Shaping the decarbonisation of marine and energy

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GLOBAL LEADER

in decarbonisation of marine and energy markets

FOUNDED IN
1834

REVENUE
EUR ~6BN

SERVICE SHARE OF SALES
~50%

ACTIVE IN
+70 countries

OUR PERSONNEL APPROX.
17,500

ENABLING SUSTAINABLE SOCIETIES THROUGH INNOVATION IN TECHNOLOGY AND SERVICES

Marine will move with an unprecedented speed towards decarbonisation

Shipping generates approx. 2% of GHG emissions [1)]

Regulations & Markets

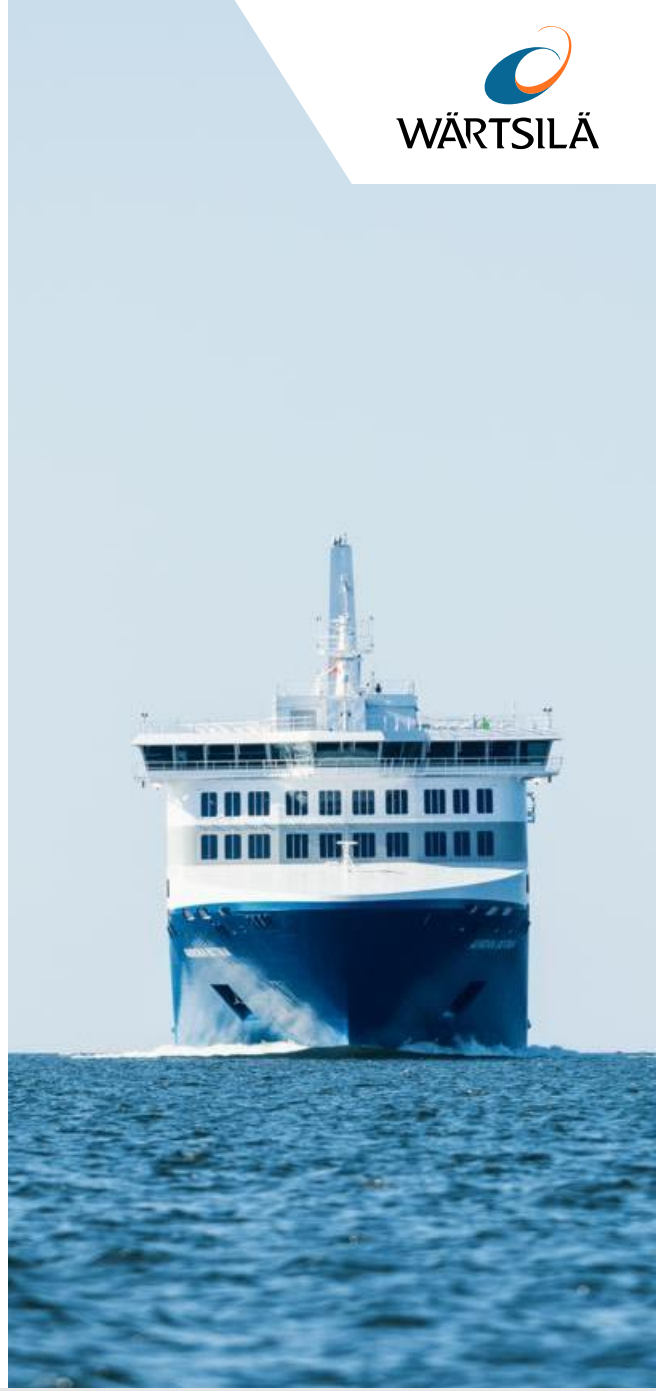
- **IMO target**: 50% lower GHG in shipping by 2050
- **Cost of compliance**: IMO design requirements, EEXI & CII
- **Access to capital**: EU taxonomy, Poseidon principles and ESG
- **Cost of carbon**: carbon certificates e.g. EU Fit for 55, IMO carbon levy and local green policies
- Green sea transport demand driven by **companies' green customer commitments and investors' push for sustainability targets**

Technology

- Focus on **carbon neutral and zero carbon fuels**. Carbon fuels still used for many years
- Increase in **hybrid and battery systems**
- Development of **energy saving devices**
- **Next steps in abatement technologies** e.g. carbon capture and storage
- **Focus on fuel efficiency**
- **Focus on fuel flexibility and upgrades**

Connectivity and Data

- **Vessels as data pools** - system complexity increasing
- **Optimisation solutions** taking an holistic view of the entire transport system
- **Performance-based agreements** with focus on uptime, reliability and fuel efficiency
- **Cyber security** growing in importance
- Different degrees of **autonomous opeartions**

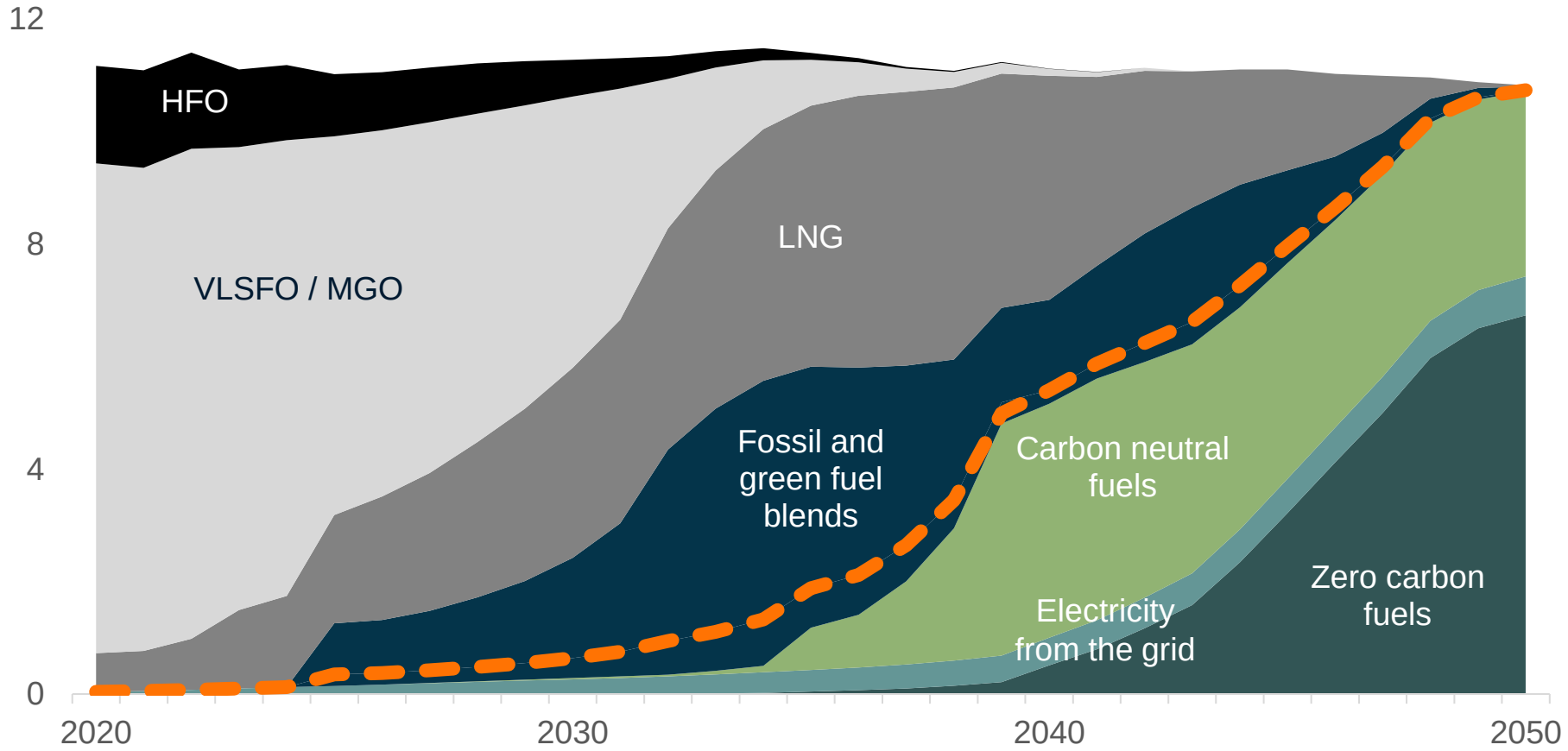


1) Source: Climate Watch, total 49.4 GtCO2e

Transition to green fuels will be slow yet relentless. 2050 is a single vessel's lifespan away – customers need to invest in fuel flexibility to avoid risk of stranded assets

Move from a single-fuel industry to a multi-fuel one

Distribution of fuel types for Decarbonisation 2050 (1.5ºC scenario), EJ



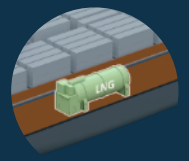
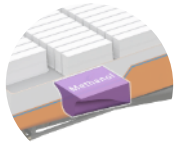
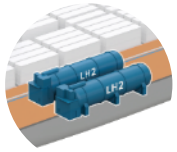
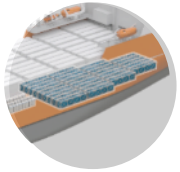
Owners will decide on technology partners now:

- Vessel life is 25-30 years
- Critical decision criteria:
  i) Multifuel capabilities for blending with green fuels
  ii) Conversion capabilities for future fuels

Carbon neutral and zero carbon fuels in maritime

Source: DNV Maritime Forecast 2050 model, Wärtsilä internal estimates

Energy density will have key impact on selection of future fuels

Fuel type	 **Heavy Fuel Oil** @ 20°C	 **Liquified Natural Gas** @ -162°C	 **Methanol** @ 20°C	 **Ammonia** @ -33°C	 **Liquid Hydrogen** @ -253°C	 **Compressed Hydrogen** @350bar	 **Marine Battery Rack**
Key considerations	▪ Standard tank arrangement	▪ Cryogenic system	▪ Mildly toxic ▪ Flexible tank arrangement	▪ Toxic ▪ Corrosive	▪ Highly reactive ▪ Cryo system	▪ High pressure ▪ Multiple tanks arrangement	▪ Marine adaptation reduces density
Fuel price factor (per GJ)	1X	0.7X [2]	2.2X-5.4X [3]	2.2X-4.5X [3]	2.7X-4.5X [3]	1.6X-2.6X [3]	1.3X-2.3X
	Production cost estimate 2025 [1]						
Gross tank size factor	1X [4]	2.4X	1.7X	3.9X	7.3X	19.5X	~40X (future potential ~20X)

1) Sources: Maersk Mc-Kinney Møller Center for Zero Carbon Shipping – Industry transition strategy 2021, Wärtsilä-DNV collaboration; 2) fuel price for e-methane is expected to be in a range similar to e-methanol; 3) fuel price range spans across blue, bio and green-electro equivalent; 4) gross tank estimations based on Wärtsilä experience

Energy is moving towards a 100% renewable future

Electricity and heat generate approx. 30% of GHG emissions [1)]

Growing electricity demand

- **Electricity generation is expected to grow by 3X, renewables by 8X** [2)]
- Gradual **replacement of coal and other fossil fuelled energy generation**
- **Power systems becoming increasingly complex** with different generation assets

Policies & Regulations

- EU: Carbon neutral by **2050**
- USA: carbon free electricity production by **2035**, net zero emissions by **2050**
- China: Carbon neutral by **2060**
- Country **climate pledges likely to become more progressive**

Technology disruption

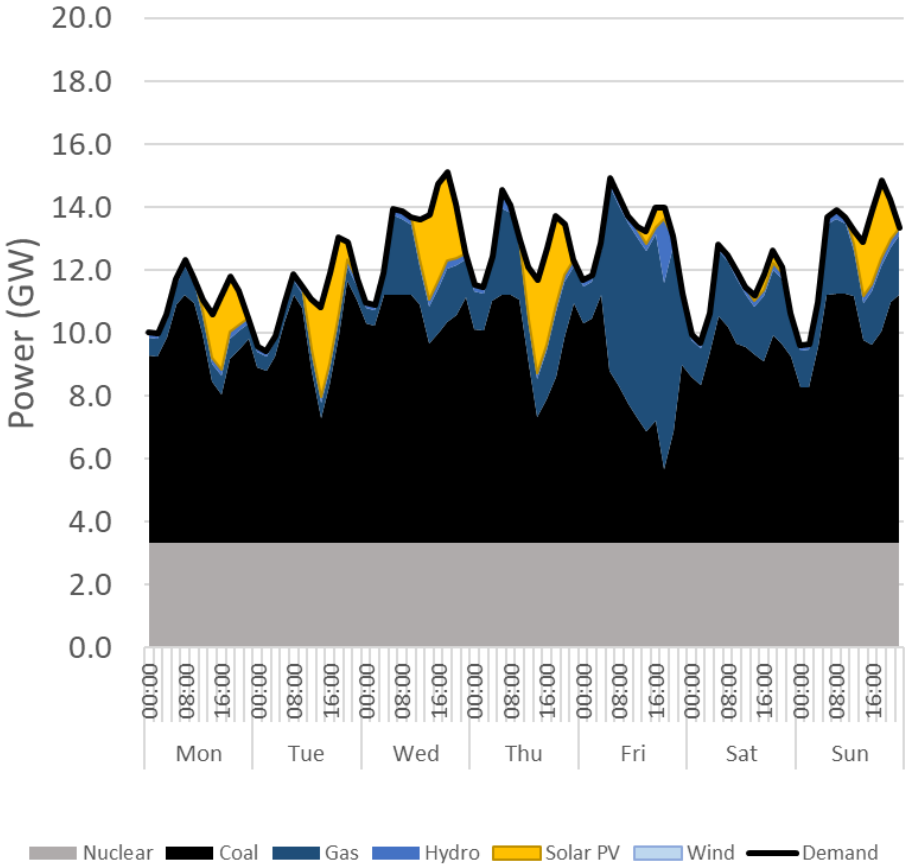
- **Wind and solar growing rapidly** for baseload generation
- **Intermittent sources requiring balancing power**
- **Green fuels** for thermal balancing
- **Digitalisation will create opportunities** for optimising energy costs
- **Cyber security** growing in importance

1) Source: Climate Watch, total 49.4 GtCO2e 2) IEA World Energy Outlook 2021 (Net Zero Emissions Scenario), until 2050 with electrification of transport, buildings and industrial sectors

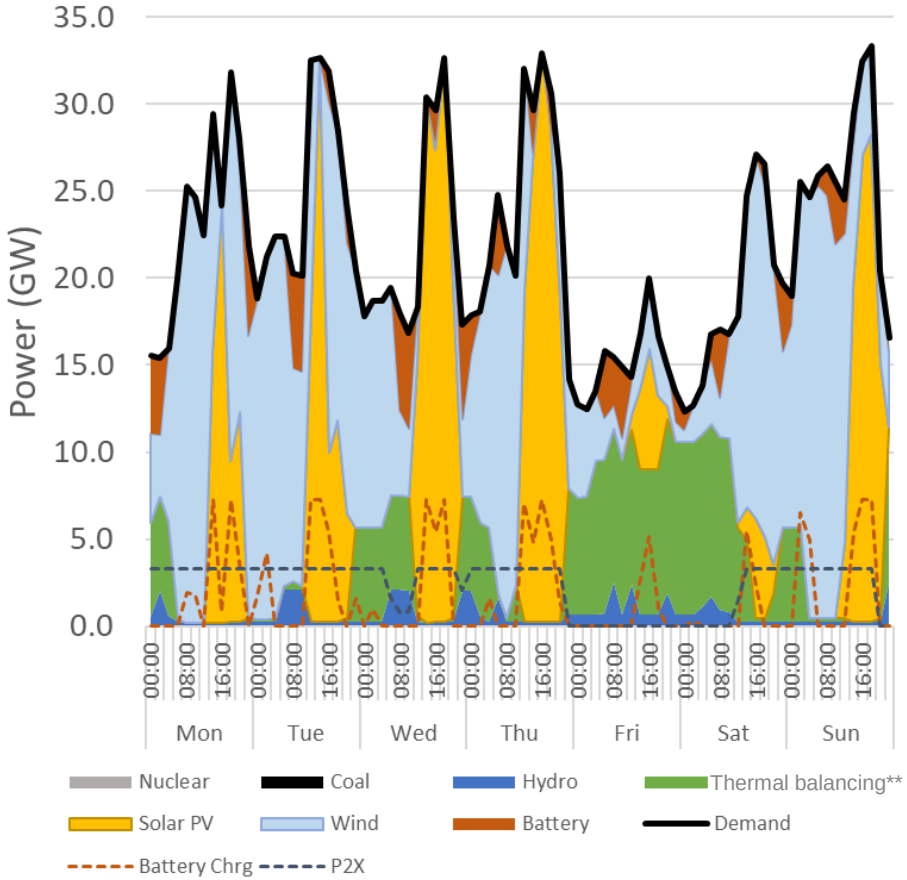
Decarbonisation and renewables will fundamentally change how electricity is generated. Renewables will provide most of the energy in the future

Flexible thermal balancing power and battery storage are needed to balance the grid and provide reliability

Power dispatch in 2020 – Dominion utility* (example week)



Power dispatch in 2040 – Dominion utility* Net zero (example week)



*Dominion Energy utility – Virginia, US.
Source: Wärtsilä analysis - Plexos modeling of utility portfolio

**Thermal balancing with carbon neutral or zero carbon fuels

Three major balancing technologies for the future

Reciprocating engines

- Superior balancing properties vs. gas turbines – quick and frequent ramp up/down
- Energy efficient and fuel flexible
- Today running on fossil gas, tomorrow on green fuels e.g. methanol, ammonia and hydrogen

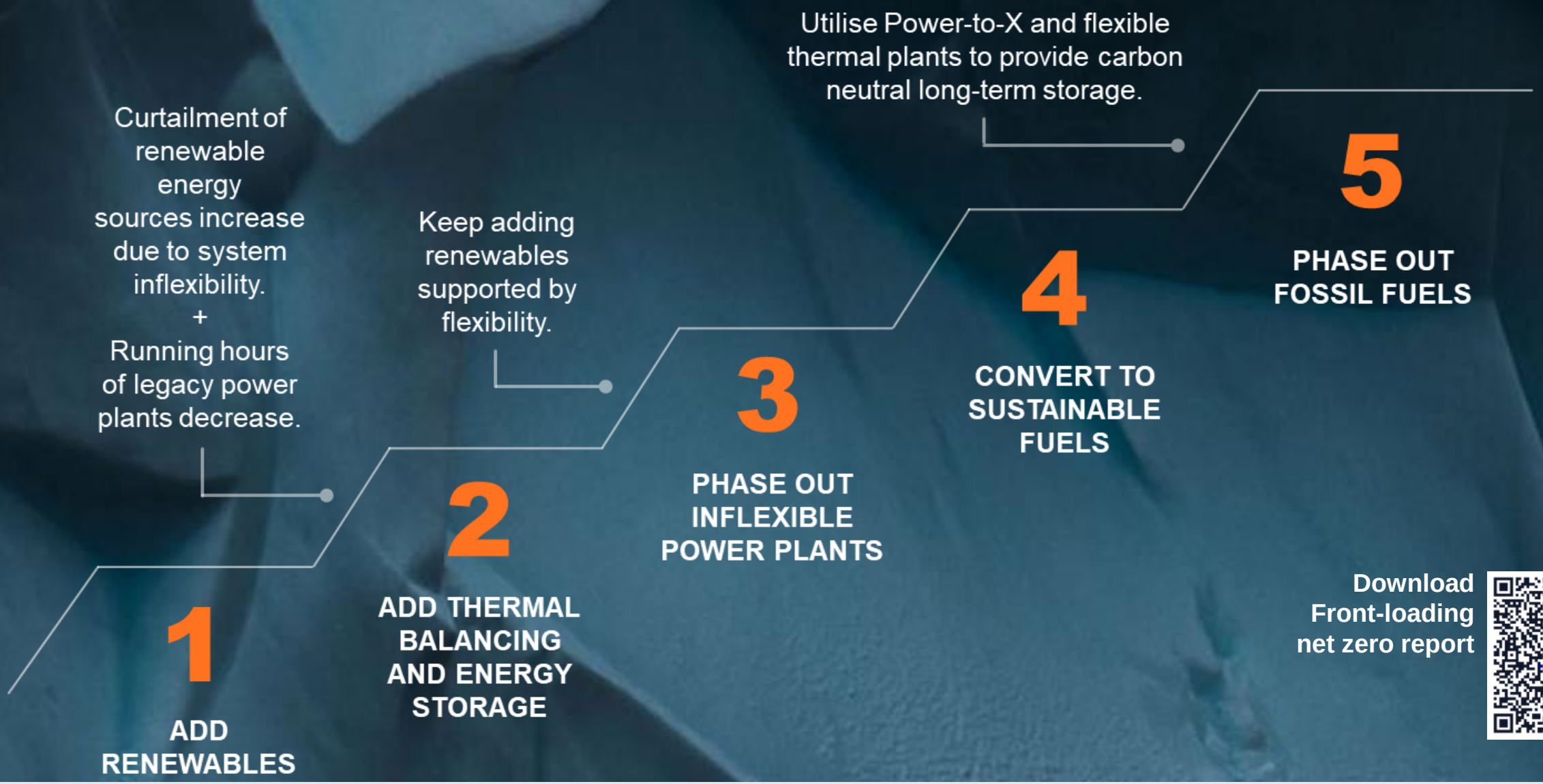
Energy (Battery) Storage

- Immediate response in milliseconds
- Providing power support for hours

Hydro Power

- Limited availability globally
- Often located far from load, need for an adequate transmission system

There is an algorithm for how to decarbonise the energy system



Download Front-loading net zero report

EU has set ambitious binding energy and decarbonisation targets. Needs to accelerate permitting process for renewables…

2030 Targets: 55% GHG reductions
42,5% renewable energy

2030 Targets: Net zero

What would it require

- Increasing investments in renewable energy generation
  - Wind 510 GW by 2030
  - Solar 592 GW by 2030
- Adding flexibility to power system by investing in balancing solutions
  - Battery storage & demand side response
  - Balancing generation capacity

- Renewable capacity needs to double
- Permit processing needs to be fast
- Electricity grid needs to strenghtened

- **More storage capacity is needed**
- **Inflexible generation needs to be replaced by flexible capacity**
- **Demand side response**

Requirements for Electricity Markets?

- Boost renewable energy investments
- Provide investment signals for balancing solutions

EC revision of market design

- Includes new measures to promote Power Purchase Agreements and Contracts for Difference

- **Support schemes for storage and demand side response**
- **No scheme for balancing generation capacity**

… and create market mechanisms for balancing power

- **There is an urgent need to deploy more of flexible capacity to balance the energy system**
  - Current electricity markets are not providing investment signals for flexibility generations
  - Support schemes and targets for flexible generation are needed for all kinds of flexible capacity.

- **Markets should be developed closer to real time markets**
  - Real-time markets give a competitive edge to modern balancing technologies, which can help to avoid unnecessary curtailment of renewable generation and support the phase out of inflexible thermal capacity

- **The EU should consider establishing a framework for incentivizing investments in flexible power generation (a “capability market/mechanism”)**
  - Operators should be rewarded for providing firm, reliable capacity and offering well-defined operational attributes such as short ramp-up and ramp-down times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