Lithuanian Hydrogen Sector Development Roadmap and the Action Plan for its Implementation

Final Report Summary

Amber Grid, EPSO-G

28th June 2022

Introduction to the study

The study combines a review of international hydrogen policy and Lithuania's specific context to develop long term scenarios for Lithuania that are used to propose a national strategy

Contents of the full report

1. Policy review	In section 1, EU policy relating to hydrogen, as well as the strategies and policies of 10 countries with published hydrogen strategies have been reviewed to assess levels of ambition, target use cases, funding, market making mechanisms, regulation, and initiatives to promote value chain participation. This Section deliberately stays agnostic to Lithuania but provides the context for appraisal of Lithuania and Sections 2 and 3
2. SWOT analysis	In Section 2, Lithuania's strengths, weaknesses, opportunities and challenges have been analysed in the context of hydrogen development. This section attempts to provide a clear context for which use cases can be targeted, what technologies can be used, what opportunities exist through development hydrogen to further broader national objectives, and what challenges exist in keeping pace with hydrogen economy development in Europe
3. Scenario modelling	In Section 3, long term scenarios for hydrogen are assessed with the intent to support a long term vision for hydrogen in Lithuania and shorter term targets for nurturing the hydrogen economy. These scenarios give a high level estimation of hydrogen demand as well as the level and cost of infrastructure needed to deliver that demand and use the benchmarks set in both Sections 1 and 2 to underpin that view
4. Strategy and implementation	In Section 4, we present a long-term 2050 vision and plan for developing the 'Base case' view of the hydrogen economy in Lithuania developed in Section 3. A roadmap and action plan complete with ownership responsibilities is provided for achieving the 2030 horizon of that vision

Context and scenarios

Lithuanian Hydrogen Sector Development Roadmap and the Action Plan for its Implementation

Putting hydrogen in context

Ambitious EU targets are driving a range of strategies, but with common themes

Scale up of industrial hydrogen demand and transport use cases within next 10 years

Sector	Use case	Incumbent fossil fuel	Likely EU scale-up period
Feedstock	Fertilizer	Grey H_2	2025 - 35
Feedstock	Oil refining	Grey H_2	2025 - 35
Transport	Buses*	Diesel / LPG	2020 - 30
Transport	Passenger cars (SUVs)	Diesel	2030 - 40
Transport	Trucks*	Diesel	2020 - 30
Transport	Rail	Diesel	2025 - 35
Transport	Shipping*	Fuel oil	2030 - 40
Transport	Aviation	Kerosene	2030 - 40
Power	Flexible power	Nat. gas	2030 - 35
Heat	Building Heat	Nat. gas	2035 - 50
Heat	Process heat	Nat. gas	2035 - 50

How other countries are responding in their strategies

Supply, transport and storage

- Increasing energy security through hydrogen is important to many
- Electrolysis is prioritised, but methane reformation with CCS is accepted as low carbon in many cases
- Some countries identify as net importers, others are net exporters

Ambition, targets and demand use cases

- 2030 used as a target horizon
- Emphasis on treating proven demand first, but targeting multiple use cases:
- Using public transport to build early confidence
- Testing, but not committing to, hydrogen blending in gas network

Mechanisms, incentives, and initiatives

- Hydrogen valleys are already emerging
- Some countries investing early in aviation and marine despite being post-2030 use cases
- Nurturing technologies through pilots but maintaining technology competition in market mechanisms
- Sourcing some hydrogen outside of EU is likely
- Supporting domestic champions and building capabilities
- Addressing total cost of ownership of vehicles, not just fuel cost

Note: Assumes USD/EUR FX rate of 1.13, *Buses, trucks and shipping have an uncertainty of 5%, 20% and 40% respectively; assumes 2019 global levels for gas and oil prices
Source: Hydrogen Council 2021 Hydrogen Insights, Project analysis

Putting Lithuania in context

Plenty of domestic demand capable of enabling renewable power, but with storage challenges

Proven domestic demand in ammonia for fertilizers which is large in context of Lithuania's overall size; HGVs also present sizeable demand in next decade

- Lithuania has a relatively large footprint in fertilizer manufacturing and heavy goods vehicles fuel demand for a country of its size. These can be the anchor use cases to provide scale in the next 10 - 15 years, driven by ambitious EU targets for low-carbon ammonia production (50% of all ammonia production by 2030) and the commercial readiness of hydrogen in HGVs, which will be cost competitive with diesel for HGVs later this decade. As a smaller country within the EU membership, Lithuania is arguably less suited to investing in less mature use cases in aviation and marine fuel, while it's ability to leverage biomass for heating needs means there is less pressure to develop hydrogen in for heating vs other countries more reliant on gas heating

Electrolysers (power to gas) drives energy security agenda and enables ambitious renewables targets

- Lithuania plans to develop more renewable power to reduce reliance on natural gas and oil, with this need accentuated by the impact of Russia's invasion of Ukraine. There is also an ambitious target for net zero power system by 2035. Consequently, there is a need for hydrogen to displace gas in the fertilizer, refining and power sectors, while also an opportunity for the production of hydrogen to lower the subsidies required for wind and solar energy. As a result there is incentive for Lithuania to prioritise hydrogen from domestic renewable power over other forms of production

More renewable power supply will need to be unlocked to serve hydrogen production in the long term

- Supply of renewable electricity is more than adequate for 2030 demand in all our scenarios but limited onshore and offshore wind resource and could impede the ability of domestic renewable power production to meet hydrogen production requirements by 2050. This can be mitigated by cooperation with other countries on either renewable power sourcing for electrolysers, LNG sourcing for blue hydrogen production, or importing hydrogen itself

Demand and feedstock supply are clustered in different regions, which can each become hydrogen 'valleys'

- Supply of electricity is likely to rely on wind, where resource is located in the north west of the country, while demand from fertilizer production means that hydrogen demand will initially be concentrated in Jonava near Kaunas. There is also a potential cluster of demand centred around oil refinery activity in the north, which could also serve heavy-duty-vehicle transport demand in Siauliai, Panevėžys and Klaipeda. This is broadly similar to other countries where industrial demand is centred on a small number of cluster locations

Well connected networks can be leveraged; storage options are more limited but ammonia demand could be an enabler

- Lithuania lacks the scale of proven geological storage potential of Germany, Denmark and Poland but may have a unique opportunity to use ammonia as a storage carrier given its outsized role in expected Lithuanian hydrogen demand. Like most EU countries it has a mature gas transmission network that will be required for natural gas in the 2020s and 2030s but can be repurposed to hydrogen over time. Hydrogen for heating will require costly distribution network retrofit but only post-2030 and likely on a small proportion of the countries heating demand that cannot be easily electrified or switched to biomass

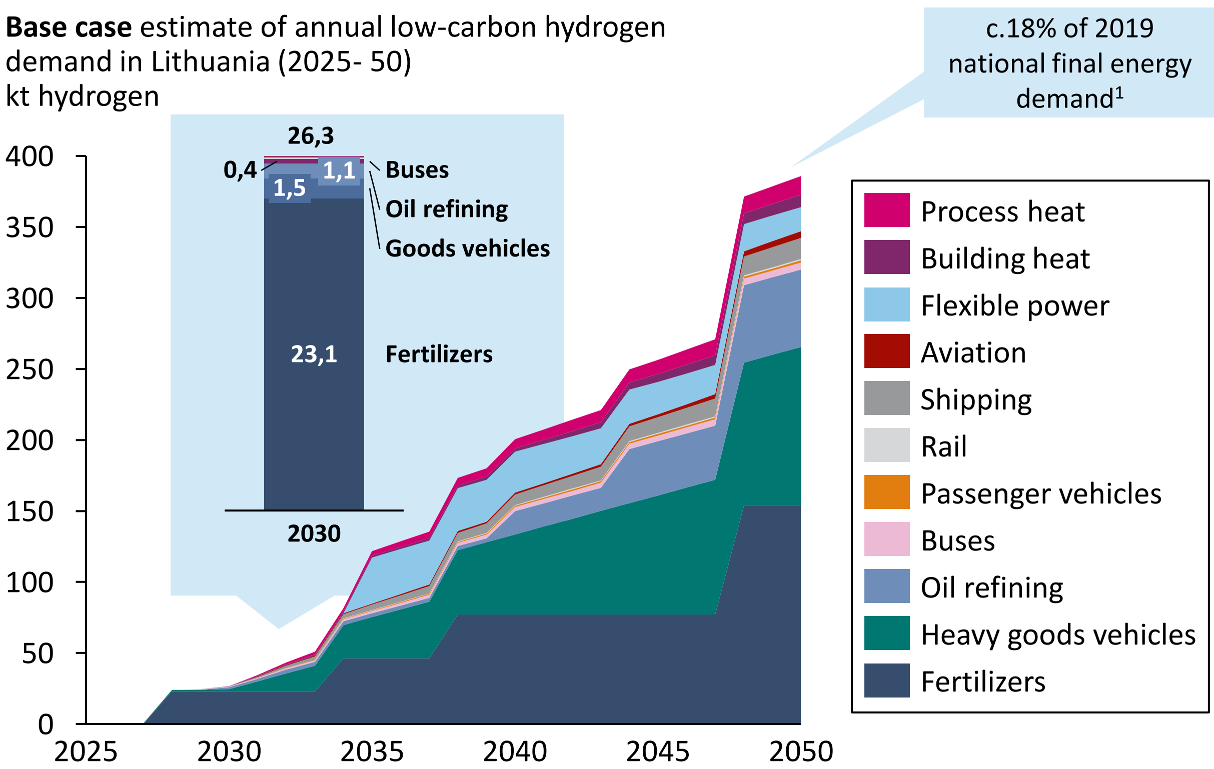
Active R&D but requiring better links with industry needed to capture value chain

- Lithuania has established R&D programs in hydrogen production technologies but has little track record of technology commercialisation and is not a currently a manufacturer of any components of the value chain. As a result, developing the ability to participate in manufacturing will require sustained investment in R&D and human capital over time focused in one or two key areas that fit with domestic infrastructure required. It is starting behind countries such as Germany, Finland, Denmark and Sweden, who have already made big steps to capture part of the value chain through existing domestic manufacturing champions

Projection for low carbon hydrogen demand

We estimate 26 kt by 2030 and over 380 kt per year of demand by 2050 in our base case scenario

Base case estimate of annual low-carbon hydrogen demand in Lithuania (2025- 50)
kt hydrogen



What we mean by 'low-carbon' hydrogen: this report refers to hydrogen *demand* as low-carbon hydrogen i.e. demand that is driven by decarbonisation (therefore excluding grey hydrogen demand), but is agnostic to technology production. The report recommends green (electrolyser) hydrogen production over other technologies when considering *supply* but does not differentiate between technologies when considering demand

Key assumptions

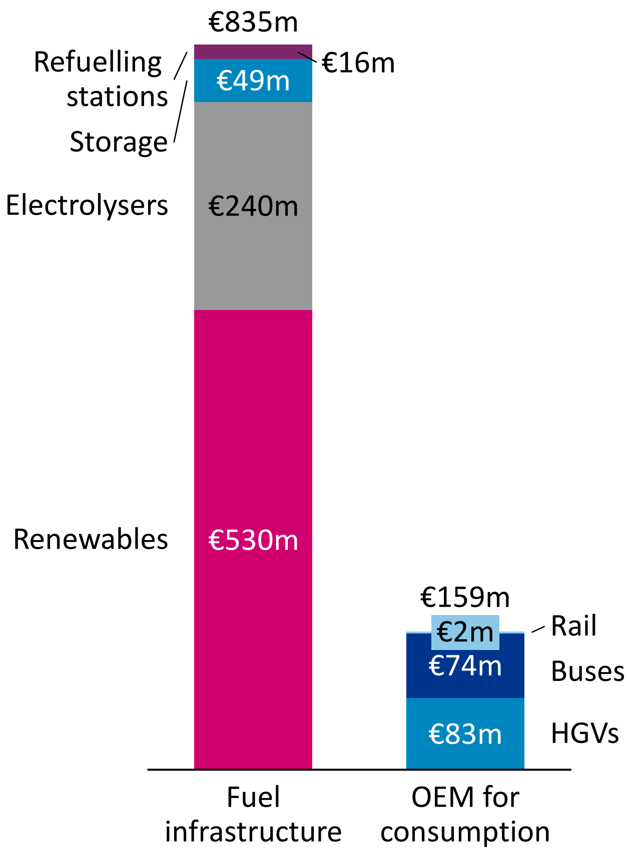
- Centralized nature of fertilizer production offers opportunity to scale early, but with full scale occurring once regulation mandates full switch
- Buses are the earliest use case and could adopt up to 1 kt per year by 2026, but this is small in proportion to fertilizer demand
- HGVs take time to roll out but eventually provide a very large demand base owing to large share of international HGV transit
- Lithuania achieved net zero by 2050 but is not as quick to achieve same level of scale in some use cases by 2030 as the more ambitious member states
- Net Zero 2035 in the power sector requires some hydrogen-to-power peakers
- No significant positive export balance is assumed given production cost will be reasonably well aligned with neighbours

Note: 1) 5,2 Mtoe final energy demand for 2019
Source: Project analysis; Enerdata

Near term investment required

Nearly €1bn will be required up to 2030 through a combination of public and private sector investment

2022-30 cumulative investment of **€994m** in the **Base Case**



All will require a combination of public and private sector investment

- Financial support for development can be administered at state level with different projects or cities competing for earlier prioritisation of funding, which is allocated in a sequenced manner. This sequenced approach has been adopted for allocating funding for industrial clusters in the UK and allows the first sequence of projects to teach and refine subsequent projects
- **Pilot projects** will require a significant portion of their capital cost funded through public support with those competing for funding allowed to present different business models and technologies
- **Scale-up** mechanisms and incentives such as mandates and CfDs then look to push more direct competition by establishing a business model (e.g., carbon CfDs or diesel fuel taxes) which project developers can compete within to provide hydrogen

Individual items to consider funding (either via EU or domestic funding):

- Pilot cases for HGVs and refueling stations
- Roll out of hydrogen buses in 5 largest cities
- Funding focused on R&D collaboration with industry
- CfD mechanisms for de-risking competitive investment in heavy industries such as fertilizer and refining
- Incentive mechanisms for vehicle switching in HGVs
- Establishment of hydrogen valleys and required network infrastructure and permitting to facilitate their growth

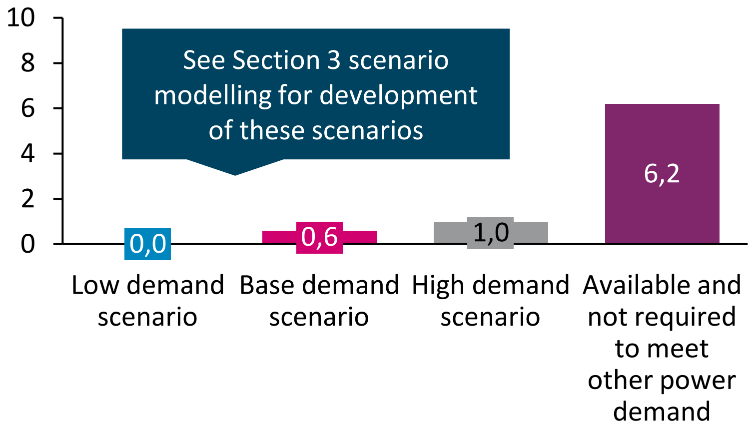
These could be funded through several revenue raising mechanisms:

- Fossil fuel taxes (supplier pays)
- Carbon taxes / carbon price premium on top of ETS (fossil fuel consumer pays)
- Electricity and gas end-user environmental levy (household / business pays)
- General taxation (individual pays)

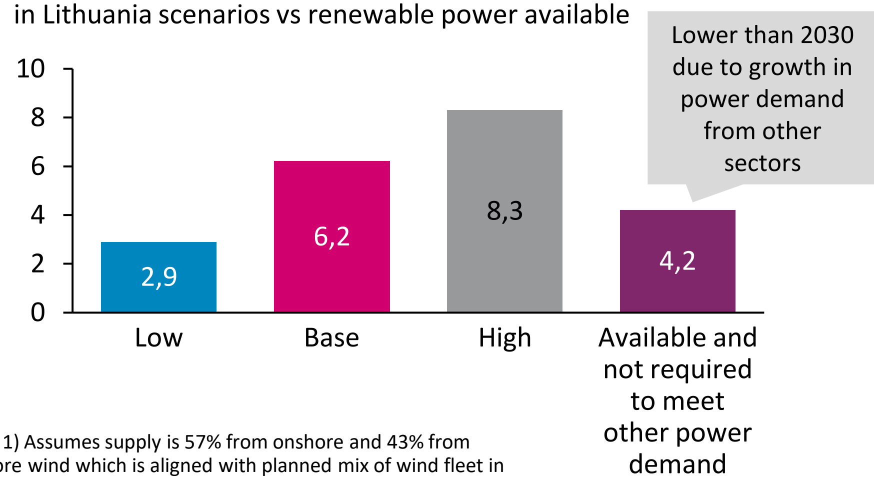
Is there enough renewable power to serve demand?

Renewable power development plans should be sufficient to cover hydrogen demand until 2030, but thereafter more renewable power is needed, and network upgrades required

2030 GW wind power[1] required for hydrogen demand in Lithuania scenarios vs renewable power available



2050 GW wind power[1] required for hydrogen demand in Lithuania scenarios vs renewable power available



Note: 1) Assumes supply is 57% from onshore and 43% from offshore wind which is aligned with planned mix of wind fleet in 2030

Basis of estimation of power available vs power required for hydrogen production

- Current plans for 7 GW of renewables (3.6 GW onshore wind, 1.4 GW offshore wind, 2 GW solar)
- Current and future demand for electricity outside of hydrogen and future plans for flexible power
- Resulting power available for electrolyser operation is conditional on these targets being met and on the price of electricity to the electrolyser being at most €35 – 40 / MWh (See Section 3) to ensure competitiveness of hydrogen

Conclusions:

- Our 2030 demand scenarios can be catered for under the existing plan for renewables deployment
- At some point between 2030 and 2050 more renewables will be required via either
  - collaboration with neighbouring states to co-develop or import more renewables
  - developing renewables and hydrogen outside the electricity network (e.g., by colocation) may be required
  - Significant investment in the electricity network to accommodate more renewables
- Meanwhile, exports of hydrogen in the near term may be limited to 'balancing' volumes of green ammonia rather than a true export industry, more like Portugal's strategy than the Australia/Chile strategies
- In the longer term, the analysis suggests expansion of renewable development plans or import of hydrogen or renewable power may be required to serve ambition set by the Base case

Vision and action plan

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Long term vision for hydrogen in Lithuania

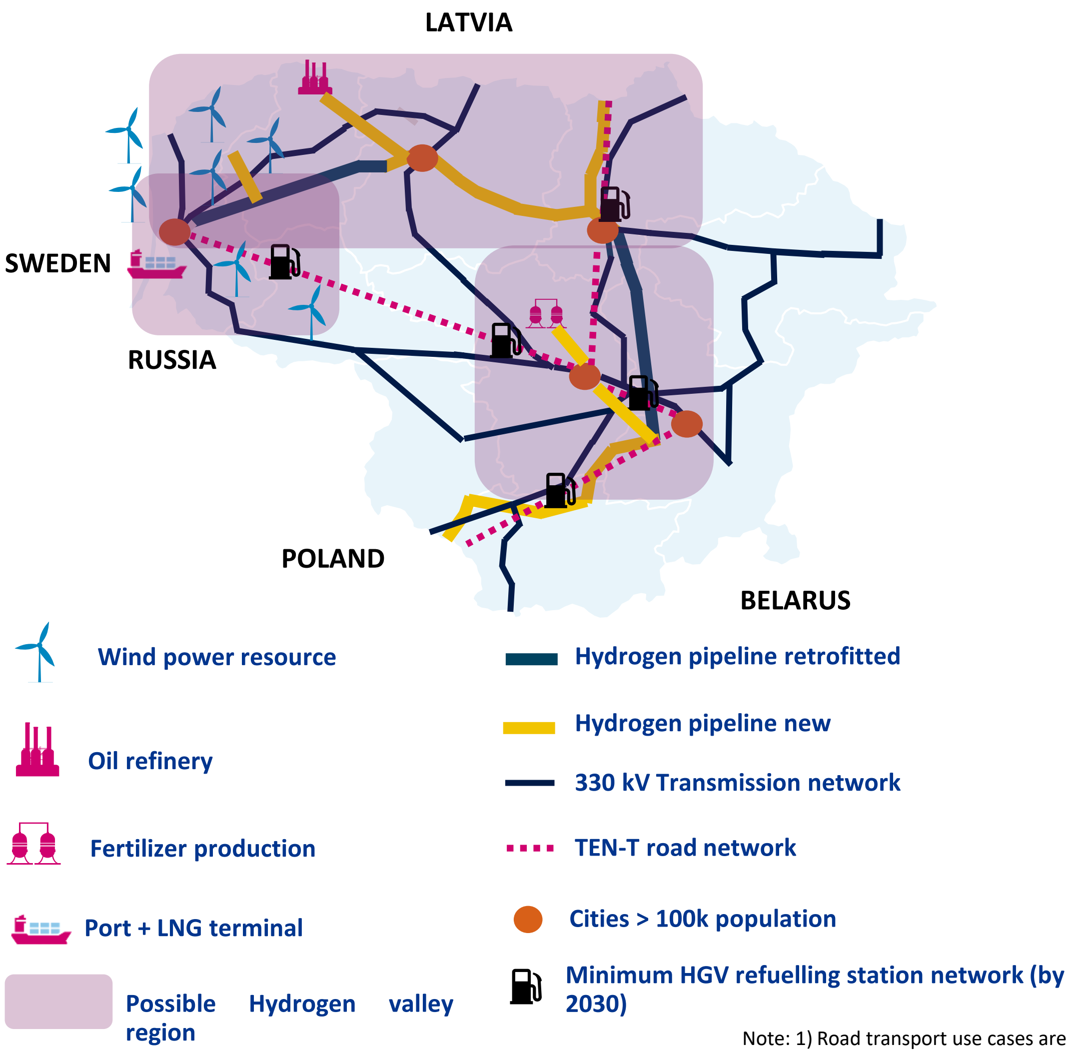
Growth will enable energy independence and can anchor around proven ammonia demand and will form part of a Baltic hydrogen backbone by the 2040s

Increasing energy independence	Low carbon hydrogen will be used to reduce Lithuania's dependence on oil and natural gas imports as part the National Energy Independence Strategy. Over time it will reduce reliance on natural gas used as feedtsock in fertilizer and refinery sectors, on natural gas as fuel for the power sector, and on liquid hydrocarbons in the transport sector. It may also help to provide heat for industrial process heating and building heat, though this is less certain and over a longer time horizon
Prioritising hydrogen from domestic renewables	In order to support the goal of energy independence, Lithuania will prioritise domestic production of hydrogen using renewable electricity over hydrogen imported or produced from fossil fuels. This recognises that renewable electricity can reduce Lithuania's exposure to commodity price volatility and geopolitical risk while still allowing other forms of hydrogen to be developed if cost competitive. This will in turn reduce subsidies required for renewables and in particular help to avoid curtailment of wind generation once wind becomes a large proportion of overall power generation
Anchored around low-carbon ammonia and heavy duty vehicles as sources of demand	As hydrogen demand takes off, green ammonia used in an established fertilizer industry will be the 'anchor' use case that enables scale up of the industry in the 2020s. It can also provide a cost competitive long-duration storage for green hydrogen, in doing so reducing the risk of requiring access to geological storage resource of other EU member states. Lithuania accommodates an outsized share of long-distance HGV transit for which hydrogen presents a realistic long-term solution to decarbonisation. As road transport becomes targeted by EU ETS regulation, a network of hydrogen refueling stations based on hydrogen or hydrogen-derived fuels is envisioned. This will be enabled by some locally based HGVs and buses switching to hydrogen
Deployment in aviation and marine fuel, but over longer term	In the longer term aviation and marine fuel demand will increasingly require hydrogen or ammonia and e-kerosene derived from hydrogen. Synthetic natural gas derived from hydrogen for use in heating is not envisaged. While in the nearer term these will come under less regulatory pressure from the EU, in the 2030s and 2040s they will scale up considerably.
Baltic hydrogen highway for transport and import/export by 2040	Hydrogen supply will be enabled by a gradual transformation of energy nework infrastructure. In the 2020s the existing electricity and natural gas network will be able to support pilots and early scale up of hydrogen while in the 2030s dedicated hydrogen pipelines will emerge to help locate production close to renewable electricity supply. This may operate in parallel to natural gas pipelines at first but could eventually replace it as the role of natrual gas will reduce in the 2040s as Lithuania's approaches Net Zero. This domestic network will be joined by the EU hydrogen backbone connecting the Baltic states by 2040, which will act to stabilise hydrogen pricing and promote cross-border trade of hydrogen in the Baltics
Capturing the value chain to create more jobs	The hydrogen economy is guaranteed to create sustainable construction and asset maintenance but the journey will also aim to capture upstream manufacturing components of the value chain. These will be built off of existing R&D capability in several hydrogen-enabling technologies but also through international collaboration on pilot projects, with a sustained focus on building capability through partnership with countries already emerging as leaders in component manufacturing, as well as targeted funding for training that creates home grown human capital

Hydrogen network infrastructure vision

Hydrogen production biased towards north-east, with high potential demand in the Central Lithuania region connected via pipeline

Stylised map of key hydrogen infrastructure for 2030 and 2040



- **Demand prior to 2030 will be concentrated around the Kaunas area** and (subject to further validation beyond the scope of this study) can be served by locating production close to demand without significant upgrades to the electricity network. Consequently, a hydrogen valley centred on colocation of electrolyser production and demand could be create in the Kaunas-Vilnius region
- In parallel, **location of production closer to renewable energy supply may be preferred as hydrogen pipelines become more economic than electrical transmission** as a means of high-volume transport. This can be located along the existing gas pipeline network, except for a new pipeline route connecting the eastern part of the line with Kaunas via the fertilizer plant at Jonava. This new route may save cost by avoiding a much longer pipeline build via Vilnius, where no concentrated large-scale demand is envisioned[1]
- **A valley can also be created around the Klaipeda region** capable of eventually linking hydrogen supply in this region with hydrogen demand at any point along the pipeline. This valley may include the port of Klaipeda if import and export infrastructure are to be built in the longer term
- This valley could **optionally extend out to the Northern part of the country** where further demand will come from the refinery and the cities of Panevėžys and Šiauliai for transport use cases
- The **minimum initial refueling network for HGVs required to meet EU criteria of one station every 150 km requires 5 stations** situated along roads connecting the major cities and onward to Poland and Latvia. Additional refueling will be required for buses

Note: 1) Road transport use cases are not considered large scale and can be served via a distribution network of refuelling trucks

Sources: Litgrid, LVEA, Ambergid

2030 goals

300 MW of production capacity by 2030 to serve 26 kt of demand

'Concrete' targets proposed

Capacity and demand	▲ Target 300 - 350 MW[1] of electrolyser production capacity (or equivalent through other technologies) by 2030 and 30 kt of low-carbon hydrogen production, representing approx. 1% of target 2030 EU capacity and 0.3% of production respectively ▲ 15% of domestic ammonia production enabled by low-carbon hydrogen ▲ Hydrogen buses in place wherever they are the preferred zero emisisons solution in 5 major cities ▲ Optional pilots: 1 pilot hydrogen train along a freight route ▲ 1% of HGV fuel demand served by hydrogen by 2030
Transport and storage	▲ Approximately 2% of demand in seasonal storage by 2030, with preferred seasonal storage method to be determined ▲ 50 – 100 HGVs powered by hydrogen by mid-2020s and at least 5 refuelling stations in place to accommodate roll out of hydrogen across TEN-T network ▲ Pilot tests on blending into the gas transmisision network
Regional and socioeconomic development	▲ Establish first valley centred around fertilizer production with aim to serve 2030 targets, including involvement from R&D and academic institutes in Kaunas and Vilnius ▲ Establish 1 – 2 other valleys strategically placed, most likely around Klaipeda, to optimise location of future supply and demand ▲ 1.2k sustainable jobs in construciton and asset maintenance created by 2030

'Softer' targets proposed

International collaboration	▲ Establish MoUs with neighbouring EU member states on areas of collaboration to increase regional security of supply and coordinate on transmissions / storage / import / and export infrastructure
Human capital investment	▲ Dedicated degree courses targeting both 'hard-hat' and 'white-collar' roles required in gas systems and renewable technologies ▲ Incentives in place for bringing interanational talent with appropriate qualifications into Lithuania
Capturing value chain	▲ Demonstrating value chain capture in at least one component of the value chain, particularly in supply and storage infrastructure where investment is heaviest

Note: 1) Assumes an electrolyser load factor of approx. 35%

A 14-point action for 2030

We have identified 14 actions required to deliver the 2030 goals and log term ambition of our proposed strategy

		Action	Assumed responsible	Timeframe for completion	Time to complete
Mid 2020s targets	1	Take ownership of strategy and lead governance	Ministry of Energy	2022	< 1 year
	2	Develop a pilot use cases in HGVs that supports the minimum EU target for refueling network on TEN-T	Ministry of Energy	2025-26	3 – 4 years
	3	Rollout of hydrogen buses across 5 largest cities	Ministry of Transport & Comms.	2025-26	3 – 4 years
	4	Enable projects through establishment of clear health and safety regulation and environmental planning	Ministry of Environment	2023-24	0.5 – 2 years
	5	Develop a pilot use case in rail	Ministry of Transport & Comms.	2025-26	3 – 4 years
2030 targets	6	Deliver scaled up project delivery in fertilizers and establish first hydrogen valley around fertilizer production	Ministry of Energy	2028-30	3 – 4 years
	7	Begin testing hydrogen blending in the gas network	Ministry of Energy	2028-30	3 – 4 years
	8	Prepare for market-based scale up	Ministry of Energy	2028-30	3 – 4 years
	9	Invest in seasonal storage for hydrogen	Ministry of Energy	2028-30	3 – 5 years
	10	Build capability and human capital in hydrogen	Ministry of Economy and Innovations	2028-30	5 – 10 years
	11	Assess pilots for aviation and shipping deliverable by 2030 (but not earlier than late 2020s)	Ministry of Energy	2030	3 – 4 years
Beyond 2030	12	Establish a business model for low carbon flexibility in power system to deliver net zero power by 2035	Ministry of Energy	2030	1 – 3 years
	13	Long term planning for role of hydrogen in fuel mix	Ministry of Energy	2030	0.5 – 2 years
	14	Long term planning for hydrogen transmission and storage	LitGrid / AmberGrid	2030	0.5 – 2 years

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14 point action plan for 2030 (1 of 3)

Points 1 – 5 focus on achieving some pilot projects and bus networks over the next 3 – 4 years

We have developed a high-level action plan for delivery that considers 4 key modes of activity. We have considered these in the context of achieving some early goals for delivery by mid-2020s, 2030 horizon, and post-2030 and grouped according to 4 primary types of activity:

- **Policy developments** required to establish market confidence and signal a market model that investors can prepare for
- **Anticipatory investments** required to establish capability and provide some of the supporting infrastructure for future investment
- **Long term planning** required to support physical infrastructure and regulatory decisions investment decisions that will be required as the transition to hydrogen continues
- **Regulation** required to support clarity on rules of market participation and promote open markets and competition

Actions to achieve mid-2020s objectives

1. Take ownership of strategy and lead governance

- Establish governance body of public and private sector participants and associated governance framework for monitoring strategy delivery ●
- Finalize and socialise strategy and mobilize groups for delivery through Hydrogen Platform ●
- Agree on share of investment from public sector for development of different use cases ●
- Update long term strategy documents of Ambergrid and Litgrid ●

2. Develop a pilot use cases in HGVs that supports the minimum EU target for refueling network on TEN-T road network

- Assemble an ecosystem / platform of participants among HGV OEMs, logistics providers, and fuel stations and integrate into Hydrogen Platform ●
- Scope projects, including locations and required public financial support ●
- Prepare bids for EU money eligible for pre-commercial / pilot projects ●

3. Rollout of hydrogen buses across 5 largest cities

- If required, expand scope of green procurement in public sector procurement to include transport services in order to promote transport use cases ●
- Provide financial / human capital support to cities to expedite feasibility assessment and action plan for hydrogen bus rollout ●
- Establish working group to assess synergies between bus projects in Vilnius, Kaunas, and Panevėžys with larger fertilizer project targeted for delivery by 2030 ●
- Prepare bids for EU money eligible for commercial-ready projects ●
- Once projects are in flight establish a working group to share knowledge across city projects ●

4. Enable projects through establishment of clear health and safety regulation and environmental planning

- Conduct full review of health and safety regulation and legislation required in production and supply, transport and storage and end-use-point ●
- Embed hydrogen electrolyser water consumption into long term water management plans ●
- Establish certification of low-carbon hydrogen, adopting emerging wider standards or establishing a basis for differing from wider standards ●

5. Develop a pilot use case in rail

- Identify target route, required private sector partners and required public financial support ●
- Prepare bids for EU money eligible for pre-commercial / pilot projects ●

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14 point action plan for 2030 (2 of 3)

Points 6 – 11 focus on scaling up road transport and fertilizer use cases and investing in storage infrastructure and human capital for 2030

Actions to achieve 2030 objectives

6. Deliver scaled-up project for green ammonia in fertilizers and establish first hydrogen valleys around region of fertilizer production

- Assist major fertilizer players in preparing for Just Transition Fund mechanism ●
- Establish location of first hydrogen valley and facilitate planning certainty and other levers aimed at providing certainty or lowering development costs ●
- Assess potential to integrated fertilizer projects with bus and rail use cases in order to benefit from economy of scale delivered by fertilizer demand ●

7. Testing hydrogen blending in the gas network

- Assuming hydrogen will have some role, establish hydrogen blending pilots with the primary aim to identify cost of introducing hydrogen to current gas distribution network ●
- From results develop a long-term heat strategy that is clear on role of biofuels vs heat pumps vs hydrogen ●

8. Enable market-based scale up of transport, fertilizer and oil refinery use cases

- Assess potential to integrated fertilizer projects with bus and rail use cases in order to benefit from economy of scale delivered by fertilizer demand ●
- Incorporate EU targets for zero emissions HGVs into National Climate and Energy Plan (NECP) and into law to create mandate for hydrogen HGV pilots ●
- Decide on whether revenue raising mechanisms are feasible e.g., whether fossil fuel taxes could be used to provide subsidies or incentives to vehicle switching ●
- Develop primary mechanism (e.g., carbon CfD) for supporting investment in low carbon solutions for industries regulated under ETS ●
- Develop a mechanism / business model for how electrolysers will contract with renewable power assets such that cost of hydrogen is minimized while providing value to power system ●
- Decide on extent to which blue hydrogen can be facilitated / encouraged for the refinery sector ●

9. Invest in seasonal storage for hydrogen

- Assess potential for geological storage and storage via ammonia to determine lowest cost long-duration (i.e. seasonal) storage solution ●
- Integrate delivery of first seasonal storage with timeline for scale up of fertilizer demand in hydrogen valleys ●

10. Build capability and human capital in hydrogen

- Develop a coherent strategy for hydrogen-related R&D that integrates current research programs, existing LNG capabilities, targeting value chain participation in manufacturing ●
- Direct bids for EU money aimed at R&D into developing projects near commercialization where industrial partners may be brought in ●
- Assess role of valleys and target participants beyond electrolyser projects, as well as what incentives will be applied to these special economic zones ●
- Invest in R&D and industry collaborations with other member states specifically focused on hydrogen ●
- Establish education pathways aimed at specialization in energy decarbonisation in low carbon gas and liquid fuels ●
- Integrate value chain participation into pilot and scale up projects ●
- Establish incentives within hydrogen valleys for value chain participation ●

11. Assess pilots for aviation and shipping deliverable by 2030 (but not earlier than late 2020s)

- Pilot scheme for hydrogen-derived sustainable aviation fuel ●
- Pilot scheme for hydrogen-derived fuels in shipping ●

● **Policy developments** ● **Long term planning**
● **Anticipatory investments** ● **Regulation**

14 point action plan for 2030 (3 of 3)

Points 12 - 14 focus on physical infrastructure planning for beyond 2030 and preparing regulation for a more mature market

Actions to prepare for after 2030

12. Establish a business model for low carbon flexibility in power system to deliver net zero power by 2035

- Establish working group for delivery and validate role of H2P in achieving net zero power by 2035 to provide go-no-go decision on pilot ●
- If go, establish location, business model and required support, ideally co-locating with other target projects in a hydrogen valley ●
- Prepare bids for EU money eligible for pre-commercial / pilot projects ●
- Include support for other forms of low-carbon flexible power in addition to pumped storage in NECP and agree what market mechanisms will be used for decarbonizing flexible power ●

13. Further system feasibility assessments which inform longer-term decision points

- Detail feasibility study of Klaipėda port area for the development of hydrogen import/export infrastructure ●
- Analysis of long-term economic feasibility of using biofuels versus hydrogen in transport and heating sectors ●
- Assess long-term role of blue hydrogen production using imported LNG and shipping of CO2 ●
- Engage neighbouring states to collaborate in analysis of potential for further renewable development outside Lithuanian waters to appraise opportunity to export hydrogen via renewables development in the Baltic Sea ●
- Assess long-term role of hydrogen in contributing to state liquid fuel reserves ●
- Develop a framework for hydrogen gas markets in anticipation of a hydrogen gas network with 3rd party access emerging in 2030s ●

14. Further network feasiblity assessments whih inform long-term decision points

- Assessment of forms of long-term storage (e.g., geological storage, LOHC) for hydrogen in Lithuania and neighbouring countries, comparing to the cost of storage via ammonia, including assessment of health and safety implications for large scale ammonia storage ●
- Assess potential zones for future hydrogen valleys close to renewable power supply and gas transmission network and accounting for electric network constraints ●
- Cost-benefit analysis of locating hydrogen production near renewables generation vs near demand in order to assist long-term network planning for Ambergrid, Litgrid, and heavy industry ●

● **Policy developments**
● **Anticipatory investments**
● **Long term planning**
● **Regulation**

Action plan: next 6 - 12 months

We have outlined immediate activities to mobilize the strategy

- Agree and legislate for levels of state funding and target levels of EU funding to apply for
- Assemble a taskforce targeting bid preparation for EU money, including responsibility for identifying the key value-add components that could be added to bids e.g., international collaboration, value chain integration, and innovation
- Begin seeking MoUs with European partners that are emerging as leaders in value chain participation (e.g., Germany, Scandinavia) with intent to share technology and capability know-how through those agreements
- Establish a public-private taskforce to develop the vision and location for the first hydrogen valley
- Establish taskforce to develop health and safety regulation across hydrogen value chain
- Establish policy group to decide on the market-based mechanisms (CfDs, taxes, etc) used to promote scale up of hydrogen demand in industry and transport in the second half of the decade
- Establish a policy group to decide on the market-based mechanism used to allow hydrogen electrolysers to contract with renewable power, in doing so liaising with the relevant European Commission group currently developing the EU definition of green hydrogen. This should be integrated with for low carbon flexible power that helps to meet Lithuania's 2035 Net Zero target. This could be a sub-committee of the Hydrogen Platform
- Develop a coherent strategy for hydrogen-related R&D that integrates current research programs, existing LNG capabilities, and defines specific outcomes for value chain participation, enabled by R&D, by 2030
- Begin to assess potential for geological storage and storage via ammonia to determine lowest cost long-duration (i.e. seasonal) storage solution

Policy developments **Long term planning**
Anticipatory investments **Regulation**

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Brighter together