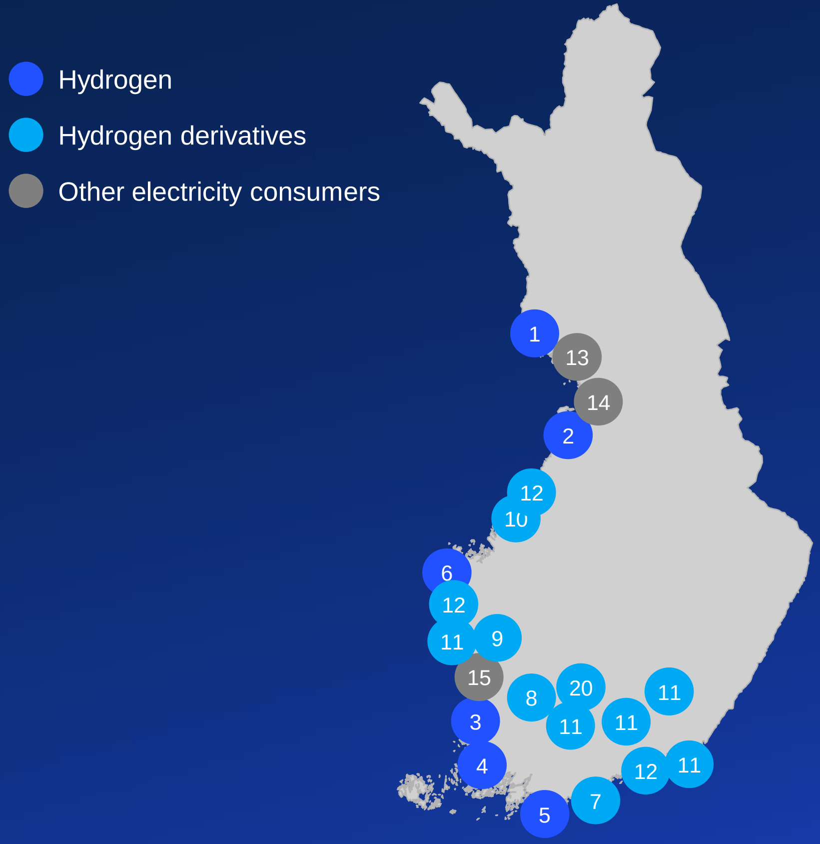
Decision factors for H_2, H_2-derivative and industrial players

- **Low LCOE (→LCOH)** expectation (wind speeds at >150m)
- Maturing ready-to-build **onshore wind pipeline**
- **Biogenic CO_2** availability
- **Low-carbon hydrogen compliant grid** (soon), incl. nuclear
- **Grid strength** and locations with >200MW connections
- **Limited NIMBYism** vs peers and permitting speed

Announced new demand, examples

NOT EXHAUSTIVE

EARLY PIPELINE



1. Based on Energiforetagen estimates; 2. Includes future demand also in other sites in addition to Kiruna; 3. Based on the SSAB electricity demand using HYBRIT technology at current production levels; 4. Assuming half of Finnish synfuels potential; 5. Assumes 70% utilization of the electrolyzers; 6. Based on the total electricity demand as per Energiforsk and the Confederation of Swedish Enterprise, assuming that majority of the growth comes from industrial sector, 7. Based on Sitra estimates on industry sector electricity demand; 8. Assuming same scale as SSAB; 9. Based on Sitra Power-to-X demand; 10. Assuming 0.3 wind capacity factor

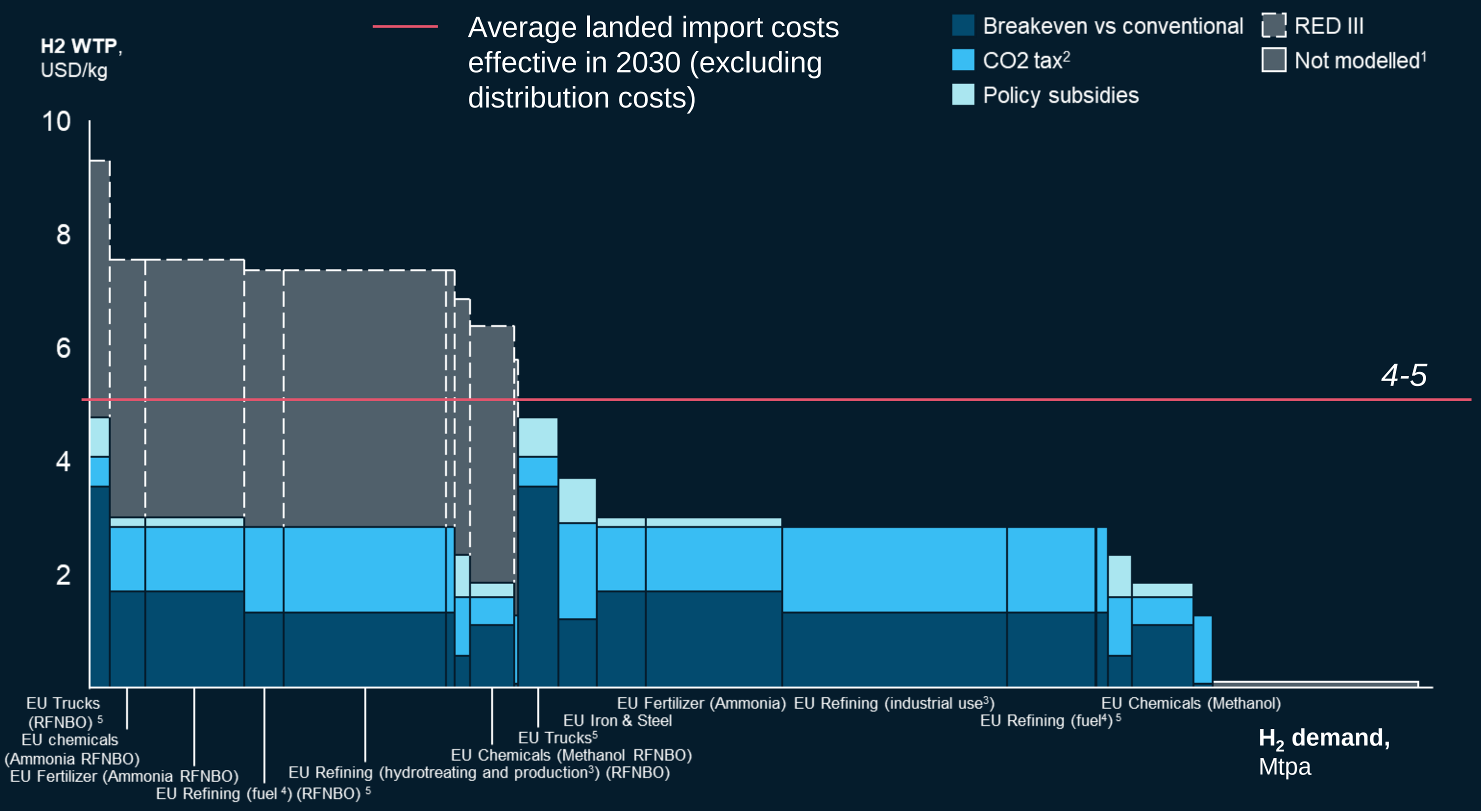
Source: Svenska Kraftnät, Energiforsk, Sitra, Confederation of Swedish Enterprise, expert interviews, press search, project announcements, company websites, TEM

Carbon tax and RED III could unlock some of the PtX demand

Modelled H_2 willingness to pay and demand in 2030

Sectors	RFNBO REDIII 2030 demand, Mtpa H_2	TWh[6]	GW RES
Chemicals	0.9	45	18
Fertilizers	1.0	50	20
Refining – hydrotreating & production	1.6	80	32
Iron & Steel	n/a	n/a	n/a
Maritime	0.1-0.5[5]	5-25	2-10
Aviation	0.2-0.7[5]	10-35	4-14
Road & Rail	0-0.8[5]	0-40[5]	0-16
Refining – transport fuels[1]	0-0.8[5]	0-40	0-16
	4-5	200-250	80-100

Technology



1. Mainly commercial and residential heating and cooking ; 2. ETS carbon price is assumed to be $140/tCO2 (capped at $45/tCO2 in ETSII for trucks). Allowances start phasing out 2026 through 2034. CO2 tax only applies to sectors where allowances fully phased out; 3. Refining products for industrial sector (hydrotreating and other H2 use such as bitumen and lubricants, accounting for 75% of refining H2 demand); 4. Refining products for transport (hydrocracking and hydrogenation, accounting for 25% of refining hydrogen demand); 5. Demand split between RFNBO and non-RFNBO hydrogen for EU trucks and EU refining (fuel) is illustrative, due to the flexibility given to the fuel retailers on how to fulfil the REDIII transport quota of 1% total energy 6 Electrolyzer

Source: McKinsey Hydrogen Insights, McKinsey Global Energy Perspective (GEP) Further Acceleration scenario

RES projects face risks that could be mitigated with PtX

Not exhaustive

PPA or downstream integration

Renewables projects

Risk of oversupply threatens the utilization / capture prices

Securing the funding given the risk of oversupply and need to de-risk demand

Hydrogen + derivatives

Create new electricity demand on the system level

PPA customers or H_2 sales to H_2 derivatives producers

De-risking of projects with offtakes

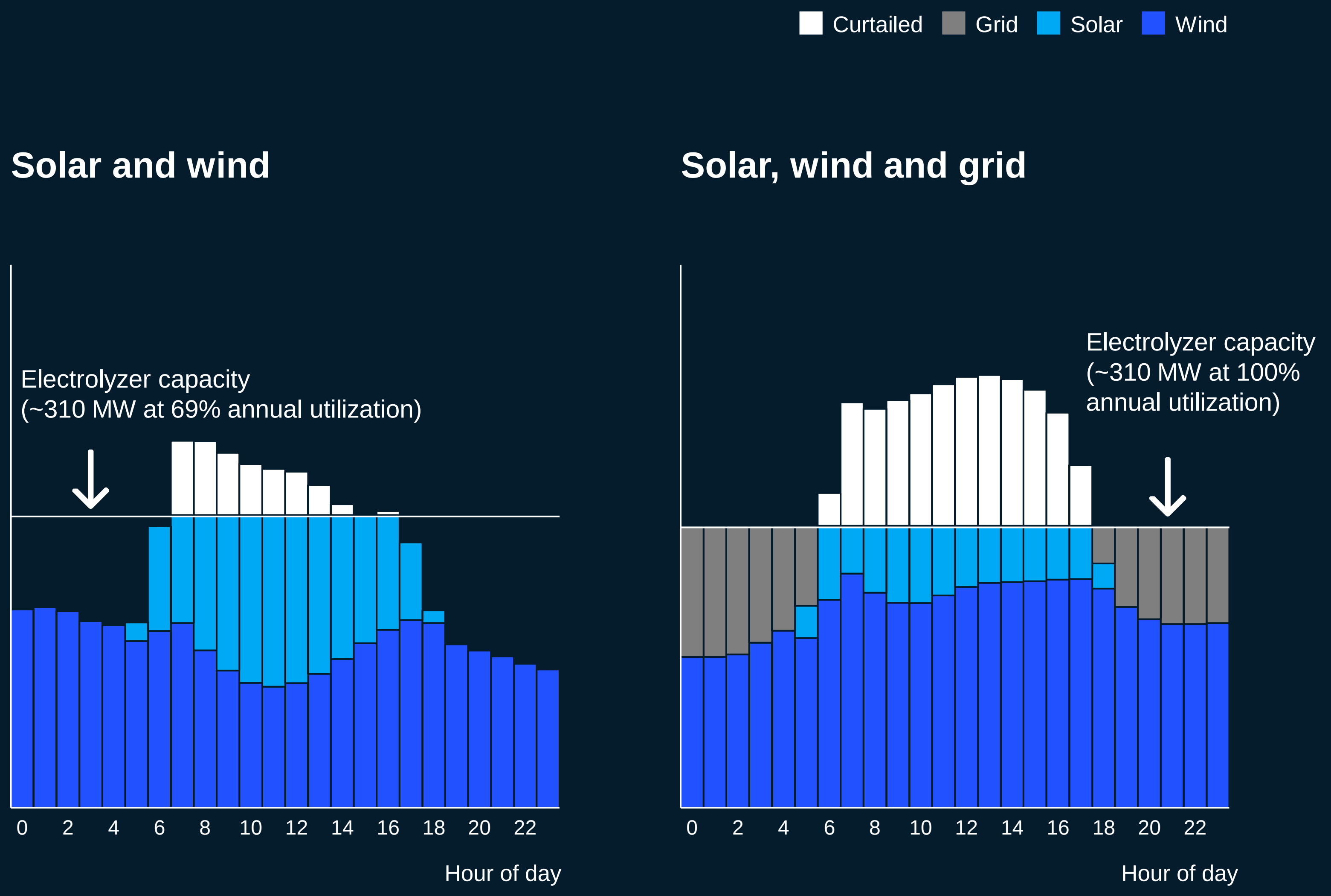
Bankability + optionality

Significant share of fixed revenue that may be possible to underwrite, depending on the counterparty

Option to integrate downstream to H_2 or derivatives, increasing the scope of activites and value capture

1. High chance of project success

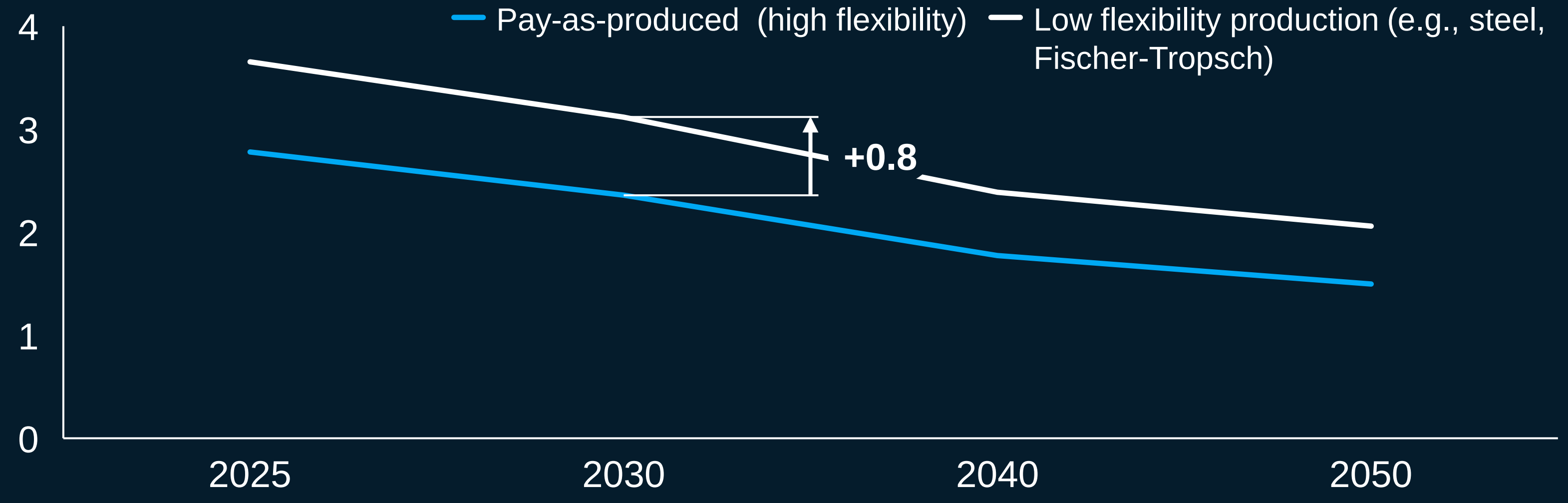
Ideally, a significant share of the future demand would be flexible



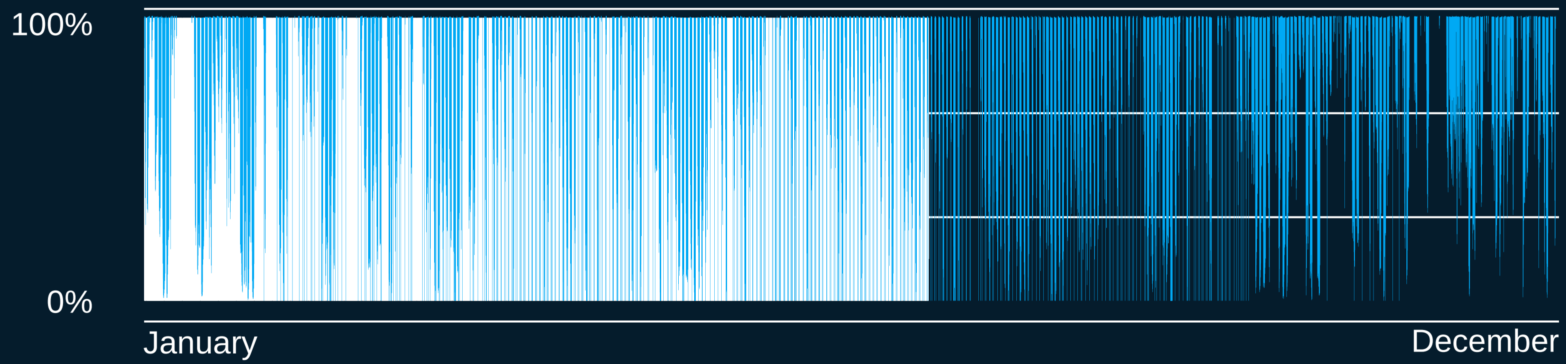
Source: McKinsey Energy Solutions H2-COM

Flexible projects also reach lower cost of hydrogen vs 24/7 operations

Spain LCOH[1,2], $/kg of H_2



Need for storage, % of 8760h/y for low flexibility production



- **On-purpose H_2 storage is expensive**
- **Finnish H2 grid would provide limited balancing**
- **New caverns would be expensive**
- **Easiest to optimize for flexibility (e.g., methane, methanol)**

1. Production costs only; hydrogen production co-located with renewable energy generation. Mix of solar and wind considered as inputs; model determines what is most cost-effective
2. The LCOHs shown are for tier3-1 of Spain from 2025 to 2050

Source: McKinsey Energy Solutions H2-COM

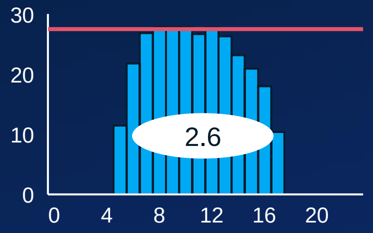
Different regions can reach competitive hydrogen cost many ways

Examples, case production for ammonia

Hourly profile

- Curtailed
- Solar to Electrolyzer
- Wind to Electrolyzer

x.x **Production LCOH,** USD/kg

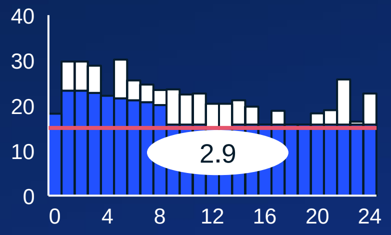


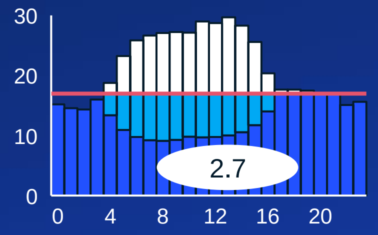
Northern Chile – High solar[1]

- One of the top solar radiation levels globally
- Average CF – 41.2%

Ireland – High wind[1]

- Geography favors wind power
- Average CF – 58.4%





West Australia – Balanced RES[1]

- Balanced wind and solar
- Average CF – 39.2%

1. Correspondence of tiers to global H2 database: Ireland tier 3-1, Chile tier 1-4, West Australia tier 1-1, Texas tier 3-1

Source: McKinsey Energy Solutions H2-COM

H2 grid could unlock a lot of the demand, but it is in early stages and has many competitors

Announced hydrogen pipelines in Europe

Nordic Hydrogen Route
1,000 km new pipeline

Baltic Sea Hydrogen Collector
offshore H_2 infrastructure by 2030

Nordic-Baltic Hydrogen Corridor
connecting Finland and Germany

Equinor + RWE
offshore pipeline from Norway to Germany

Hydrogen Network Netherlands
85% retrofit, starting 2025

HyPerLink
610 km, starting 2025

Doing hydrogen & Green Octopus
900 km H_2 pipelines by 2030, 60% retrofit

MosaHYc project
100 km, 70% retrofit

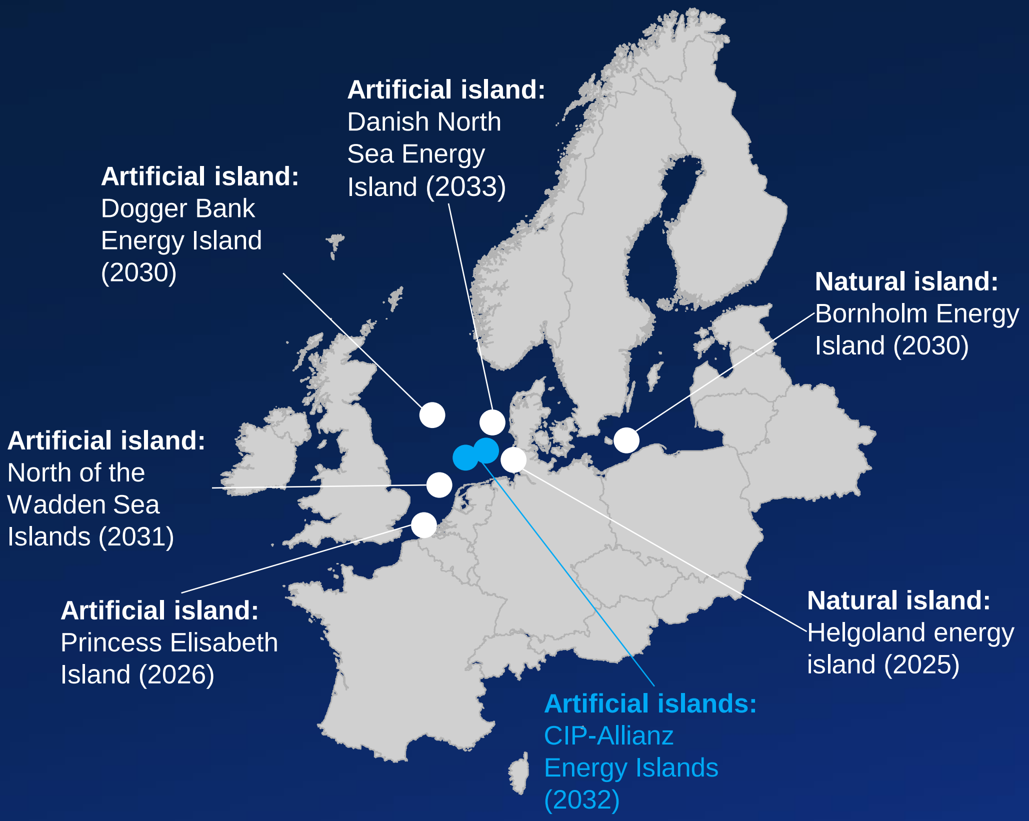
H2Med
to cover 10% of EUs H_2 demand

What does it take to realize even one Nordic pipeline by early 2030s?

Source: Company publications; Press

Energy islands could be the way to leverage offshore

Planned energy islands in the North / Baltic Sea – case CIP-Allianz



>10 GW of **offshore wind**

Electrolyzers to convert part of the offshore wind into **green hydrogen**

Hydrogen delivered to the mainland via dedicated pipelines

Investment of up to **EUR 5 bn**

150 km off the coast

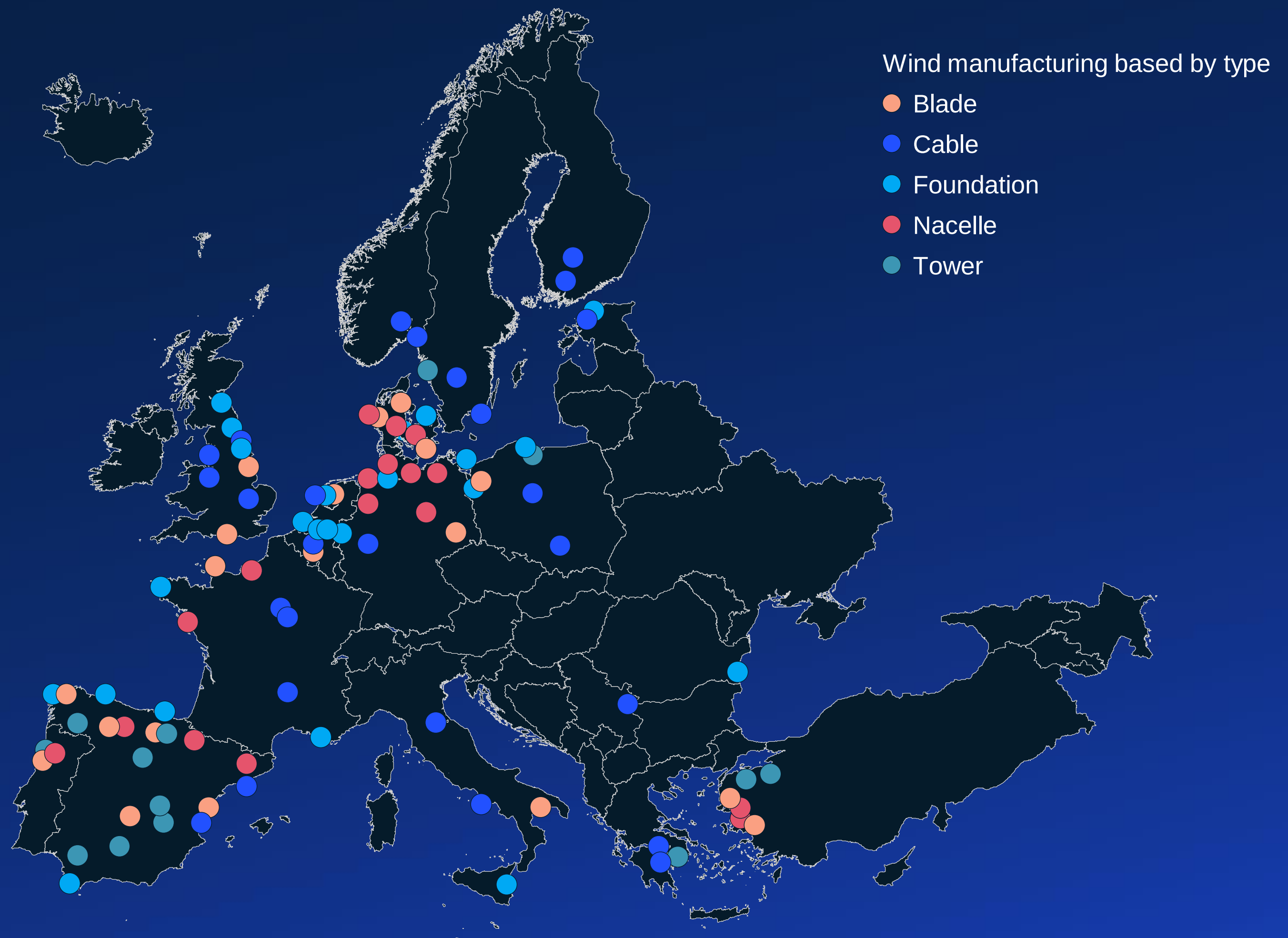
0.5 km² each

Source: Company publications; Press

What is the opportunity for the supply chain buildup?

Europe's wind manufacturing bases by type

What would it take to create competitive blade, tower, offshore installation, electrolyzer, etc industries?



Source: Company publications; Wind Europe; GWEC – Global Wind Report 2023; Rystad Energy – The State of the European Wind Energy Supply Chain; Press

The Finnish RES landscape could be strengthened through

De-risk projects & ensure competitiveness

5-7 year+ offtakes for 80%+ of volumes for the H_2 derivatives?

Many demand-side projects still early, do they understand their own competitiveness?

Shape PPAs / PaPs to unlock the projects

PPA PaPs for RFNBO compliance

Hydro + wind + solar or + nuclear bundles for those with the assets

Unlock the new projects, many aiming for 30-50 EUR/MWh LCOE

Build a more competitive RES ecosystem

Larger park sizes

Leveraging digital and analytics

Building local supply chain

Potential priorities to support the RES GDP boost realization

Based on discussions with multiple different stakeholders

1	**Grids**	Ensure RES and industrials grid connection buildup + push H2 pipeline decisively (case North Sea)
2	**Markets**	Revisit the power market mechanisms given the huge volatility in production (and demand)
3	**Permitting**	Accelerate permitting speed. Special focus on giga-scale sites!
4	**Capital**	Target top global investors, consider structures that allow capital accumulation locally over time
5	**Ecosystem**	Establish high-tech/machinery businesses with “absurd ambition”, work in collaboration
6	**Masterplan**	Define a transition master plan to capture the significant GDP growth potential at stake
7	**BioCO_2**	Encourage industrial CCU (use in PtX) activity instead of just CCS (storage)

Thank you!

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