Lithuania Energy System Transformation to 2050

About EPSO-G

EPSO-G is a state-owned group of energy transmission and exchange companies. The shareholder rights and obligations of EPSO-G holding are implemented by the Ministry of Energy of the Republic of Lithuania. The group consists of a holding company, the transmission system operators managing the infrastructure of electricity and natural gas transmission, the marker operators managing gas, biofuels and wood exchange, as well as the company providing the infrastructure maintenance services.

The EPSO-G group is to be a transparent, innovative, efficiently managed and future oriented group of companies that ensures safe and secure energy transmission and provides fair energy exchange option to market participants.

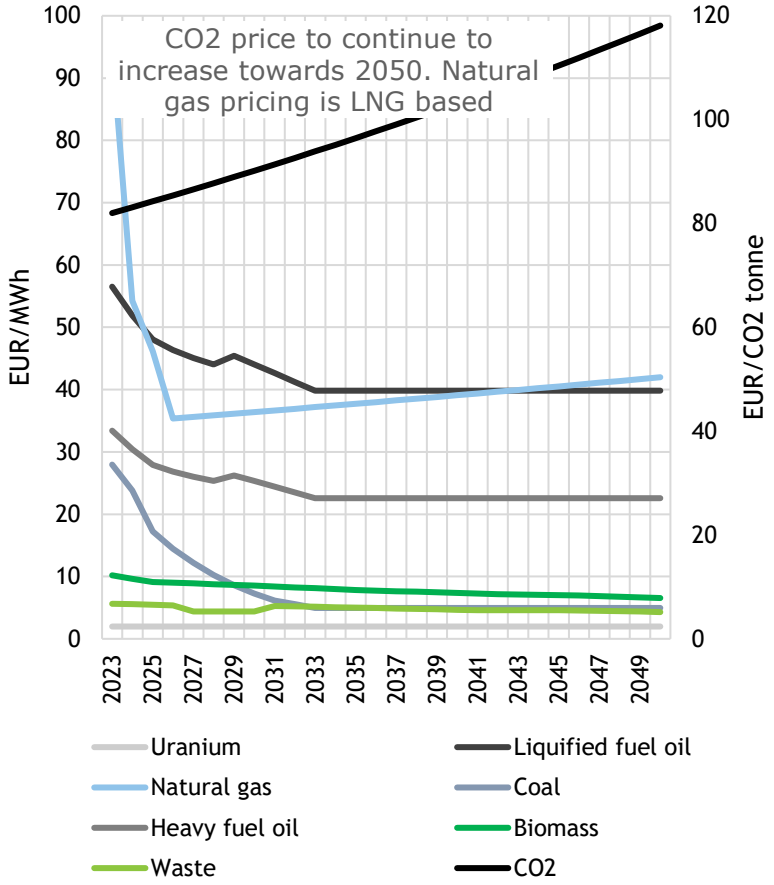
1.

Global & regional outlook

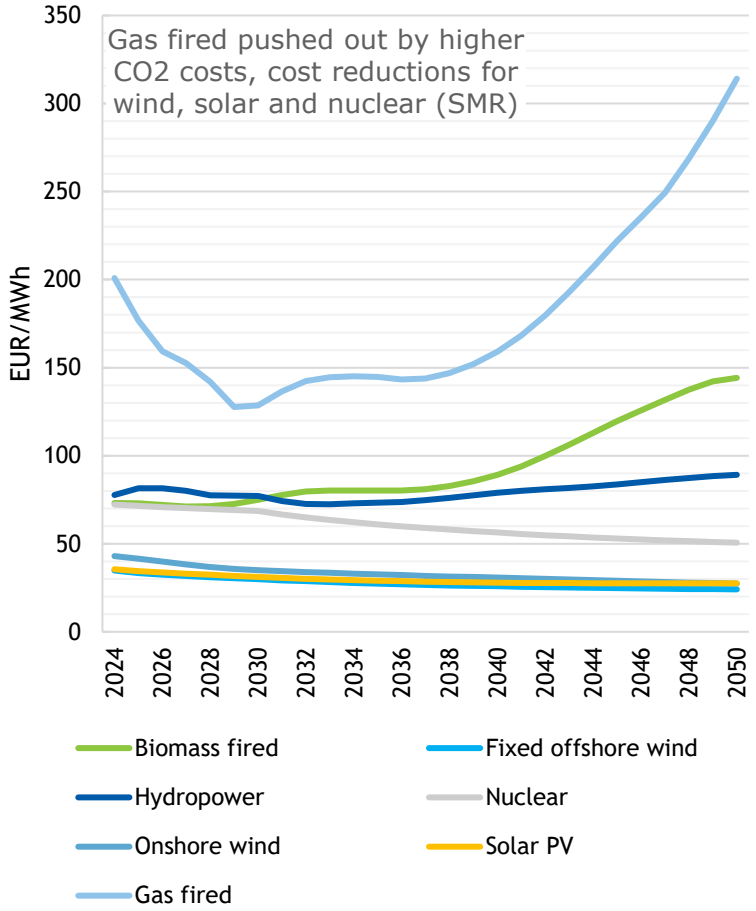
Global commodity and LCOE development

Declining costs of green technologies and growing cost of carbon

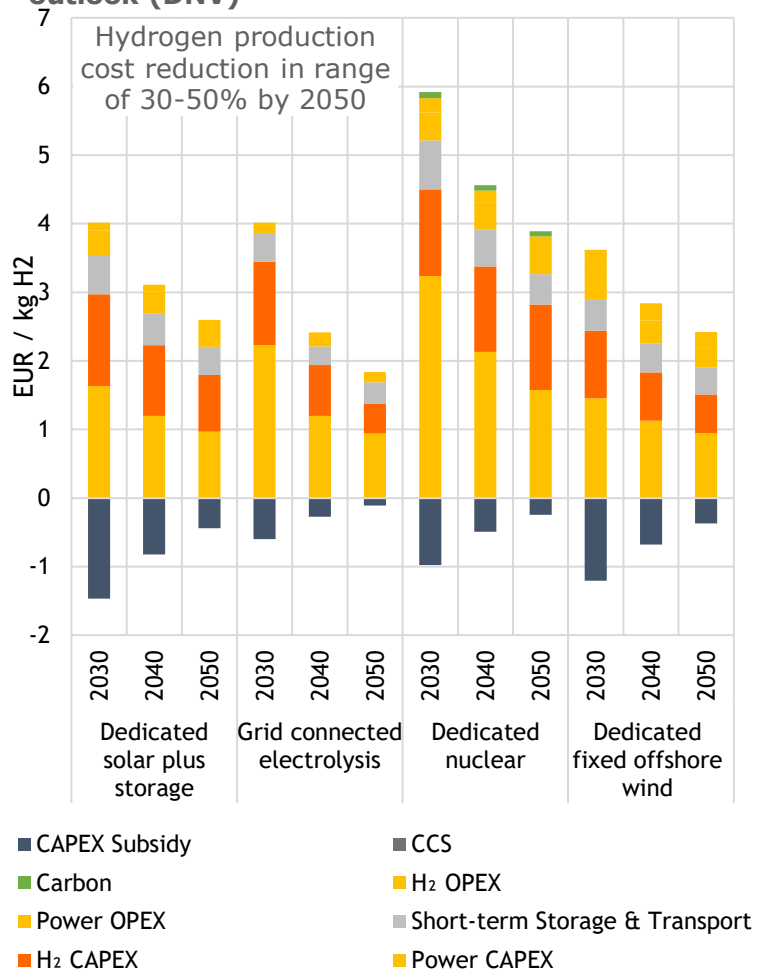
Europe commodity price outlook (DNV)



Europe LCOE outlook (DNV)



Hydrogen production LCOH outlook (DNV)

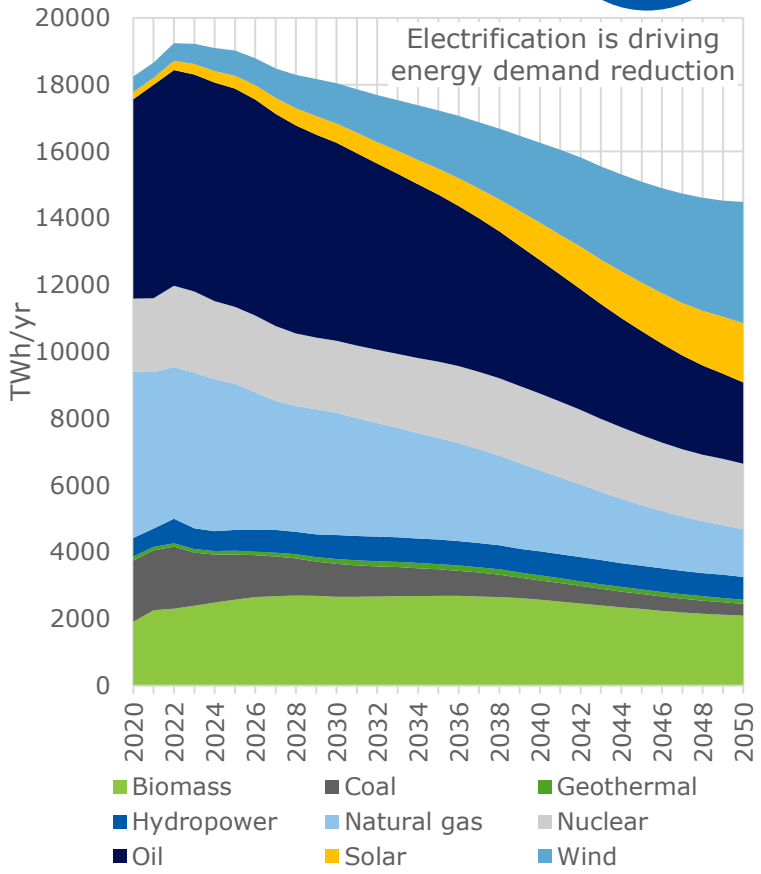


Source: Energy Transition Outlook – DNV
Note that methane in the right chart is natural gas

Global energy tendencies

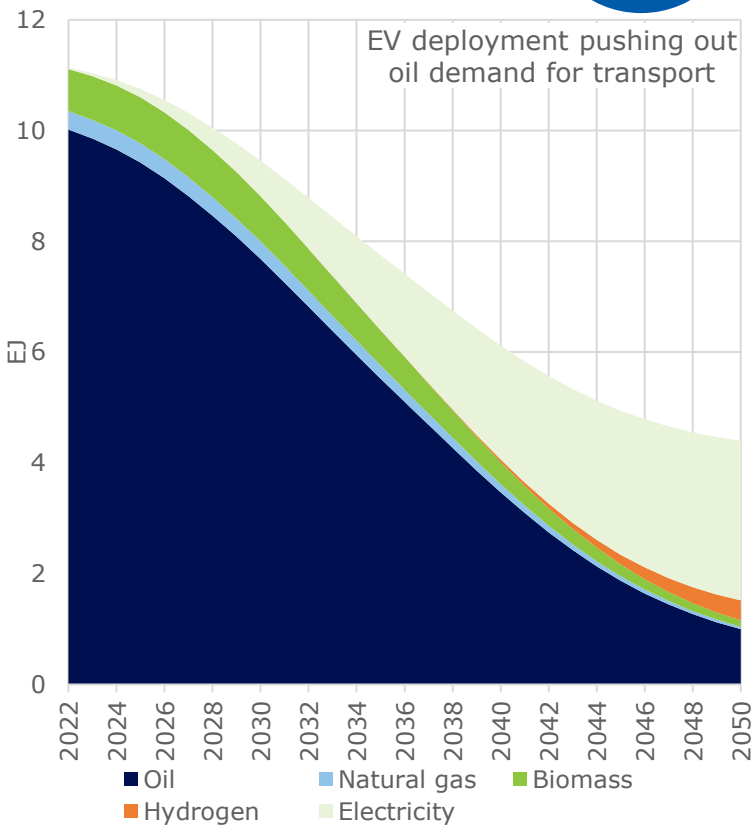
Primary energy demand forecast for European region per fuel type (DNV ETO 2022)

-20%



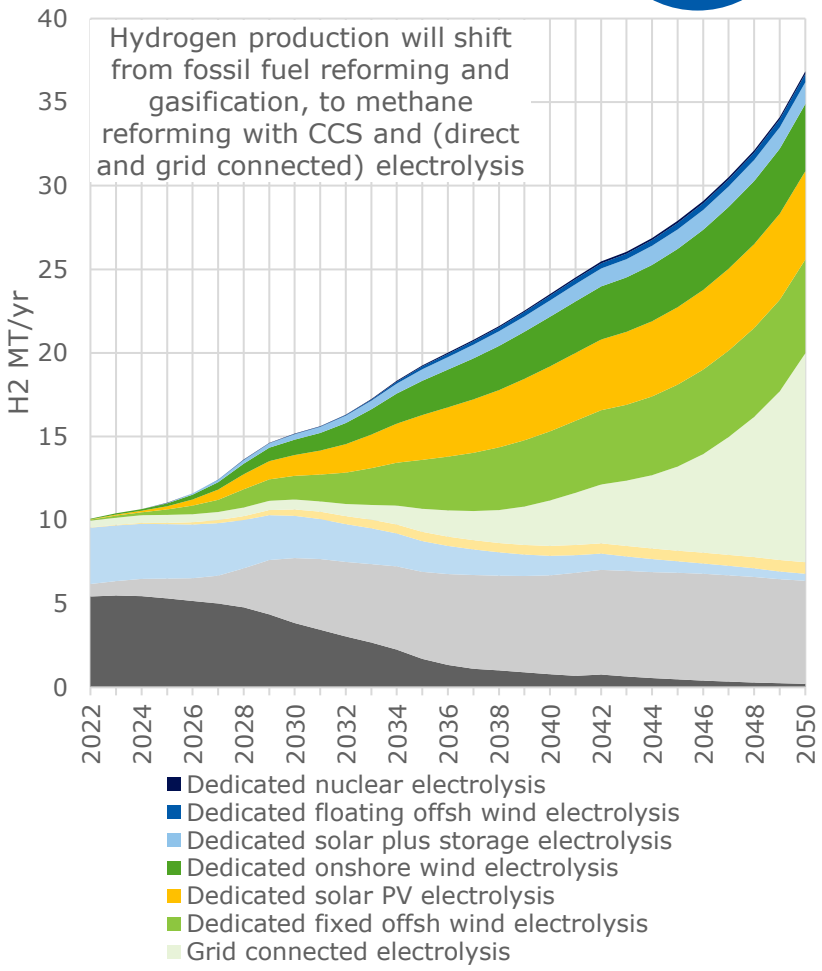
Europe road transport final demand outlook (DNV)

-2x



Europe hydrogen production by source outlook (DNV)

X3,5



Source: Energy Transition Outlook – DNV
Note that methane in the right chart is natural gas

Baltic Sea Region Developments to 2050

Scandinavia and the Baltic States will become substantial suppliers of both electricity and hydrogen for Central Europe and in particular – Germany & Poland

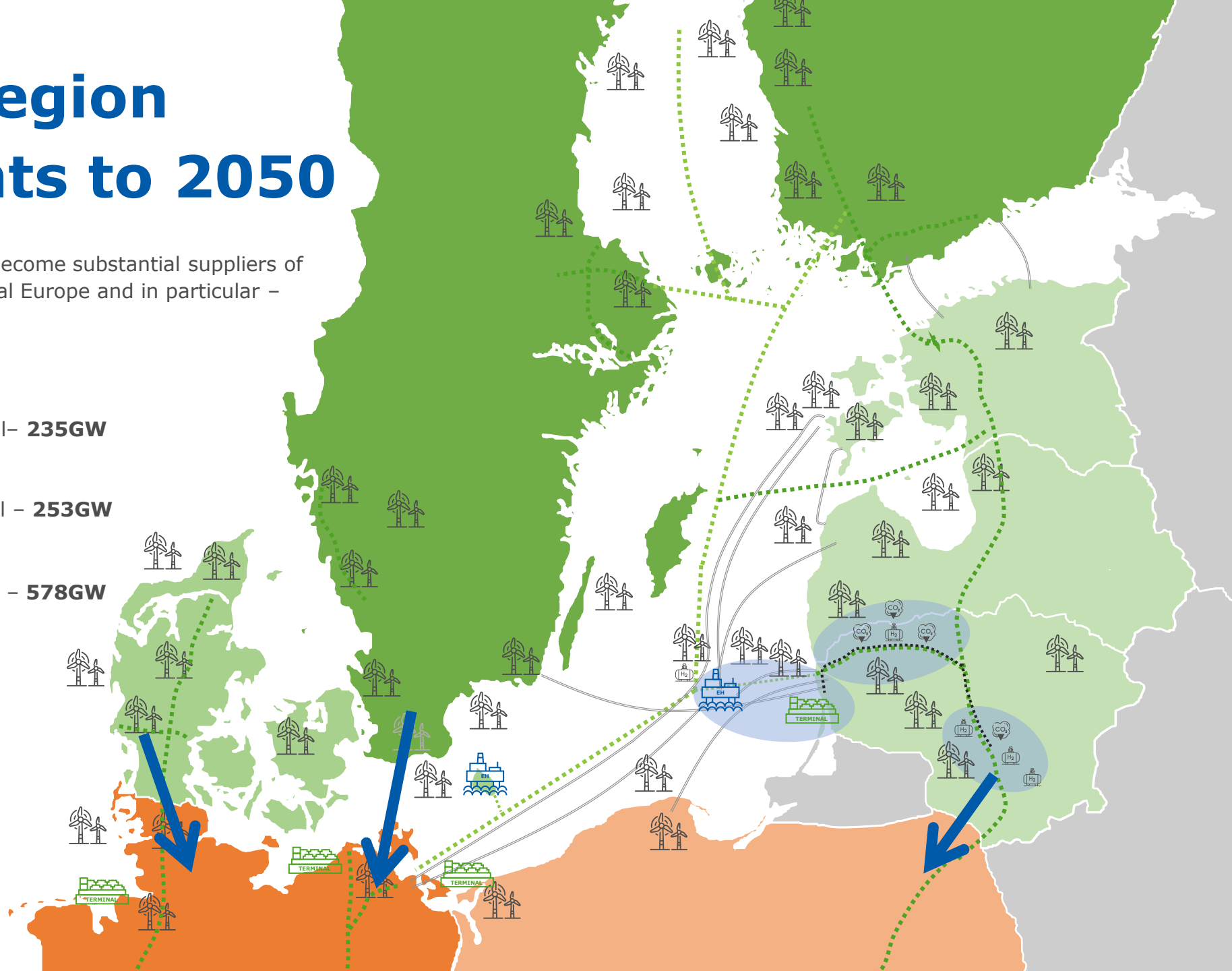
Regional offshore wind potential– **235GW**

Regional onshore wind potential – **253GW**

Regional solar energy potential – **578GW**

Total electricity demand – **2 328TWh**

Projected achievement of net-zero targets – **2045-2055**



Source: Lithuania Energy System Transformation to 2050

2.

Lithuania Strategic Energy Objectives

Lithuania Strategic Energy Objectives

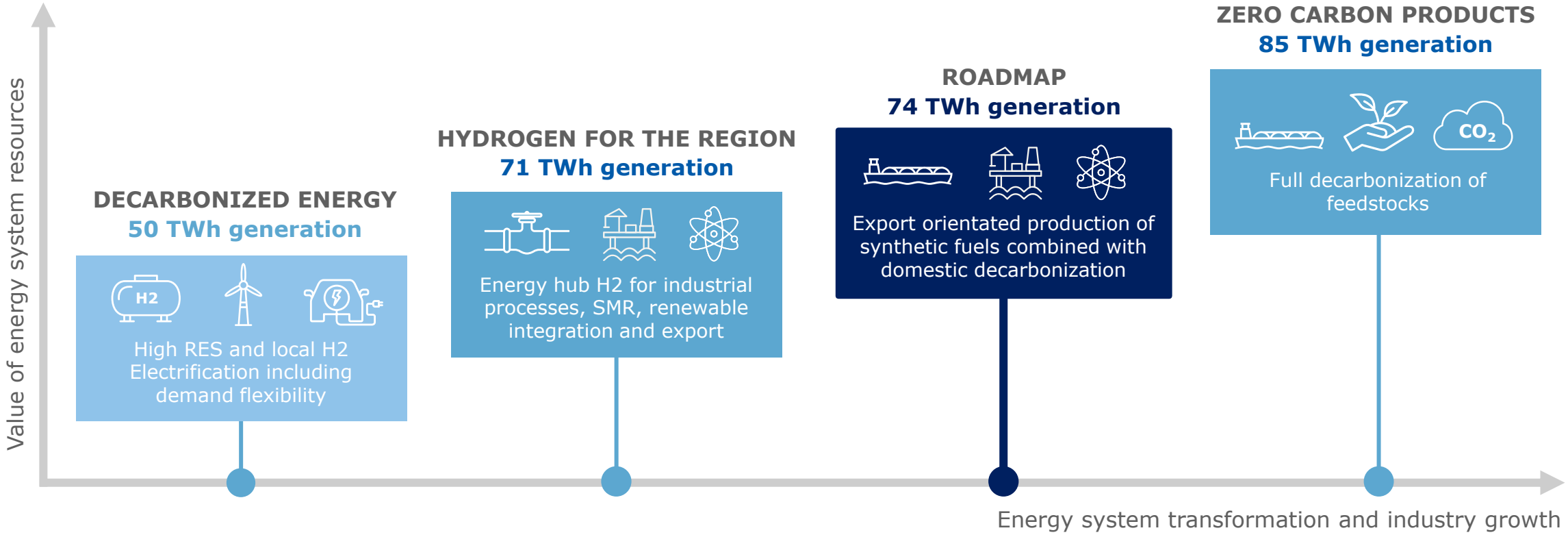
Combining security, environmental, economic and social ambitions

ENERGY INDEPENDENCE	Energy independent and self-sufficient by 2050
100% DECARBONISATION	Acceleration towards 100% renewable energy in cost effective way
BECOME AN ENERGY EXPORTER	Energy and higher value products supplier for the region
PURSUE INDUSTRIAL GROWTH	Energy sector transformation - opportunities for industrial growth
ENERGY COSTS & AFFORDABILITY	Ensured energy affordability and maximized export opportunities

Source: Lithuania Energy System Transformation to 2050

Transformational changes for Lithuania

From domestic decarbonisation to a regional energy player by 2050



From energy transition to next generation industry

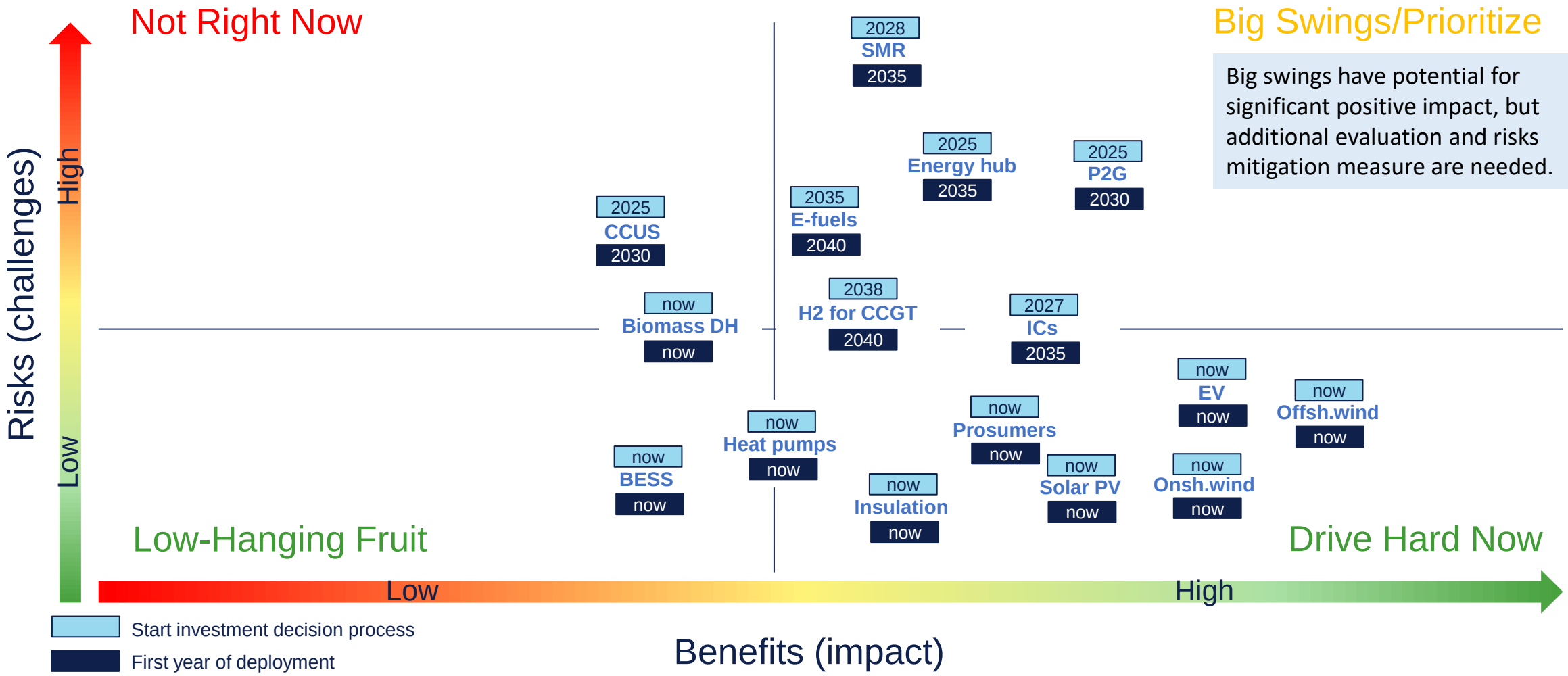
Source: Lithuania Energy System Transformation to 2050

3.

Lithuania infrastructure development

Building blocks of energy transition

We think of transformation in context of what we know and what we don't yet know



Source: Lithuania Energy System Transformation to 2050

DNV outcomes based on Energy Transition Model

Infrastructure development outlook

Investment requirements are highest from 2030 to 2040

2030

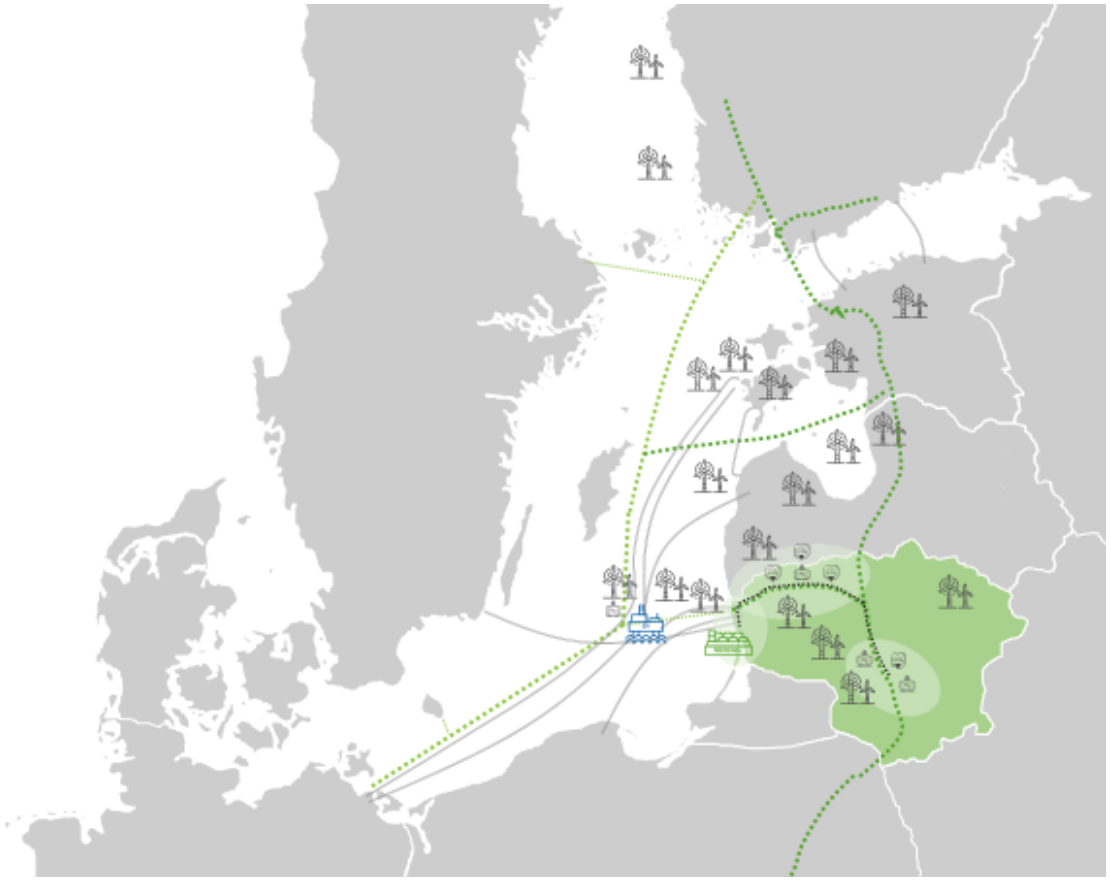
Build-out of onshore wind, near-shore offshore wind, solar PV, battery (BESS) capacity, electrical interconnection with Poland, and an onshore H2 backbone.

2040

Build-out of an Energy Hub and offshore wind connected to it, electrical interconnectors with Germany, SMR in operation and the formation of industrial clusters.

2050

Build-out of an electrical interconnector with the Nordics, and further expansion of (electrified and H2-consuming) industrial clusters.

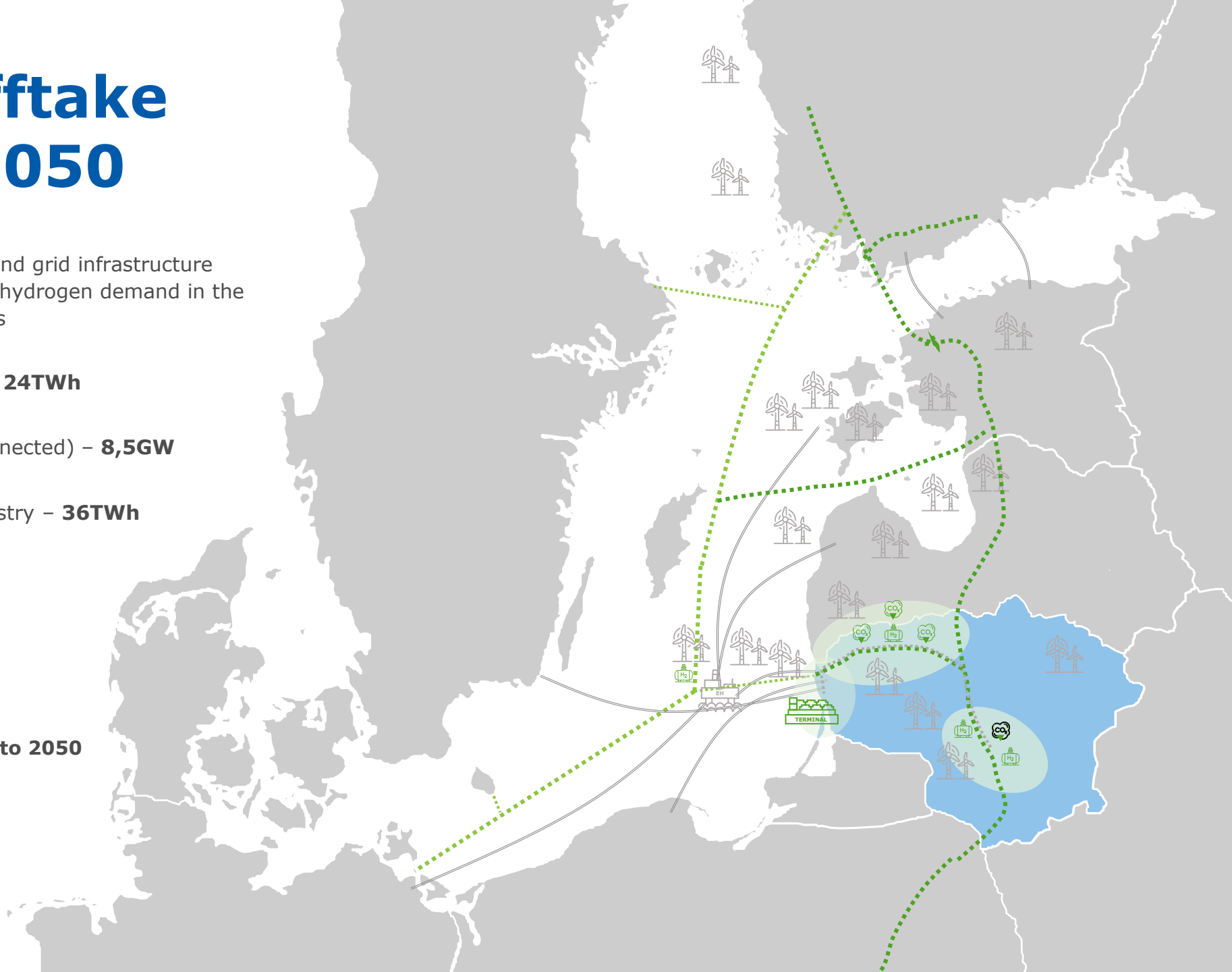


Hydrogen offtake potential - 2050

Hydrogen generation capacity growth and grid infrastructure development will be driven by growing hydrogen demand in the domestic and regional industrial centres

- Lithuania's hydrogen demand – **24TWh**
- P2G capacities (grid and EH connected) – **8,5GW**
- Electricity demand for P2G industry – **36TWh**
- Projected exports:
  - Hydrogen – **1,4 TWh**
  - Synthetic fuels – **3 TWh**

9bn EUR value investment to electrolysers and H2 network to 2050



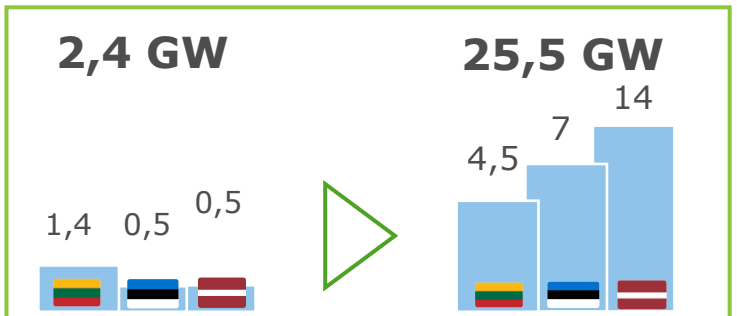
Hydrogen Backbone
Power interconnections
CO_2 pipelines
CCU
H_2 electrolysers
CO_2 products terminal
Energy Hub
Offshore/onshore wind

Source: Lithuania Energy System Transformation to 2050

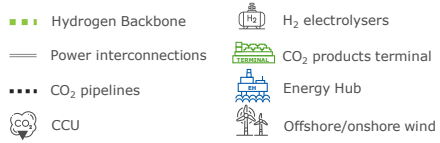
Role of the Baltic Energy Hub

Energy Island – a large-scale offshore energy project, that:

- enables the Baltics to **maximize the development of offshore wind** potential
- enables **better interconnectivity** with central-nordic European markets and provides crucial **system flexibility** via hydrogen electrolysis
- A reliable source of energy to meet the demand of Baltics via better **utilization of connections** to mainland;



Over 2,4GW installed offshore capacity, further investment in the Baltics will become less attractive / bankable **due to curtailment**.



Source: Lithuania Energy System Transformation to 2050

Lithuania – future Baltic Energy Hub

Energy transition is **potentially the largest growth opportunity for Lithuania & the Baltics,** because of their major future export commodity products towards Germany and the rest of central Europe.

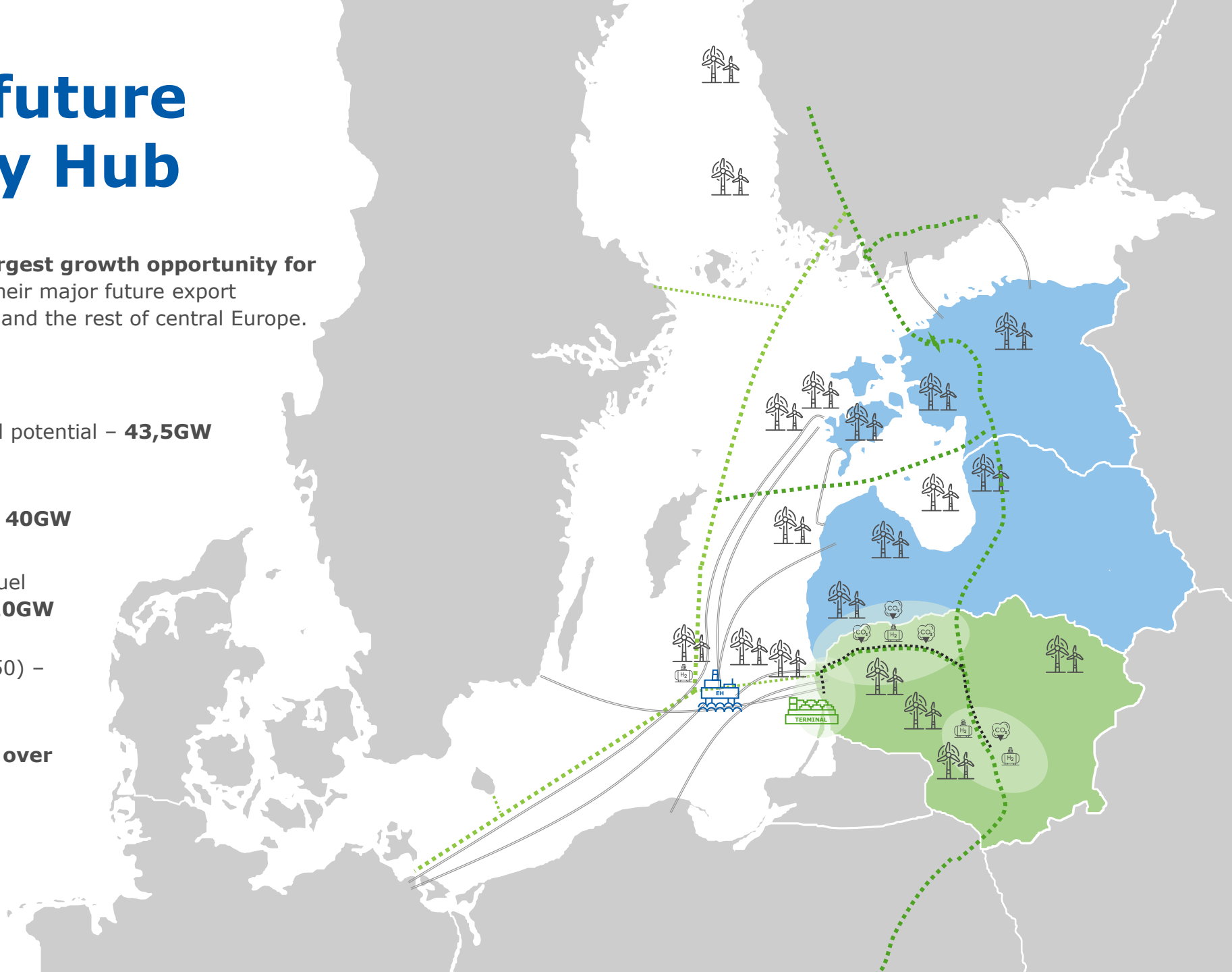
Baltics onshore & offshore wind potential – **43,5GW**

Baltics solar energy potential – **40GW**

Onshore & offshore synthetic fuel production facilities (2050) – **10GW**

P2G capacities in Lithuania (2050) – **8,5GW**

150B EUR value investment over the next 20-25 years



Hydrogen Backbone
Power interconnections
CO_2 pipelines
CCU
H_2 electrolysers
CO_2 products terminal
Energy Hub
Offshore/onshore wind

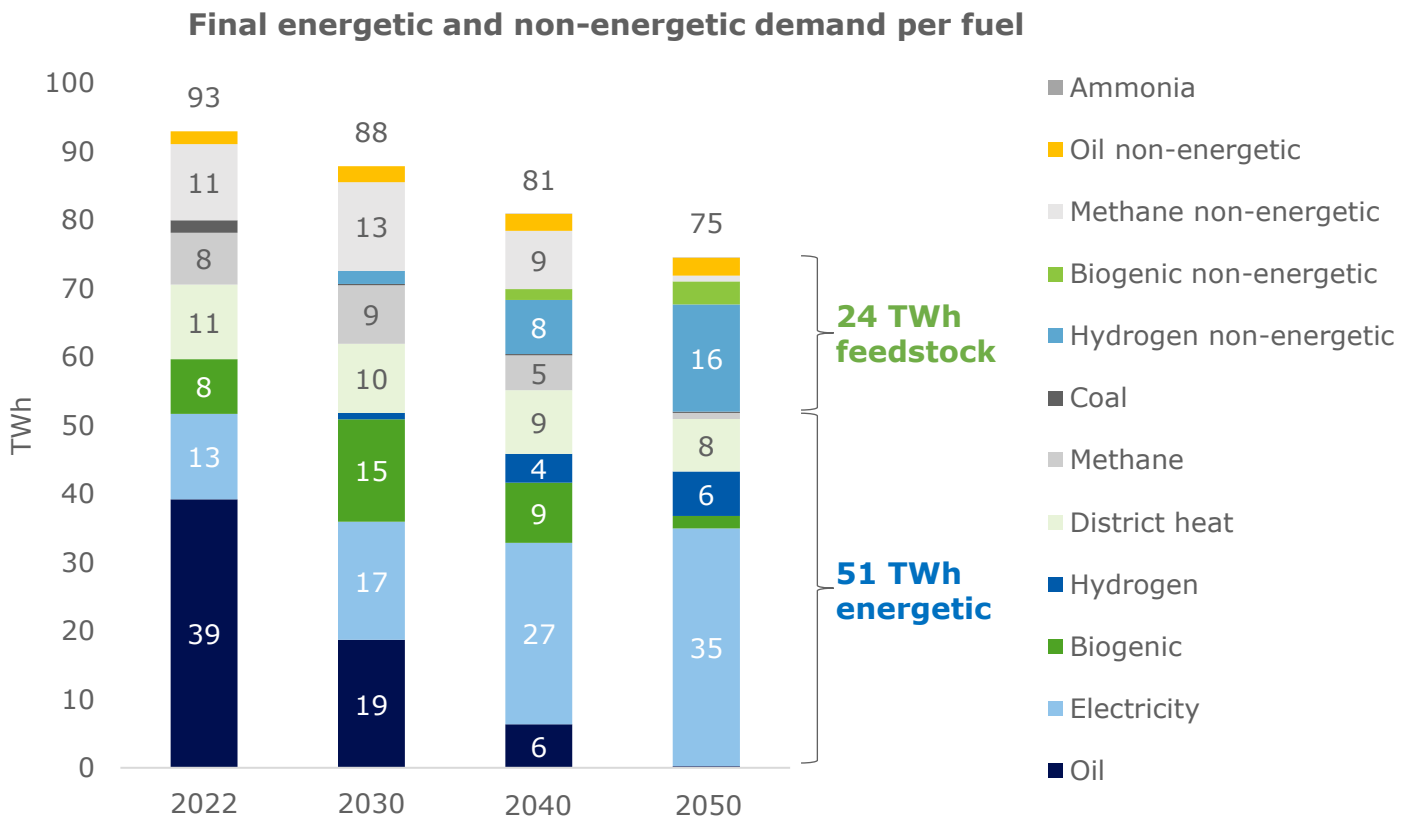
Source: Lithuania Energy System Transformation to 2050

4.

Implication on energy demand and supply

Lithuania Final energy demand

decrease from 93 to 75 TWh



Trends:

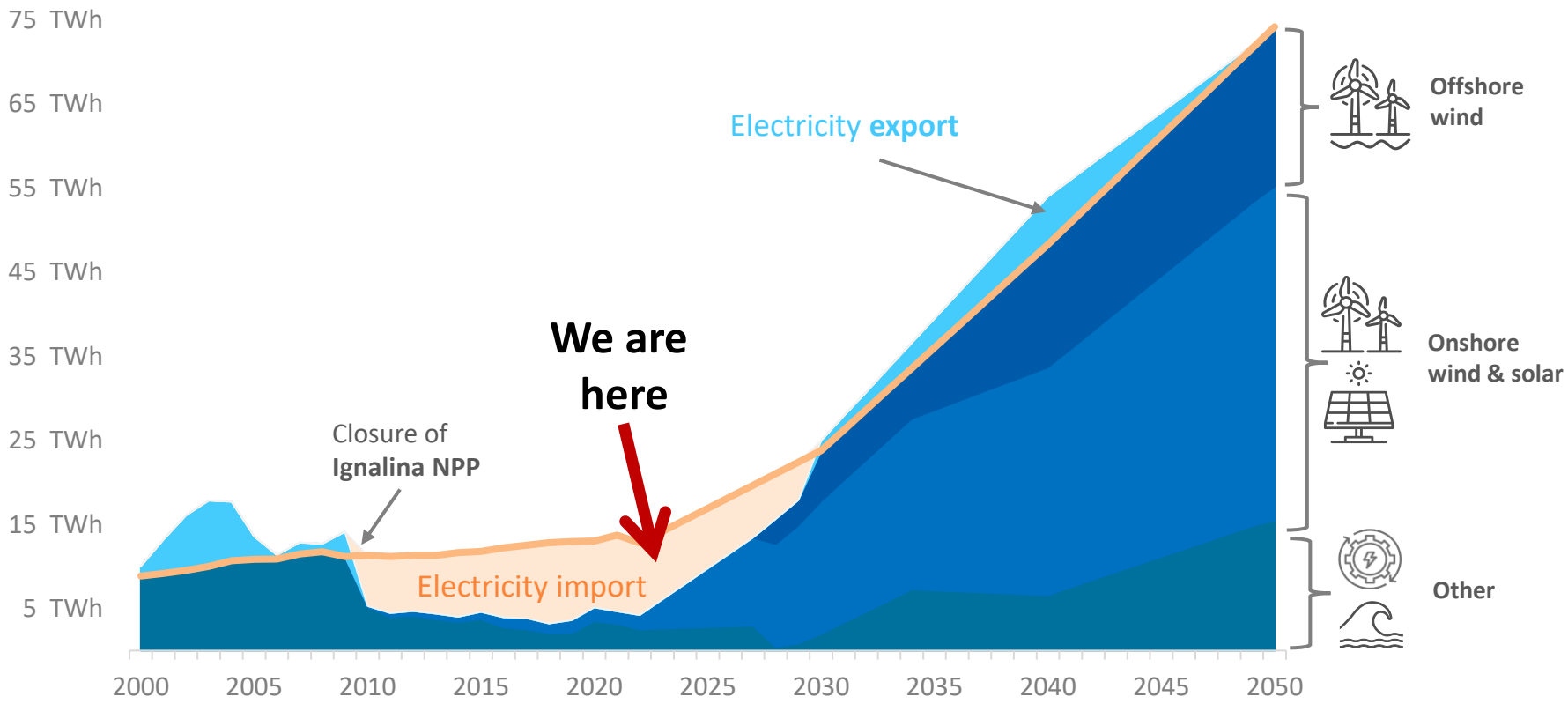
- Oil is phased-out in favour of electricity, biomass and hydrogen.
- Significant increase in electricity and hydrogen use simultaneously improve energy efficiency.
- Hydrogen demand kicks-off in 2030, and further increases in 2040 in response to low electricity price periods.
- Significant natural gas phase-out only after 2040.

Source: Lithuania Energy System Transformation to 2050

DNV outcomes based on Energy Transition Model

Lithuania transformation roadmap

pace and balance of supply and demand growth



By 2030: renewable energy will cover the current generation gap

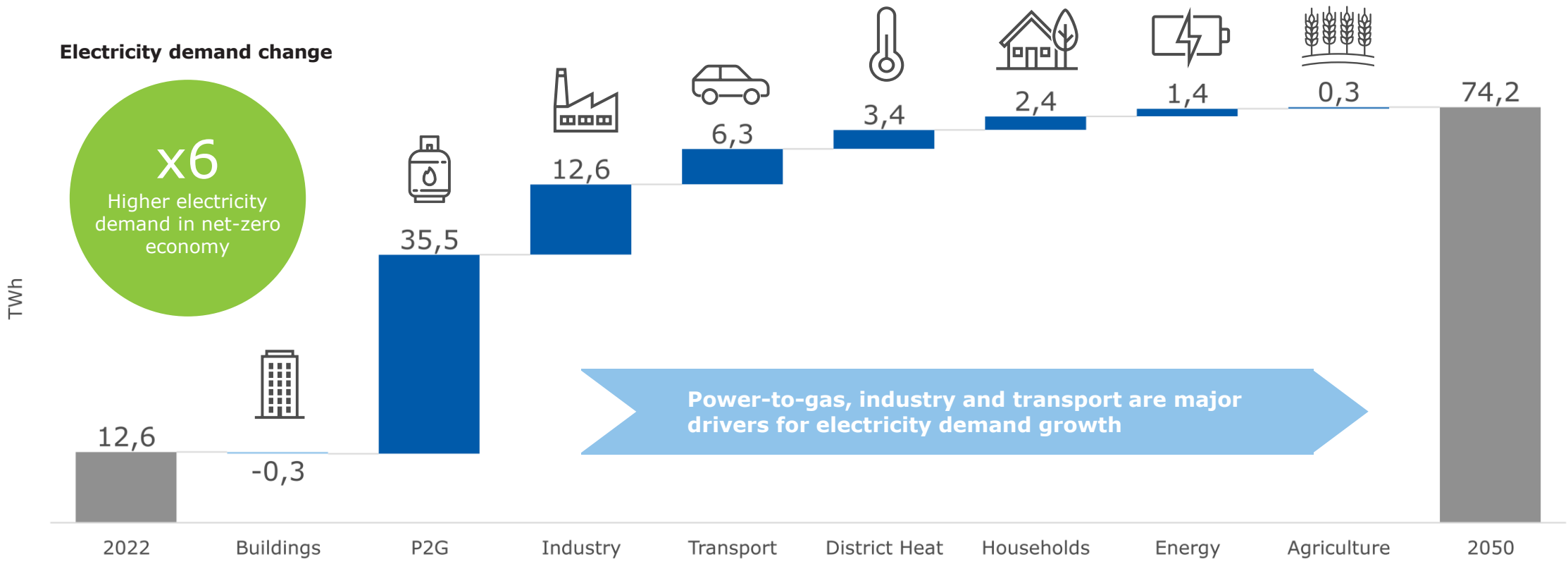
We must aim to enable further massive growth in local green energy

The future challenge will be to ensure instep and balanced growth of supply and demand

By 2030, Lithuania electric system will be self-sufficient with 100% of the annual electricity production provided by renewable energy resources

Electricity demand change to 2050

P2G, Industry and Transport are major drivers for demand growth

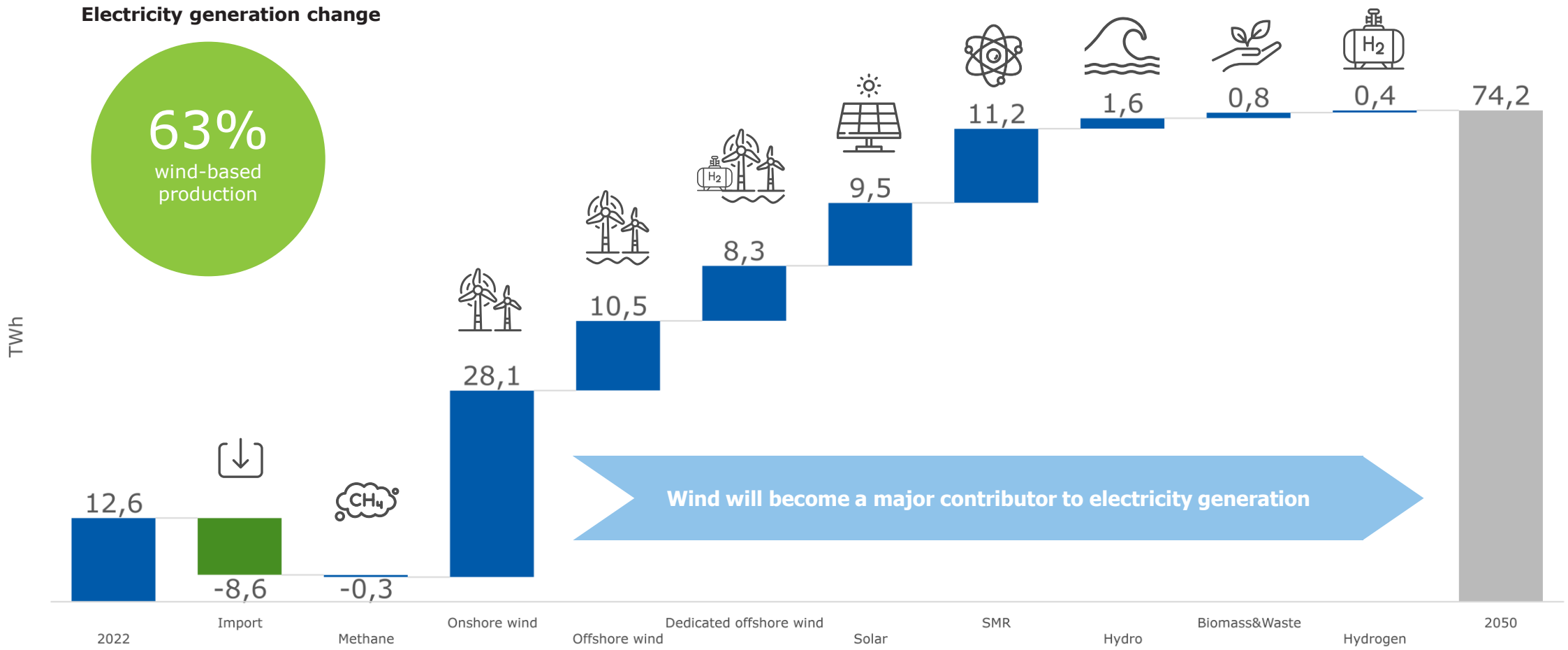


Source: Lithuania Energy System Transformation to 2050

DNV outcomes based on Energy Transition Model

Lithuanian Electricity generation change to 2050

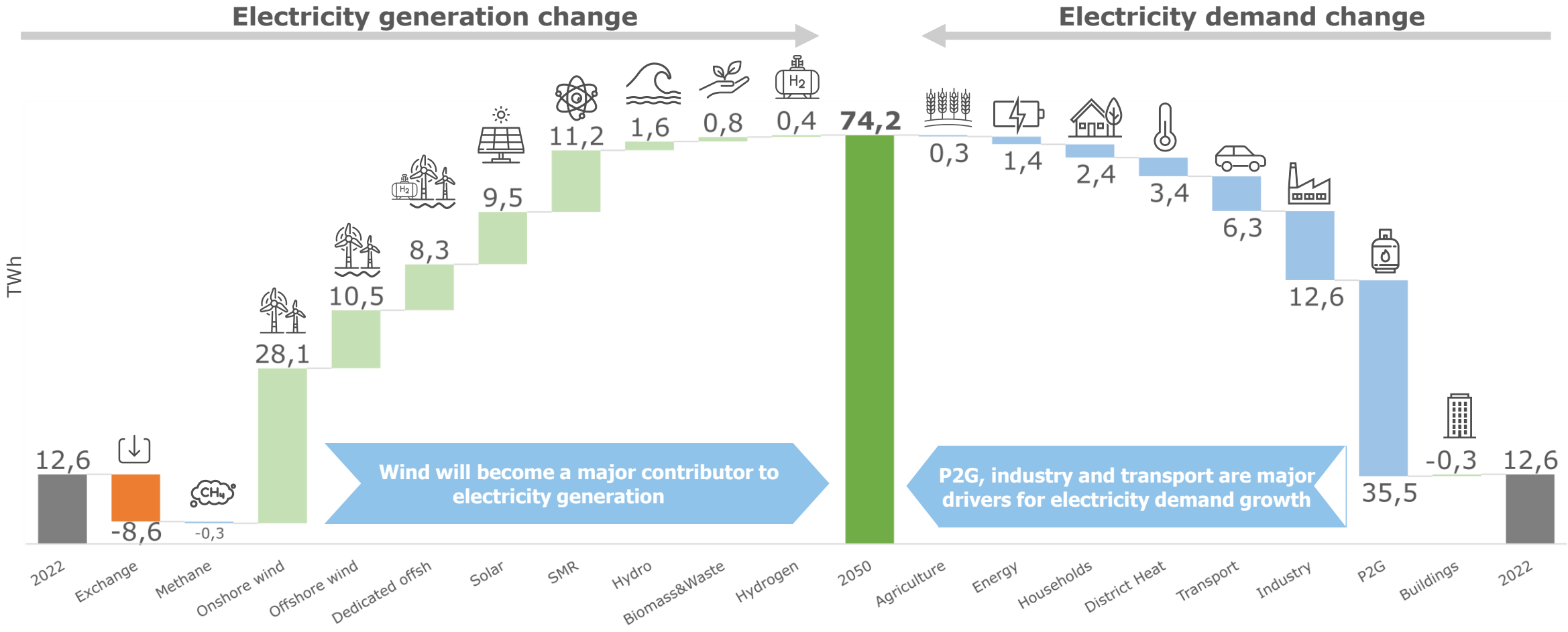
Massive growth of from wind, solar and SMR generation



Source: Lithuania Energy System Transformation to 2050

DNV outcomes based on Energy Transition Model

Electricity generation and demand change to 2050 – Roadmap scenario



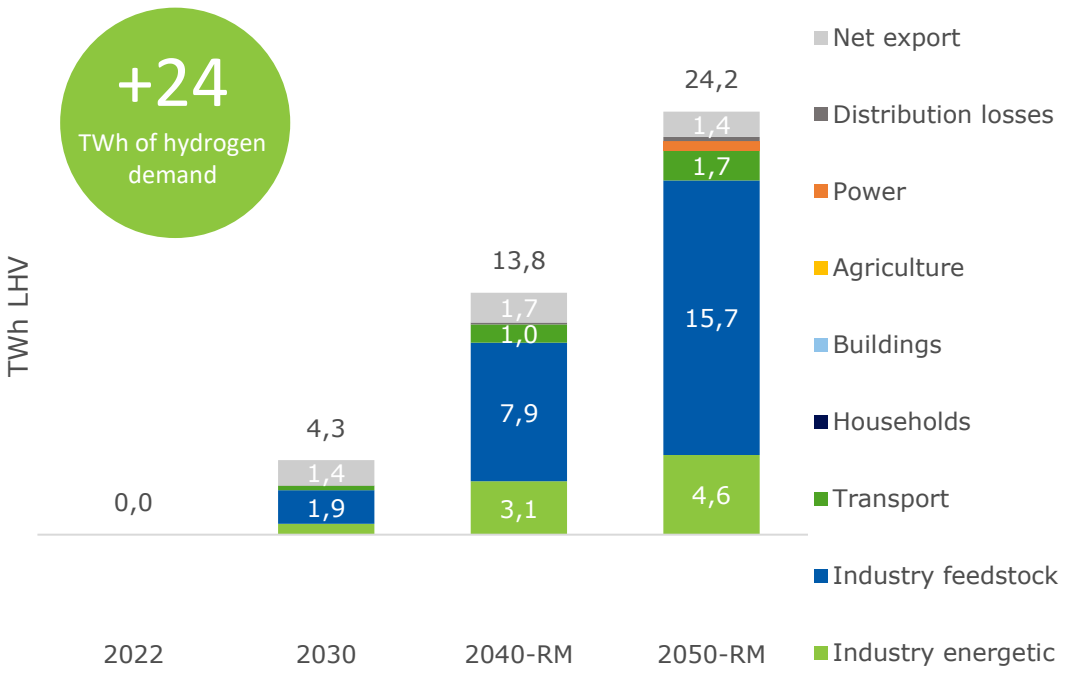
Source: Lithuania Energy System Transformation to 2050

DNV outcomes based on Energy Transition Model

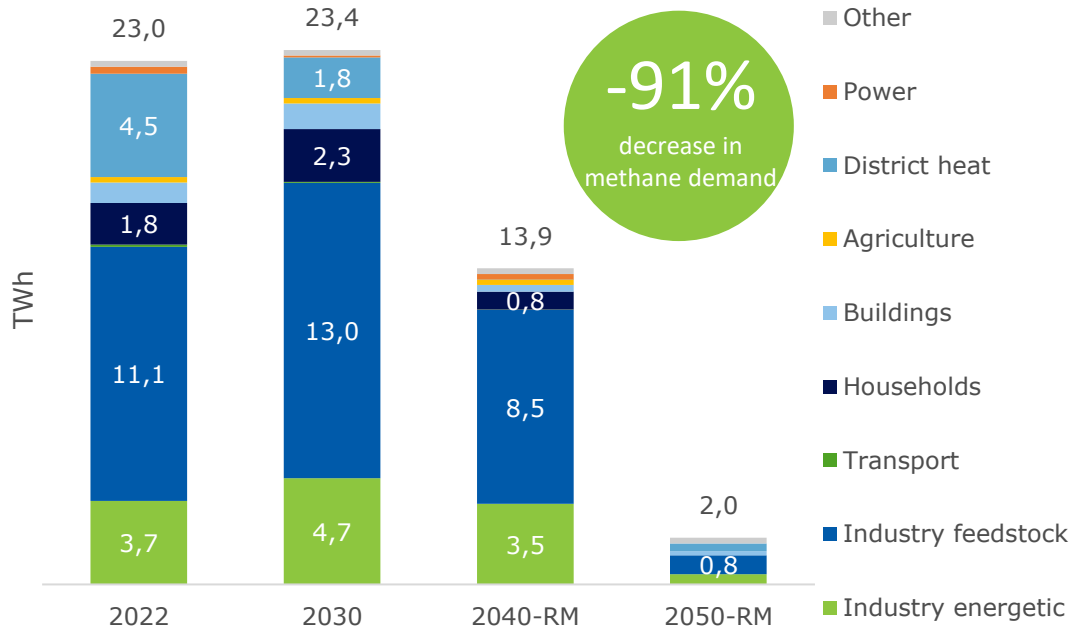
Demand for hydrogen and methane fuels

As of 2030, methane to be replaced by hydrogen

Hydrogen demand outlook



Methane demand outlook



Decarbonization of industry feedstock is leading to rapid growth of hydrogen and…

… decline of methane demand, which will be increasingly covered by domestic biogas

Source: Lithuania Energy System Transformation to 2050

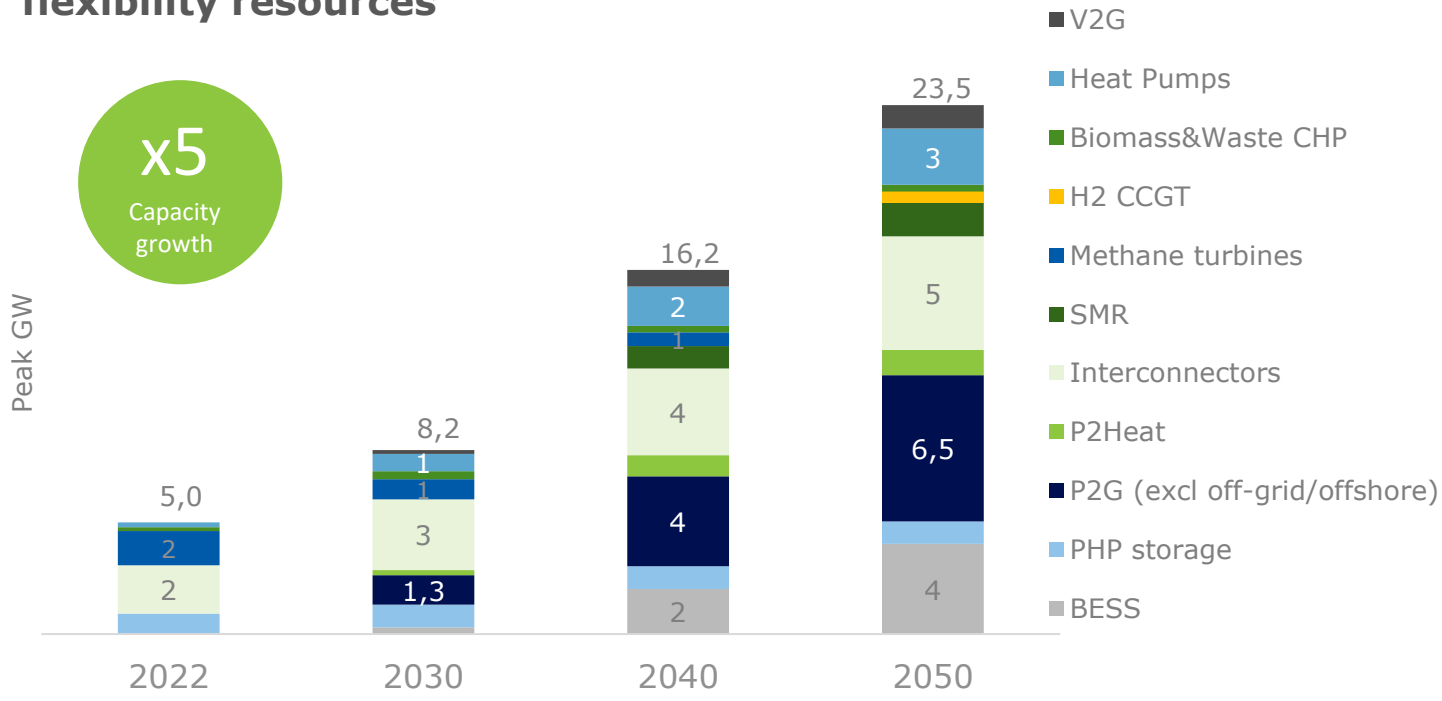
* The numbers correspond to 2021 methane demand since 2022 was an abnormal year in terms of methane consumption due to the impacts of Russian invasion in Ukraine

DNV outcomes based on Energy Transition Model

System flexibility

cross-sector integration by 2030 and beyond

Available dispatchable flexibility resources



P2G, interconnectors and BESS have the highest potential to provide system flexibility

Cross-sector flexibility is a key for the security of supply in weather-based energy system

Maximum ramp rate (residual load) increase from current **0.3 GW/h** to **5.0 GW/h** in 2050

P2G, interconnectors and **BESS** are becoming the largest sources of dispatchable flexibility

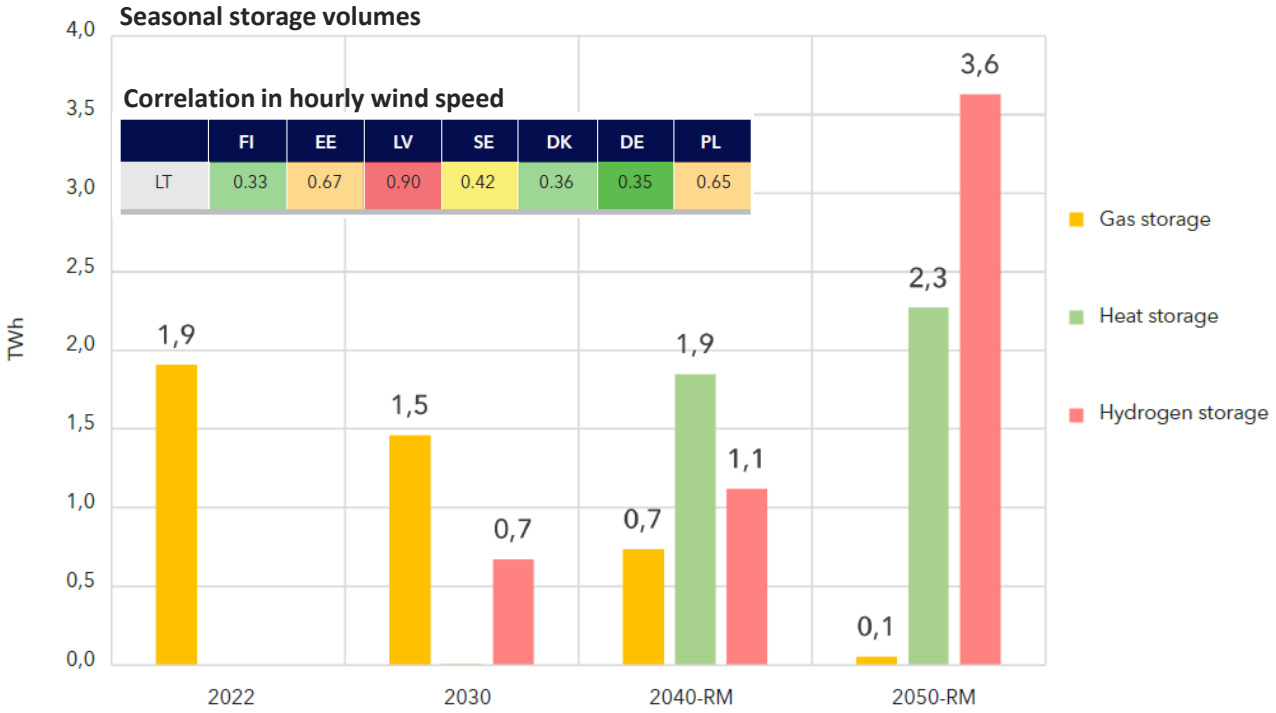
Source: Lithuania Energy System Transformation to 2050

DNV outcomes based on Energy Transition Model

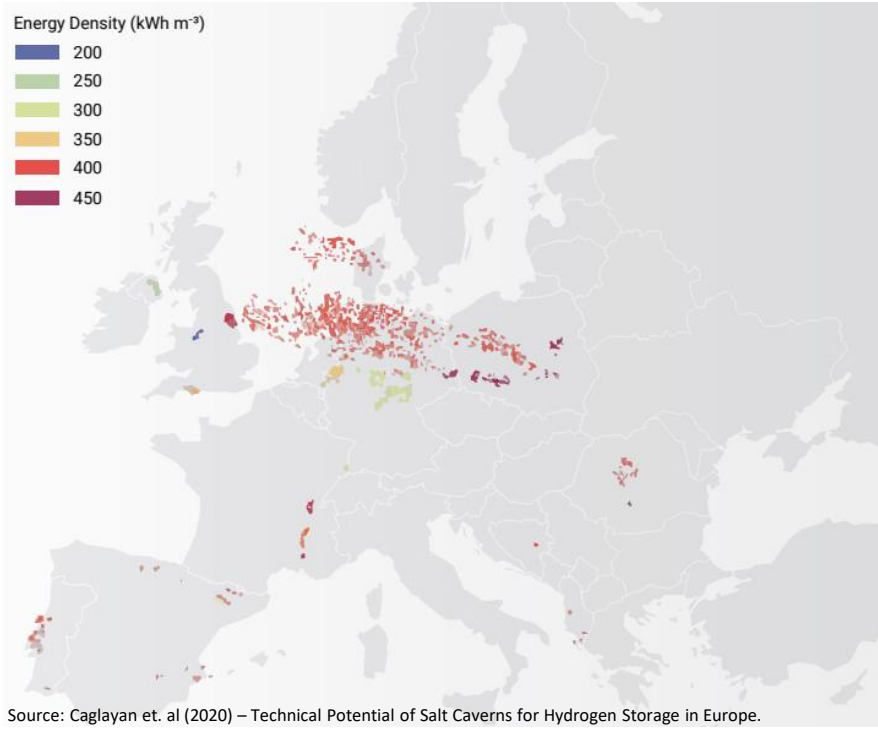
Seasonal storage

Storage and cross-border infrastructure is critical for zero-carbon products industry

Regional dunkelflaute – days of low wind and solar



Large scale underground hydrogen storage



Source: Caglayan et. al (2020) – Technical Potential of Salt Caverns for Hydrogen Storage in Europe.

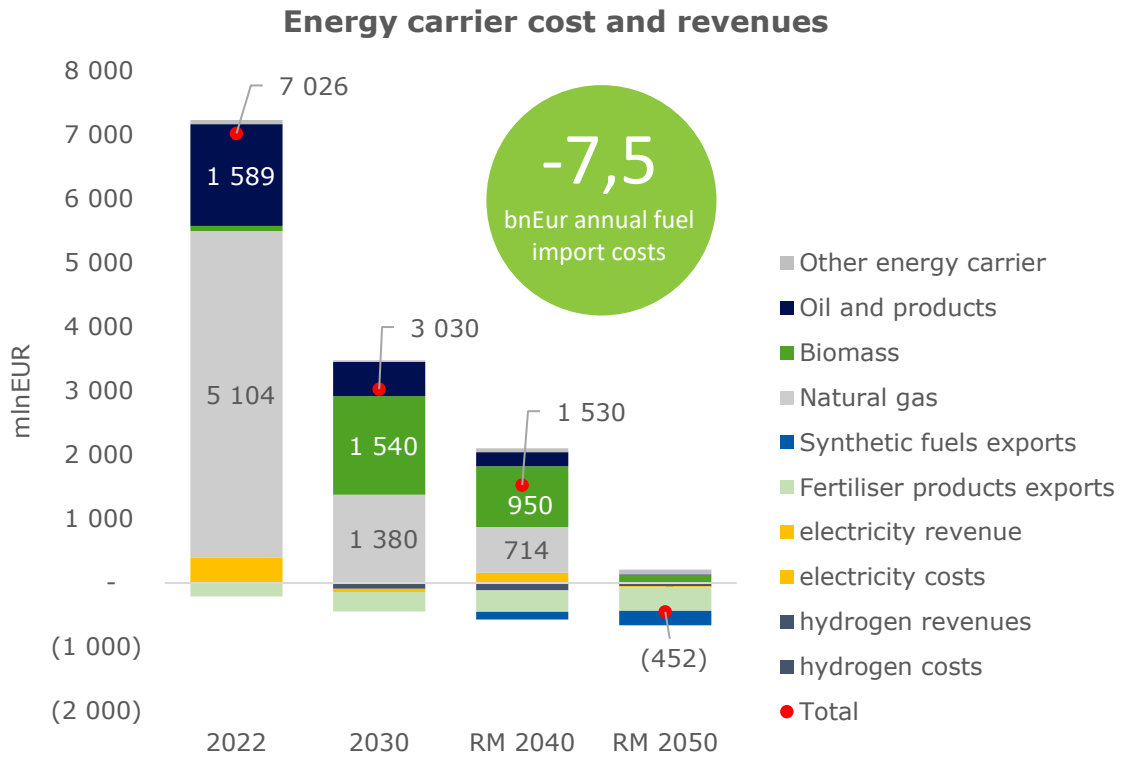
Flexible electrolysis, domestic resources (e.g. biomass CHP, heat & H2 storage, SMR, H2 CCGT) and interconnectors ensure system adequacy during dunkelflaute…

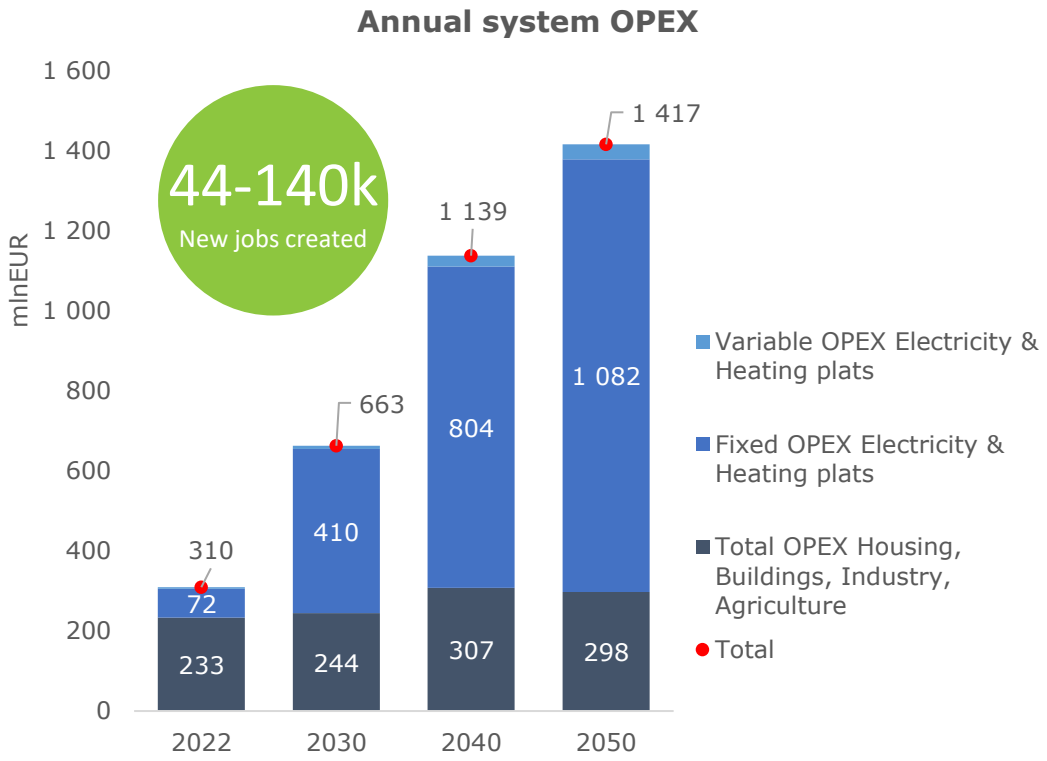
…it is critical to develop large cross-border hydrogen transmission and storage infrastructure to enable higher than 1GW domestic electrolysis scale

Source: Lithuania Energy System Transformation to 2050

DNV outcomes based on Energy Transition Model

Significant reduction in import expenditures, but increase in O&M costs





Significant decline of annual expenditures for fuel and CO2, as well as growing revenues from exports

Energy system O&M costs are largely driven by fixed O&M costs for electricity and heat generation, which are largely driven by costs for onshore and offshore wind

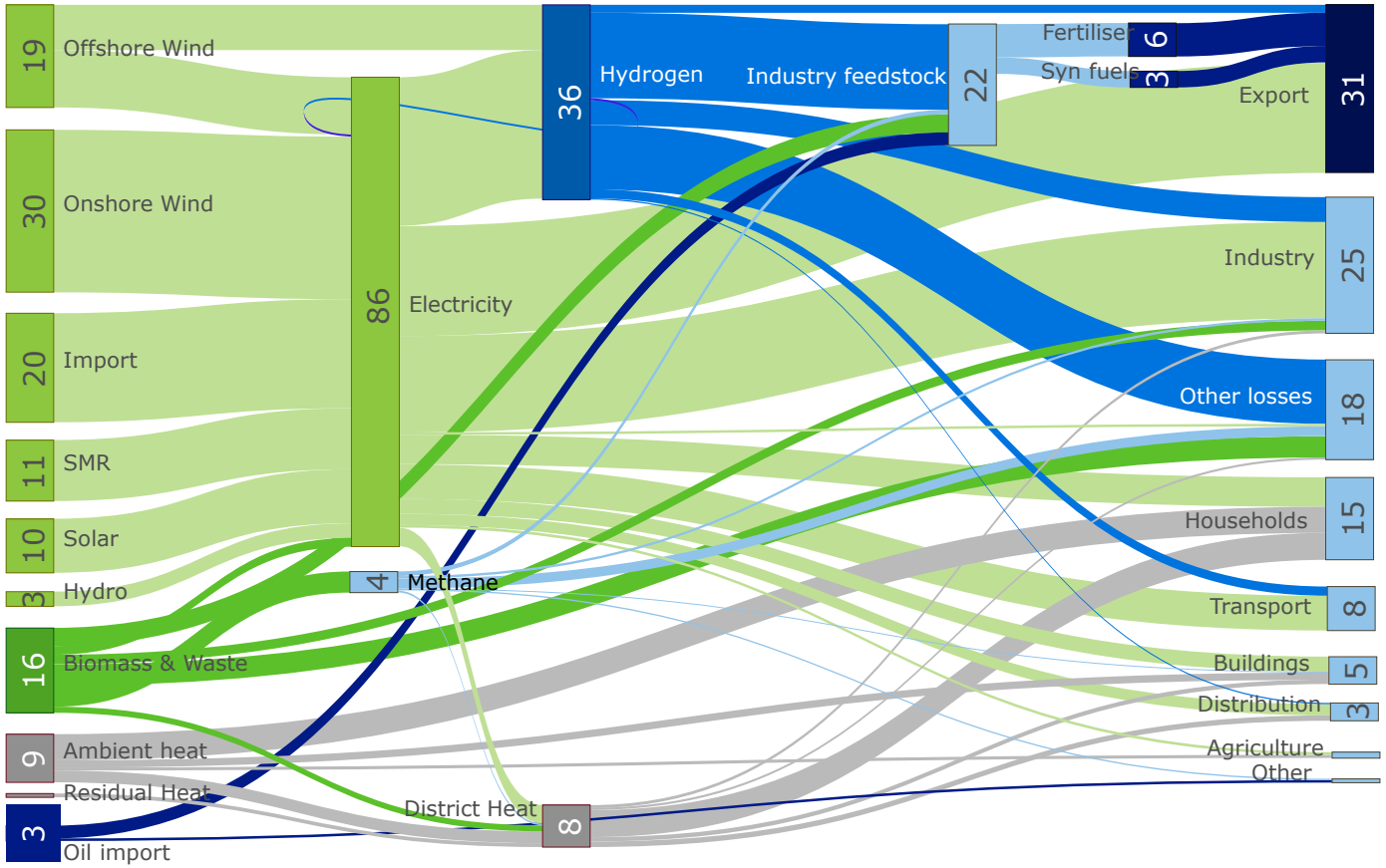
Source: Lithuania Energy System Transformation to 2050
Graphs present the annual cost for the respective year. Exports include electricity, hydrogen, fertilizer products and synthetic fuels

5.

Investment and socio-economic benefit

Final energy and non-energetic demand 2050

Lithuania - largely electrified system with big proportions of hydrogen and derivatives



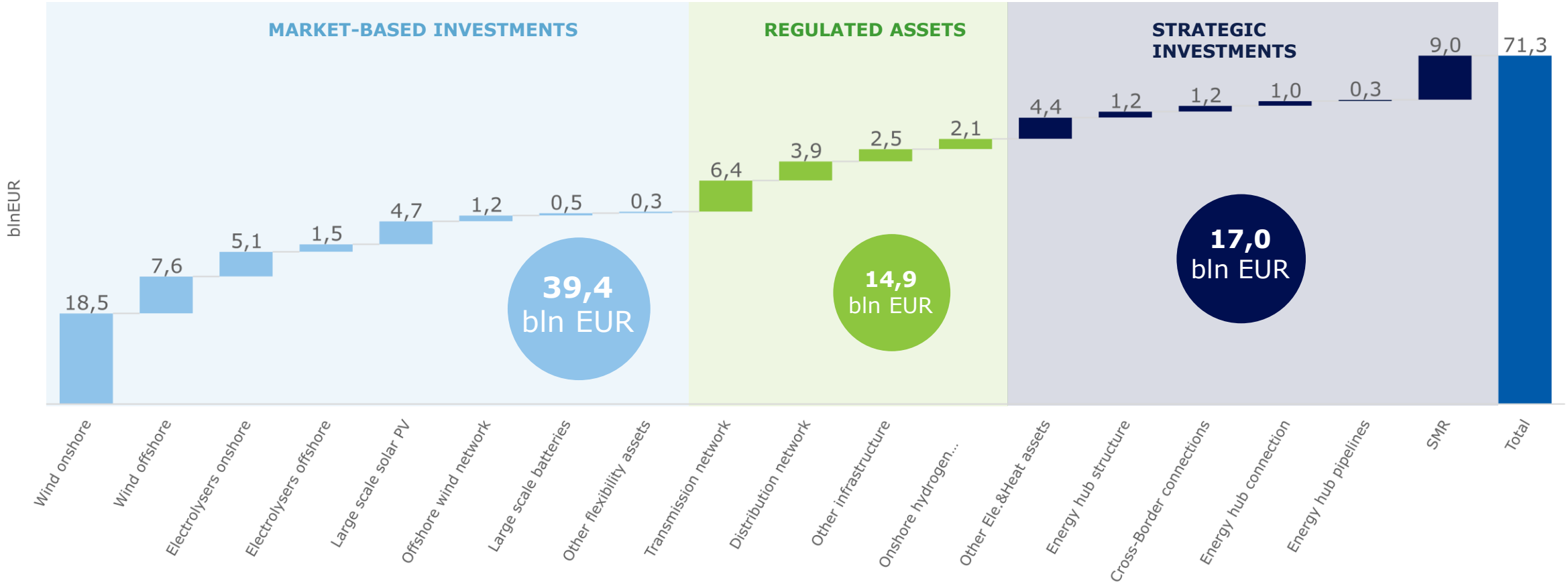
- Almost half of Lithuanian final energetic and non-energetic energy covered by electricity.
- Hydrogen serves as feedstock for fertilizer, chemical and synthetic fuel industries, heat production for industry, and transportation fuel.
- Industry sector emerges as largest energy off-taker especially for hydrogen.

Source: Lithuania Energy System Transformation to 2050

DNV outcomes based on Energy Transition Model

Investment breakdown and sources for different assets

A range of investors to mobilize the required volume of capital



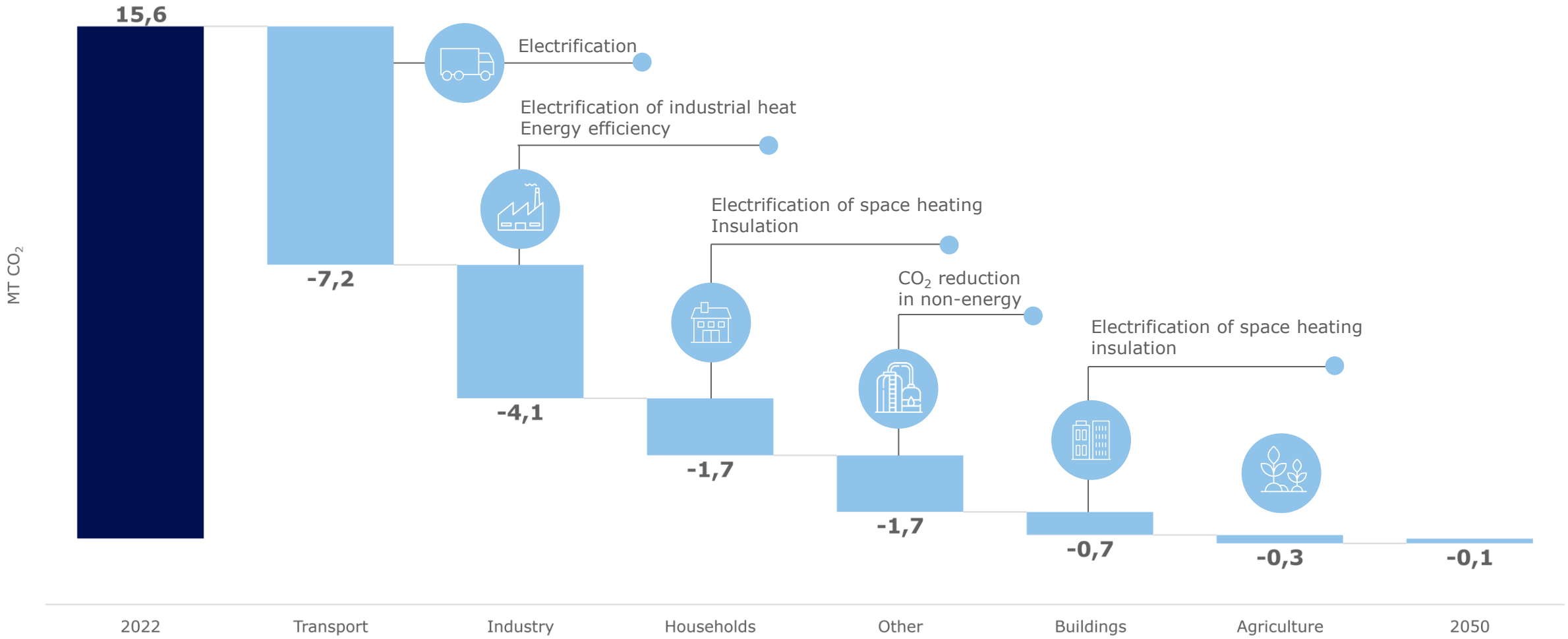
Source: Lithuania Energy System Transformation to 2050
Other infrastructure includes infrastructure for heat, gas, biomethane

DNV outcomes based on Energy Transition Model

CO2 emissions reduction per sector until 2050

Main decarbonization levers

$MtCo_2e$



Source: Lithuania Energy System Transformation to 2050

DNV outcomes based on Energy Transition Model

Socio-economic benefit by 2050

Key Performance Indicators

Energy independence

100%

Electricity independency

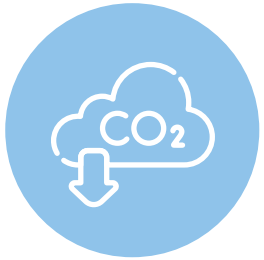
Energy export

1.4 TWh

Hydrogen exports

9.1 TWh

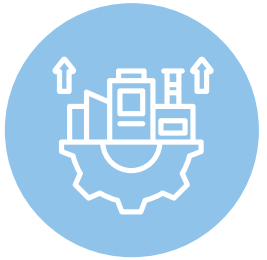
Zero carbon product exports



100% decarbonisation

0 MT

Carbon emissions reached



Industrial growth

4-11%

GDP growth

44,000-140,000

Jobs created

Energy costs & affordability

-6,3 blnEUR

Reduction in annual operational costs (energy carriers & O&M)

Source: Lithuania Energy System Transformation to 2050

DNV outcomes based on Energy Transition Model

6.

Key take-away

Top 5 priorities for energy transformation

System growth across the whole value chain, internally and regionally

Renewable auctions and incentive schemes

Road transport electrification

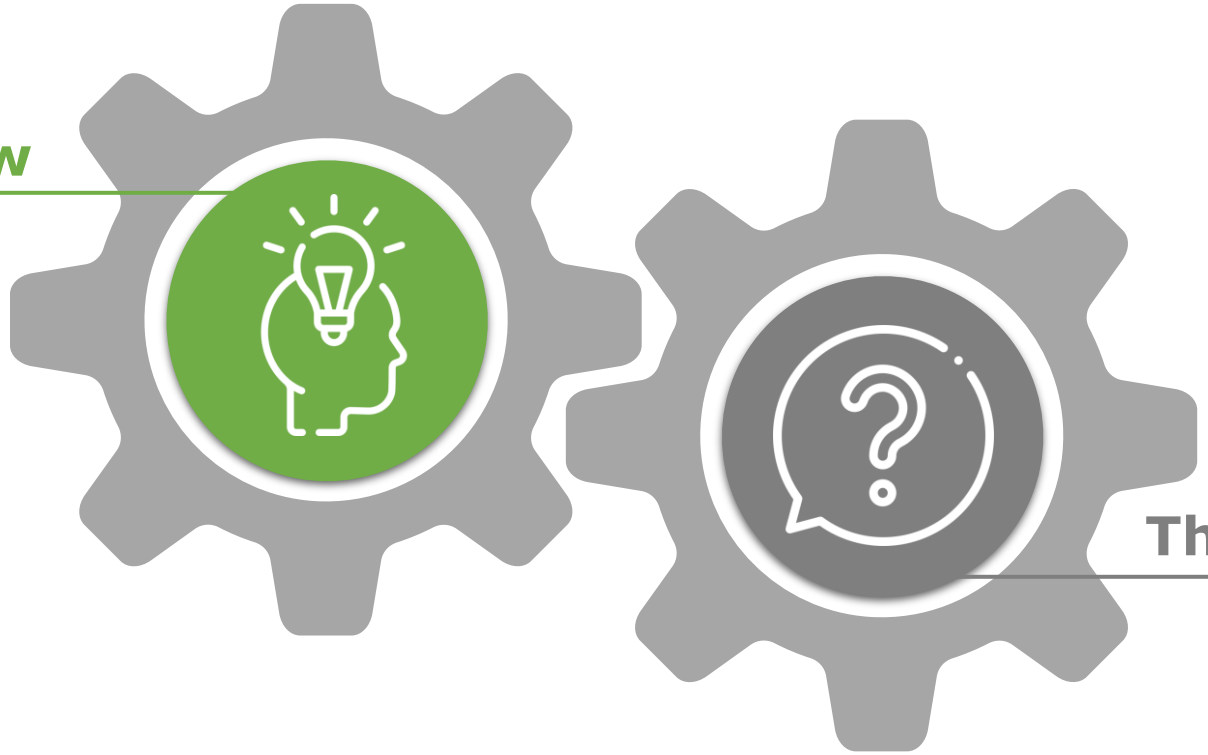
Regional hydrogen and electricity infrastructure

Zero carbon products industry

Reinforcement of power grids at all voltage levels

We think of transformation in context of what we know and what we don’t yet know

Things we know

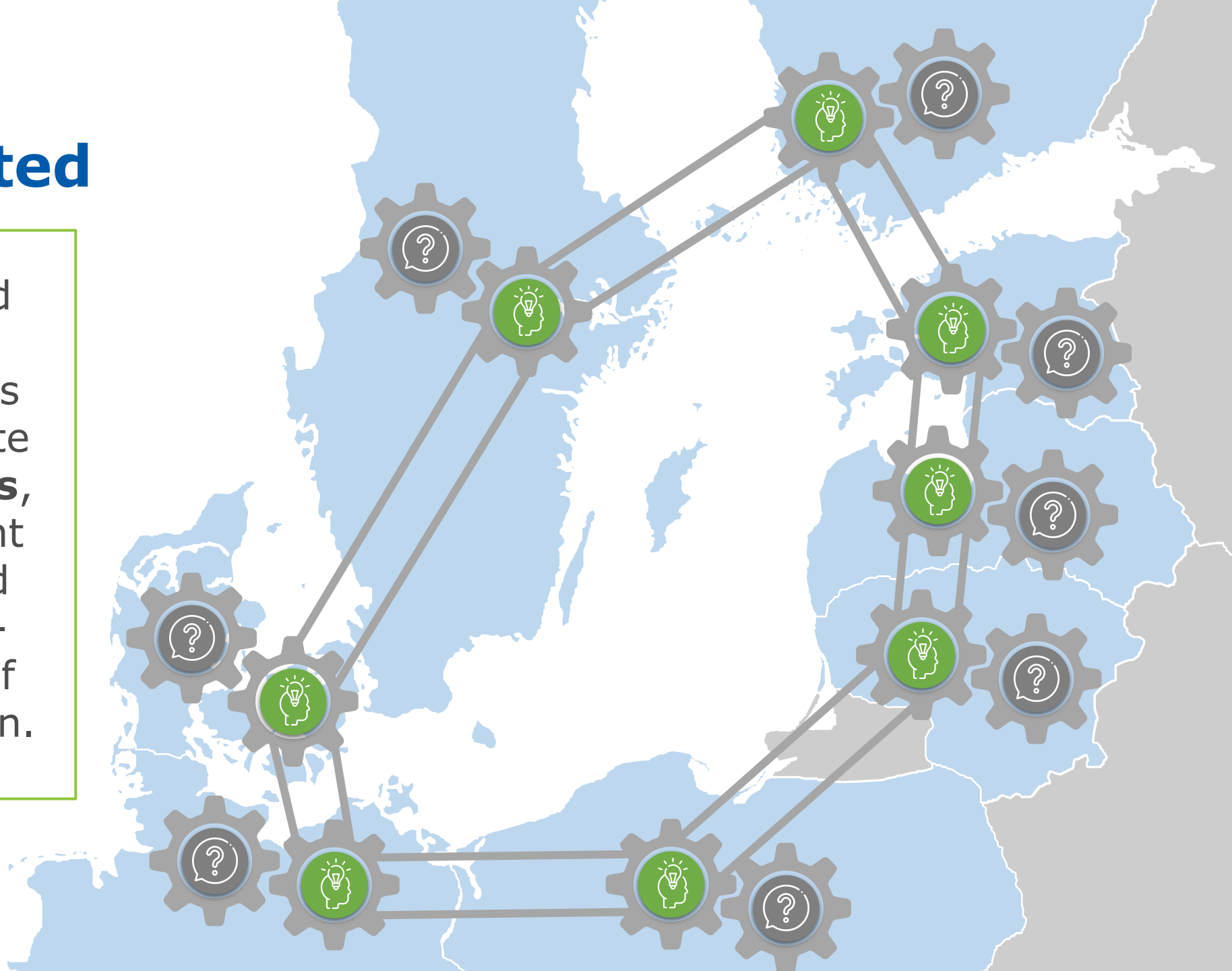


Things we don’t know

- Interdependencies
- Moving targets
- Optionalities

It's all interconnected

Progressing toward net-zero energy systems requires us to grasp the intricate **interdependencies**, explore the different **optionalities**, and adjust to the ever-**moving targets** of the energy transition.



Acknowledgements

EPSO-G and the project team would like to acknowledge that Lithuania Energy System Transformation to 2050 has been prepared in close cooperation with key stakeholders in the Lithuanian energy and related sectors. They extend their sincere gratitude to the organizations that have made significant contributions to the preparation of this study and the advancement of Lithuania's energy sector.

They would like to thank Ignitis Group, Klaipėdos nafta (KN), Vilniaus šilumos tinklai (CHC), Lithuanian Energy Agency and Lithuanian Energy Institute for their active involvement, valuable comments, and insightful feedback throughout the process. Their expertise and input have greatly improved the content of this document.

Thank would also like to express their thanks to ESO, the Ministry of Communications and Transport of Lithuania, Ignalinos AE, Lithuanian Confederation of Industrialists, Achema Group, ORLEN Lietuva and Akmenės cementas for their participation in the interviews and discussions. Their perspectives and experiences have played a crucial role in shaping the recommendations and strategies presented in this study.

Furthermore, a special thanks to the Ministry of Energy of Lithuania for their strategic guidance and thoughtful discussions regarding the future vision of the energy system. The Ministry's insights and support have been instrumental in shaping the overall direction of this study.

Lithuania Energy Vision To 2050

SCAN ME