
Gas decarbonization pathways for the Baltic states and Finland

SEI working paper
June 2024

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Published by

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Note: This working paper is based on the report Gas Decarbonisation Pathways for Estonia (3 Baltic states + Finland). This study was implemented by Trinomics, in association with the Stockholm Environment Institute and E3-Modelling between February 2022 and October 2023, in close cooperation with the European Commission and the Estonian Ministry of Economic Affairs and Communication.

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DOI: <https://doi.org/10.51414/sei2024.020>

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Contents

Key messages

Introduction

1. Context

2. Scenarios to decarbonize the gas sector

3. Scenario modelling results

- 3.1. Potential paths for gas market decarbonization
- 3.2. Socio-economic impact assessment
- 3.3 Risk analysis

4. Proposed actions for policymakers

- 4.1. Action set 1: Governance of the gas system decarbonization
- 4.2. Action set 2: Gas market design and integration
- 4.3. Action set 3: Support and requirements for renewable and low-carbon gas production and/or consumption
- 4.4. Action set 4: Infrastructure planning
- 4.5. Action set 5: Energy and Carbon Taxation
- 4.6 Country-specific policy approaches

Key messages

- While natural gas currently plays a crucial role in the energy mix, conflicts and crises in recent years have revealed the need for an ambitious decarbonization path for the gas sector to achieve a climate-neutral future, energy security and price stability.
- Based on modelling of four different scenarios, achieving full decarbonization of the gas sectors in Finland, Estonia, Latvia and Lithuania (the Regional Gas Market Coordination Group countries) by 2050 is feasible.
- Socio-economic impact assessment has shown that the Cost minimal (CM) scenario presents the lowest total costs among the scenarios studied, and stands out for its rapid emission reduction. In all scenarios, existing liquefied natural gas (LNG) terminals will provide security of supply to balance the cut-off Russian gas supply.
- Higher investment in decarbonization not only yields positive environmental benefits, but also contributes to economic growth, enhanced energy security and faster progress in transitioning towards sustainable energy solutions.
- Policymakers should set clear priorities for a successful decarbonization transition, as rapid implementation of proactive measures is paramount for maximizing the societal net benefits of decarbonizing the region's gas system and navigating the associated risks.

Introduction

This working paper is based on the report *Gas Decarbonisation Pathways for Estonia (3 Baltic states + Finland)* (Aeby et al., 2023). The study assessed four scenarios—Business-as-usual scenario (BAU), Renewable methane scenario (REN-Methane), Renewable hydrogen scenario (REN-Hydrogen) and Cost minimal scenario (CM)—for transitioning toward a decarbonized gas system and identified viable options for decarbonizing the gas sector in Estonia, Latvia, Lithuania and Finland.

1. Context

The Baltic Regional Gas Market (Estonia, Latvia, Lithuania and Finland) faces a pressing challenge that intertwines concerns related to energy security, environmental sustainability, and geopolitical dynamics. Currently, gas plays a significant role in the regional energy mix, constituting 6% in Estonia, 16% in Latvia, 19% in Lithuania, and 3% in Finland of total energy supply (*Countries & Regions*, n.d.). However, Russia's war on Ukraine has heightened concerns about energy security and raised the necessity for a strategic shift to diminish the dependence on Russian gas. Moreover, the reliance on gas has become increasingly problematic due to volatile prices and concerns about its environmental impact.

Additionally, fossil gas contributes to climate change, posing a threat to the region's commitment to decarbonize by 2050 in line with broader European Union (EU) sustainability goals. The EU Green Deal emphasizes the need to phase out natural gas and transition to more environmentally friendly alternatives, such as hydrogen and biomethane, referred to as renewable gases. As highlighted in the 2023 Production Gap Report, coordinated implementation of these initiatives, like in the Baltic-Finland region, is crucial for a smooth, equitable, and effective energy transition (Stockholm Environment Institute et al., 2023).

Thus, natural gas demand must be further reduced and replaced by renewable and low-carbon electricity and gases if the region is to achieve net full decarbonization by 2050 and reduce its exposure to high fossil gas prices and external supply shocks.

2. Scenarios to decarbonize the gas sector

The study thoroughly examined four distinct scenarios to map the path for decarbonization:

1. Business-as-usual (BAU) scenario. This scenario considers the continuation of existing policies and practices, projecting the potential outcome if no significant changes are made. It serves as a benchmark for evaluating the impact of alternative strategies.
2. Renewable hydrogen (REN-Hydrogen) scenario. Focused on replacing natural gas with renewable hydrogen, this scenario explores the feasibility and implications of shifting towards hydrogen as a primary energy source.
3. Renewable methane (REN-Methane) scenario. Like the hydrogen scenario, this alternative envisions replacing natural gas with renewable methane. The study evaluates the potential of biomethane production to contribute to decarbonization.

4. Cost minimal (CM) scenario. Representing an integrated approach, this scenario combines renewable hydrogen and renewable methane with a gradual phase-out of natural gas. It aims to strike a balance between achieving decarbonization, maintaining the security of the gas supply, and minimizing costs.

The study's exploration of the decarbonization scenarios provides policymakers with a comprehensive understanding of the potential pathways for decarbonizing the gas sector, allowing for informed and strategic decision-making. The analyses show that it's possible to preserve the security of the gas supply while we decarbonize the sector even before 2050.

The modelling process projected that annual energy demand for new supply or storage capacity was added as needed to meet each fuel and country, taking into account the monthly load shape. By forecasting the demand, fuel requirements were determined and met through different production capacities, storage facilities, or pipelines. In addition, a decarbonization goals. The impacts of energy efficiency and direct electrification measures, aimed at reducing overall gas demand from 63 terawatt hours (TWh) in 2021 to 38 TWh in 2050 (a 40% reduction for the region), have been taken into account in the demand projection.

3. Scenario modelling results

3.1. Potential paths for gas market decarbonization

By 2050, in the BAU scenario, the region mostly relies on LNG imports which are approximately 51% (27 TWh) of the overall gas demand. This is primarily due to limited capacities for domestic renewable gas production. The REN-Methane scenario instead emphasizes a shift towards biogas, biomethane, and synthetic natural gas (SNG) as primary gas supply sources, which constitute 69% (26 TWh) of the overall gas demand. The REN-Hydrogen scenario presents a transformative vision of a complete shift to pipelines supplying only renewable hydrogen by 2041, with overall renewable hydrogen constitutes 78% (30 TWh) of the overall demand. The CM scenario predicts a 100% decarbonized gas supply by 2040, heavily relying on renewable sources like biomethane for 64% of supply (23 TWh) and renewable hydrogen for the remaining 36% (14 TWh). To put this into perspective, consider that Estonia's current electricity generation is around 8.5 TWh. The region would be producing roughly three times more biomethane in the REN-Methane scenario, four times renewable hydrogen in the REN-Hydrogen scenario and 3 times more biomethane and 2 times more renewable hydrogen in the CM scenario.

Renewable electricity is required to produce renewable hydrogen and synthetic natural gas (SNG). By 2050, the REN-Hydrogen scenario has the highest regional electricity demand of 66 TWh; in comparison, the CM scenario requires 56 TWh and the REN-Methane scenario requires 44 TWh. Based on these electricity requirements, the study explored the onshore or offshore wind capacities needed to generate all the required renewable electricity for each scenario. In the REN-Hydrogen scenario, Estonia would need to deploy 1.2 gigawatts (GW) of onshore wind capacity and 0.859 GW of offshore wind capacity to meet the regional electricity demand. Similarly, Latvia's requirement includes 1.8 GW of onshore wind capacity and 1.3 GW of offshore wind capacity.

Lithuania would need to deploy 8.7 GW of onshore wind capacity and 5.4 GW of offshore wind capacity, reflecting its larger energy needs. Finland's projections indicate the necessity for 3.9 GW of onshore wind capacity and 3.6 GW of offshore wind capacity to fulfill the regional electricity demand for renewable hydrogen production. These deployment figures underscore the significant role of both onshore and offshore wind power in meeting the growing electricity requirements for renewable hydrogen production across the Baltic region.

The roles in the future supply chain will vary by country. Gas flows in the region will experience significant changes, with Lithuania emerging as a major importer by 2050, especially leaning on Finland's excess biomethane production. This is because Lithuania's gas demand is higher in the region, but at the same time, their biomethane potential is comparatively low for domestic production to cover their own gas demand. Latvia's exclusive underground gas storage (UGS) plays a varied role across scenarios; the CM scenario, in particular, would see significant utilization of UGS in 2040 and 2050.

Biomethane emerges as the most economically produced gas by 2050. The average region cost (across scenarios) of biomethane is 55 EUR/MWh. However, there are significant differences between the countries. Latvia has the lowest levelized production costs around 44 EUR/MWh for biomethane in the region, as biowaste is the only feedstock allocated and there is no feedstock cost associated with it. Renewable hydrogen production costs will have a drastic decrease around 64% from 2030 to 2050, attributed to technology advancements and efficiency improvements. The average renewable hydrogen cost of the region across the scenarios is around 154 EUR/MWh which is significantly higher than methane price, hence making it less attractive as a decarbonization gas option. Due to economies of scale, the REN-Hydrogen scenario has the lowest production cost compared to the other scenarios: 144 EUR/MWh.

For decarbonization scenarios, existing LNG terminal capacities, especially Klaipeda, will be sufficient to serve the region's needs until 2044. Repurposing existing LNG terminals to adapt to future energy demands and environmental targets presents a viable strategy for the region. For instance, all LNG terminals, present and future, can already import synthetic methane and bio-LNG without the requirement for conversion. For the hydrogen derivatives like green methanol or green ammonia, however, repurposing efforts are required. Apart from technical measures, additional safety measures and environmental permits are required as these chemicals are different than LNG in nature; for example, ammonia is toxic and requires reassessed safety zones.

The CM scenario states that the region requires a total of EUR 11.3 billion by 2050 for renewable gas production and storage to completely decarbonize the gas sector. Of this, 88% of the total cost is associated with Lithuania and Finland since their gas market is much larger compared to Estonia and Latvia. Due to the high availability of economically feasible biomethane potential, aside from Lithuania, all the other countries produce high proportions of biomethane compared with their overall gas production. The required renewable gas production capacity to be deployed for the investment in the CM scenario for Estonia includes 357 megawatts (MW) of biomethane and 200 MW of hydrogen. Latvia would need to deploy 363 MW of biomethane and 242 MW of hydrogen. Lithuania's CM scenario targets are more extensive with 1074 MW of

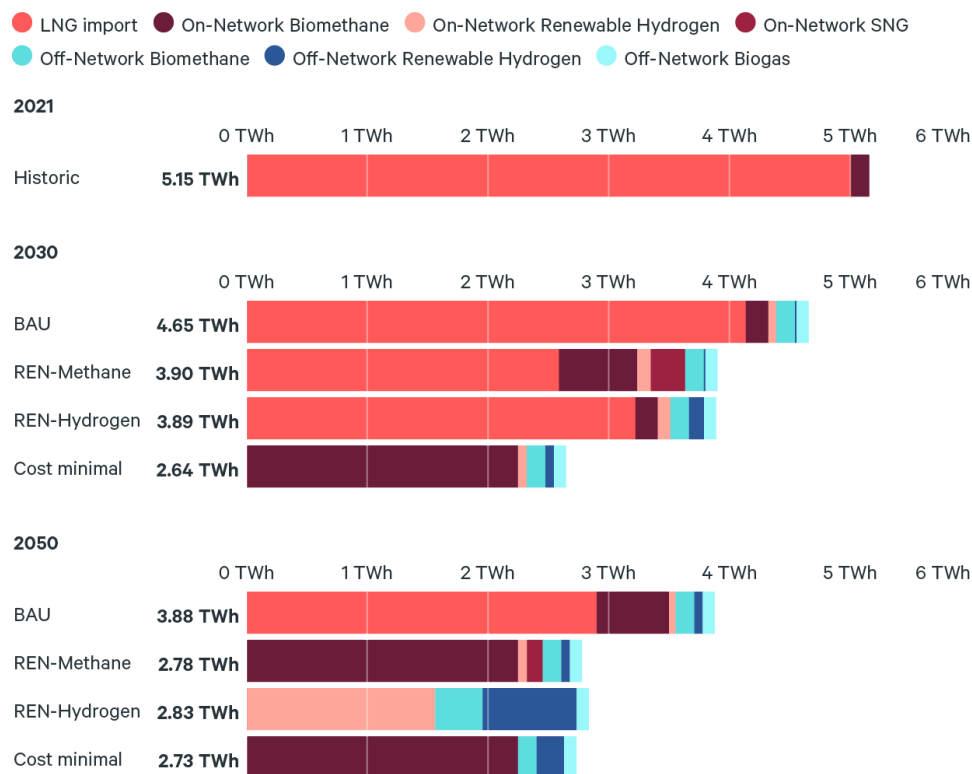
biomethane, 3783 MW of hydrogen, and 1031 MW of SNG. Lastly, Finland would need to establish 1497 MW of biomethane and 2689 MW of hydrogen production capacity.

The overarching theme across scenarios is a move towards decarbonization and regional self-sufficiency. Currently, the region is importing LNG for more than 80% of its total gas demand on average. The three decarbonization scenarios, however, would lead to all four countries stopping the use of fossil LNG by 2050 due to an increase in domestic renewable gas production (see Figure 1).

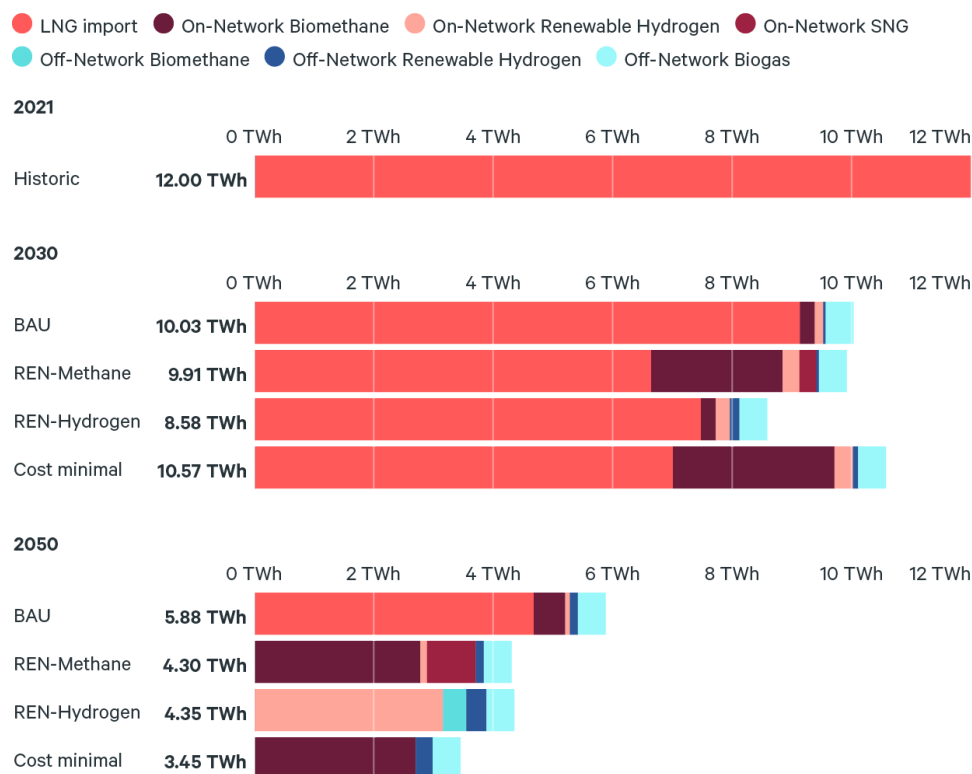
Overall, the region's energy landscape is on the brink of significant transformations, with an intricate balance between renewable gas production, storage and the efficient use of LNG terminals.

Figure 1: Gas supply of (a) Estonia, (b) Latvia, (c) Lithuania, and (d) Finland, historically and projected for each scenario. Source: Authors' own.

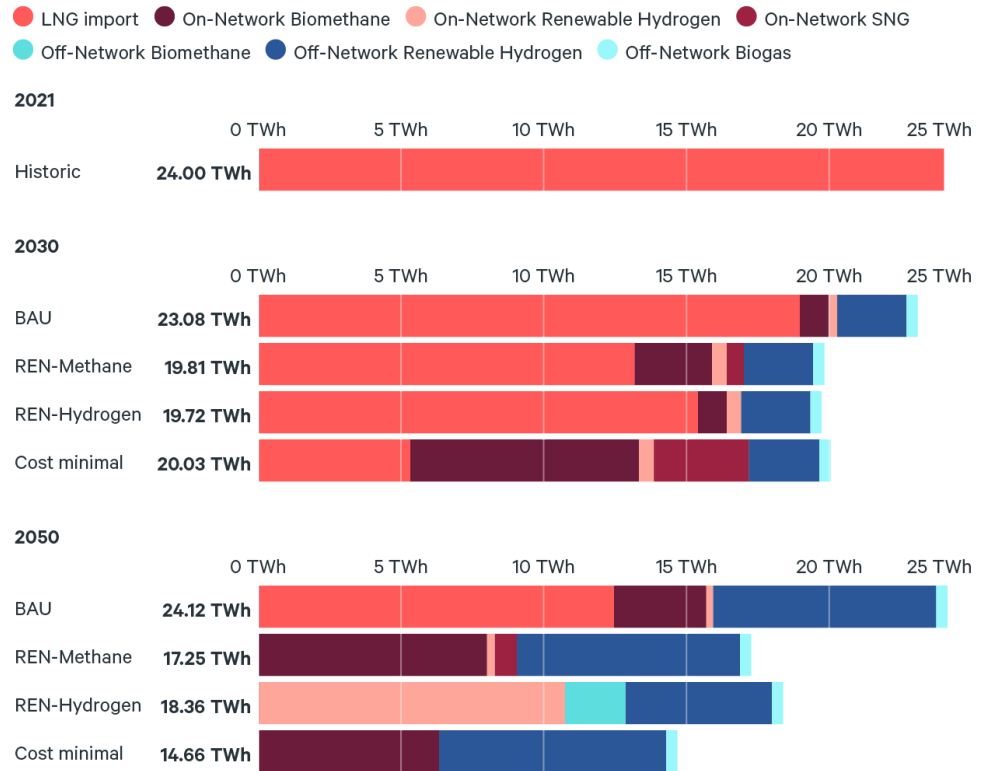
a. Estonia



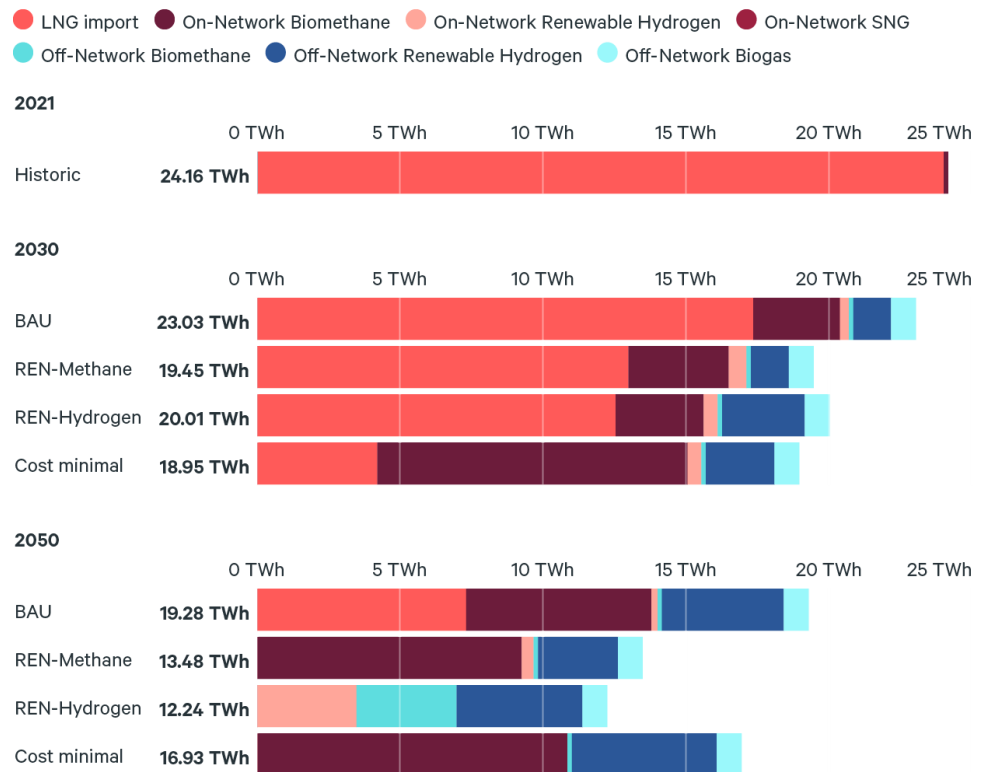
b. Latvia



c. Lithuania



d. Finland



3.2. Socio-economic impact assessment

All three gas decarbonization scenarios exhibit substantial economic and energy system benefits compared to the BAU scenario. Despite necessitating higher investment levels, the CM scenario emerges as the most economically advantageous, yielding cumulative output gains ranging from 0.25% to 0.33% of regional GDP. This scenario also generates between 20 189 to 21 268 additional jobs compared to BAU. Moreover, it achieves a noteworthy 44% reduction in total gas system costs compared to BAU, highlighting its cost-effectiveness and market competitiveness.

The REN-Methane scenario demonstrates moderate economic benefits, with regional output growing by approximately 0.13% to 0.14% of GDP and an average employment gain of around 15 000 jobs. It delivers a 23% saving on total gas system costs compared to BAU and offers competitive biomethane pricing for on-network users by 2050. However, this scenario still requires substantial investments in LNG terminals until 2040. The REN-Hydrogen scenario, while providing marginal gains compared to BAU, presents challenges in terms of economic viability. Cumulative output increases range from EUR 4 to 18 billion over the projection period, with approximately 13 000 additional jobs created on average. However, it exhibits the lowest savings in total gas system costs (-18% compared to BAU) and requires significant capital investments in LNG terminals until 2040. Despite these challenges, the scenario allows for meeting decarbonization targets and offers potential system flexibility from electrolyzers.

The study emphasizes that the positive direct and indirect impacts outweigh the increased capital expenditures. For instance, the CM scenario, which requires significant investments in renewable gas production from 2022–2030 (EUR 8 billion), offers substantial benefits. It results in lower total gas system costs compared to other scenarios (44% savings compared to BAU) while also excelling in market integration, meeting decarbonization targets, and reducing energy import dependence. However, it necessitates mitigating the risk of short-term higher gas costs and ensuring the availability of suitable biomass feedstocks and renewable electricity for successful realization.

3.3 Risk analysis

Risks linked with gas decarbonization scenarios in the Baltic Regional Gas Market countries were assessed by evaluating the likelihood and seriousness of each risk, exploring potential measures to mitigate them, identifying risks specific to each country, and assessing how these risks apply to various decarbonization scenarios. The findings and recommendations are presented in Table 1.

Table 1: Risks and mitigation strategies

Risk	Mitigation
Economic downturns, potentially exacerbated by climate change impacts, might constrain the financial capabilities of stakeholders, making investments in decarbonization less viable.	Implement financial measures to curb downturn effects and introduce supportive price signals for decarbonization initiatives.
The timely development, refurbishment, or repurposing of essential infrastructure could be hampered due to poor regional planning or investment uncertainties.	Ensure proactive planning, regular market assessments, and appropriate regulation for timely infrastructure investments.
Reliance on external gas supplies can pose risks, especially if geopolitical tensions or environmental disasters disrupt supply chains.	Strengthen solidarity arrangements, reduce natural gas consumption, and pool gas demand for better procurement negotiation power.
Successful gas decarbonization, whether through biomethane or hydrogen, depends on the consistent availability of inputs like biomass and renewable electricity.	Allocate funding for renewable sources development, upgrade power grid infrastructure, and ensure sustainable biomass sourcing.
Continued investments in natural gas infrastructure might cause a dependency on natural gas, delaying the shift to renewable gas or electrification.	Minimize new natural gas infrastructure investments and re-evaluate natural gas network tariffication.
While policies can facilitate gas sector decarbonization, uncertainties in policies and regulations can deter necessary investments.	Create a coordinated strategy for the gas sector and establish clear legal frameworks for renewable energy.
The success of gas decarbonization hinges on the advancements in related technologies. If they don't achieve the required cost or performance benchmarks, the transition away from fossil fuels could be stalled.	Fund Research and Development (R&D) programs focused on gas decarbonization technologies and reduce subsidies to fossil fuel technologies.

4. Proposed actions for policymakers

The proposed measures serve as a starting point for reviewing the current policy landscape at both the EU and national levels and aim to complement or revise existing regulatory frameworks. They may align with measures under consideration by national governments, even if not yet publicly announced. A summary of the key recommended actions can be found in Table 2.

Table 2: Key actions for the different gas decarbonization scenarios

Recommendation	Renewable Methane scenario	Renewable Hydrogen scenario	Cost Minimal scenario
Action 1: Governance of gas system decarbonization			
1a) Improve the governance structure and strategic policies for renewable gases	x	x	x
Action 2: Gas market design and integration			
2a) Further integrate the Baltic Regional Gas Market and facilitate access for new actors	x		x
2b) Review energy certification system (including biogas and off-grid gas and extension to low-carbon fuels	x	x	x
2c) Consider measures to develop a liquid hydrogen/derivatives market in the long term		x	
Action 3: Support and requirements for renewable and low-carbon gas production and/or consumption			
3a) Review/introduce coordinated production and/or consumption support measures to foster methane-based gases	x		x
3b) Assess the need for and implement specific support measures for renewable hydrogen production and/or consumption		x	
3c) Consider legal ban on connecting new buildings to the natural gas grid and/or to new gas boilers	x		x
Action 4: Infrastructure planning			
4a) Increase regional methane/hydrogen/electricity infrastructure planning coordination	x	x	x
4b) Review and harmonize connection requirements and coordinated planning for transmission and distribution	x	x	x
4c) Review and harmonize gas quality standards where appropriate	x	x	x
Action 5: Energy and carbon taxation			
5a) Review energy excise tax across energy products	x	x	
5b) Review/introduce carbon taxation	x		

4.1. Action set 1: Governance of the gas system decarbonization

Action 1a: Improve the governance structure and strategic policies for renewable gases

Collectively develop a Comprehensive Regional Strategy for Decarbonized Gas Development in the Baltic states and Finland, setting targets and infrastructure roadmaps while incentivizing investment. Utilize platforms like the Nordic/Baltic cooperation group within ENTSO-G to facilitate coordination and communication, accelerate the transition to sustainable biogas and hydrogen economies and contribute to broader European energy transition goals.

4.2. Action set 2: Gas market design and integration

Action 2a: Further integrate the Baltic Regional Gas Market and facilitate access for new actors.

Enhance regional cooperation among Estonia, Finland, Latvia, and Lithuania to integrate national gas markets, aiming to reduce dependency on external suppliers. Prioritize inclusion of Lithuania in the single tariff area and expand balancing areas. Foster competition and market liquidity by facilitating access for new market players.

Action 2b: Review the energy certification system (including biogas and off-grid gas and extension to low-carbon fuels).

Develop a harmonized certification framework for renewable and low-carbon gases, including biogas, biomethane, and hydrogen, to ensure transparency and stimulate market uptake. Align with EU directives, engage stakeholders, and harmonize certification schemes to foster a seamless regional gas market.

Action 2c: Consider measures to develop a liquid hydrogen/derivatives market in the long term.

Catalyze the development of a liquid hydrogen and derivatives market by leveraging existing initiatives and projects. Establish hydrogen price benchmarks, facilitate hydrogen clusters, and formulate a hydrogen target model for regional integration. Assess potential for imports and participate in joint procurement initiatives for competitive pricing and supply diversity.

4.3. Action set 3: Support and requirements for renewable and low-carbon gas production and/or consumption

Action 3a: Review/introduce coordinated production and/or consumption support measures to foster methane-based gases.

Coordinate efforts among Estonia, Finland, Latvia, and Lithuania to review and align support schemes for biogas and biomethane. Develop tailored mechanisms to stimulate market growth, prioritize technological diversity, and transition towards competitive incentives. Ensure stakeholder involvement and transparency throughout implementation to drive sustainable methane gas production.

Action 3b: Assess the need for and implement specific support measures for renewable hydrogen production and/or consumption.

Conduct a review of current policies and implement targeted support measures to accelerate the adoption of renewable hydrogen production and consumption. Prioritize investment support, operational mechanisms like Contracts for Difference, and consumption obligations. Foster cross-border cooperation and alignment with EU initiatives to maximize regional renewable energy potential.

Action 3c: Consider legal ban on connecting new buildings to the natural gas grid and/or to new gas boilers.

Explore the possibility of implementing a legal ban on connecting new buildings to the natural gas grid and installing fossil fuel boilers. Enhance energy performance standards, tighten ecodesign standards, and prohibit subsidies for fossil fuel heating appliances. Mitigate upfront costs through interest-free loans or subsidies, prioritizing electric heat pump adoption to accelerate decarbonization efforts in the building sector.

4.4. Action set 4: Infrastructure planning

Action 4a: Increase regional methane/hydrogen/electricity infrastructure planning coordination.

Enhance coordination in infrastructure planning for methane, hydrogen, and electricity across the Baltic-Finnish region. Align national development plans with EU directives, prioritize stakeholder involvement, and collaborate on identifying infrastructure gaps and opportunities. This ensures a resilient and integrated energy system, supporting decarbonization goals.

Action 4b: Review and harmonize connection requirements and coordinated planning for transmission and distribution.

Review and harmonize connection requirements for renewable and low-carbon gas production, ensuring transparent and efficient procedures. Transpose EU gas package provisions into national legislation, coordinate planning for transmission and distribution networks, and streamline connection procedures. This accelerates the deployment of biomethane markets and promotes a sustainable energy transition.

Action 4c: Review and harmonize gas quality standards where appropriate.

Review and harmonize gas quality standards, particularly for hydrogen blends, to align with the recast Gas Directive. Transpose new provisions into national legislation, eliminate technical specifications hindering biomethane injection, and adapt oxygen content standards. This facilitates the integration of renewable gases into the grid, supporting a more sustainable energy system.

4.5. Action set 5: Energy and Carbon Taxation

Action 5a: Review energy excise tax across energy products.

Conduct a comprehensive review of energy excise tax policies in the Baltic-Finnish region to align with decarbonization goals. Harmonize taxation rates, phase out exemptions for fossil fuel users, and anticipate revisions of the Energy Taxation Directive (ETD). Stakeholder involvement is essential to ensure transparency and mitigate opposition. Implementation should be short-term to align with EU directives and contribute to decarbonization objectives.

Action 5b: Review/Introduce carbon taxation.

Prioritize the review or introduction of carbon taxation schemes to incentivize emission reduction and promote low-carbon energy sources. Align with regional efforts to decarbonize the economy, considering lessons from successful models like Sweden. Ensure fairness, transparency, and stakeholder involvement in scheme design. Implementation should be short to medium-term, considering administrative complexity and social acceptance.

4.6 Country-specific policy approaches

Estonia, Finland, Latvia, and Lithuania each have unique opportunities and challenges in developing their biogas, biomethane, and hydrogen sectors.

Estonia's focus on policies like the Feed-in Premium system and investment in methane-powered buses demonstrates a commitment to biogas and biomethane. Expanding renewable hydrogen infrastructure, aligned with initiatives like Hydrogen Valley Estonia, will further enhance Estonia's position in the hydrogen economy. Collaborating within the Nordic-Baltic Hydrogen Corridor initiative will ensure seamless integration of production and distribution networks.

In Finland, enhancing support mechanisms for biogas and setting specific targets for hydrogen deployment are key. Investment in renewable hydrogen production technologies and collaboration with stakeholders will solidify Finland's leadership in both sectors. Leveraging clean energy strengths can position Finland as an exporter and regional cooperation driver through platforms like the Nordic/Baltic cooperation group within ENTSO-G.

Latvia should focus on reinstating or introducing support mechanisms for biogas and developing a comprehensive hydrogen strategy in line with regional goals. Collaboration with Baltic neighbors and initiatives like the BalticSeaH2 project will drive research and innovation in both sectors.

In Lithuania, aligning energy policies to support renewable hydrogen and biomethane integration is crucial. Collaboration among industry, academia and government through platforms like the Lithuanian Hydrogen Platform will advance technology in both sectors.

Funding statement: The study this working paper is based on was funded by the European Union via the Technical Support Instrument and implemented by Trinomics, in association with the Stockholm Environment Institute and E3-Modelling between February 2022 and October 2023, in close cooperation with the European Commission and the Estonian Ministry of Economic Affairs and Communication.

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