Transitioning to a climate-neutral electricity generation

Deliverable 5 Report: Risk analysis of climate-neutral pathways

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Transitioning to a climate-neutral electricity generation

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Transitioning to a climate neutral electricity generation

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1 Introduction

This report presents the methodology and findings for Deliverable 5 – Risk analysis – of the study on *Transitioning to a climate-neutral electricity generation in Estonia*. The objective of the risk analysis is to explore the risks that might prevent Estonia from achieving net-zero electricity production by 2050. The analysis investigated potential technological, regulatory, societal, market, and economic risks that could impact each of the climate-neutral pathways developed in Deliverable 3 of the study.

To understand how different risks might influence the different pathways, a survey was developed and circulated to stakeholders familiar with the Estonian electricity market and with different climate-neutral power generation technologies. The survey and the stakeholder group consulted are described in more detail in Chapter 2 of this report.

Responses from stakeholders were then analysed and supplemented with additional desk research to develop risk matrices for different risk categories. The matrices present the likelihood and potential severity of key risks that might threaten each pathway's implementation. They are analysed in detail in Chapter 3 of this report, which also outlines strategies that could be deployed to mitigate the identified risks.

Chapter 5 of the report presents a comparison of risks across pathways and describes how outputs from the risk analysis will inform the development of policy action plans in upcoming project phases.

1.1 Notes on the project

"Transitioning to a climate-neutral electricity generation," sponsored by DG REFORM and the Estonian Ministry of Economic Affairs and Communications, was commissioned to explore which pathways Estonia could follow to achieve net-zero power by 2050.

In Deliverable 2 of the study, data was collected on the state of Nordic and Baltic electricity markets on known and anticipated changes in the markets, and on the costs and operating features of different decarbonisation technologies. This data was used to model seven different climate-neutral pathways in Deliverable 3, which ran least-cost optimisations to determine how electricity market dynamics would evolve if Estonia was to invest in the different climate-neutral electricity generation technologies. In Deliverable 4 of the study, a socioeconomic impact assessment was carried out to determine how each of these climate-neutral pathways would affect investment levels, power prices and costs, and employment in Estonia.

The risk analysis summarised in this report as Deliverable 5 of the study will be followed by a sensitivity analysis in Deliverable 6, with the aim to further test the results of the pathway modelling and socioeconomic impact assessment. In Deliverable 7, policy action plans will be developed, outlining the key strategies that should be deployed for Estonia to implement each of the seven pathways. Deliverable 8 will summarise the core findings of the entire project in a final report, with balanced recommendations for the Estonian government to consider as it develops new policies for reaching climate neutrality.

1.2 Description of climate-neutral scenarios

The climate-neutral scenarios core to the project were developed in Deliverable 3 and are summarised in detail in the Deliverable 3 report. The impacts of these scenarios on Estonian and regional energy markets were quantified in Deliverable 3, while socioeconomic impacts of these scenarios were quantified in Deliverable 4. The risk analysis explores potential risks associated with the same scenarios, outlined in Table 1-1.

Table 1-1 Climate-neutral pathways assessed in the risk analysis

	Pathway name	Description
0	Reference	Business as usual scenario
1	Renewables + Storage	Evaluates a large deployment of offshore wind in Estonia (1 GW by 2030, 2 GW by 2035, 3 GW by 2040, and a total of 4 GW by 2050)
2	Nuclear	Simulates climate-neutral electricity production in Estonia given an addition of 900 MW of Generation III+ small modular nuclear capacity by 2040
3	CCUS	Explores the impacts of adding carbon capture to two large oil shale generators in Estonia
4	Renewable gas	Assumes implementation of 1 GW of new biogas generation by 2030
5	All technologies	The least constrained climate-neutral pathway explored, which allows for the model to endogenously invest in any electricity generation technology based on least-cost optimisation
6	No net imports	Supplements the “All technologies” pathway by requiring that Estonia’s electricity imports and exports should approximately offset each other
7	1000 MW dispatchable capacity	Reassesses the “All technologies” pathway by applying the constraint that Estonia must have at least 1000 MW of readily dispatchable electricity production capacity at all times

As part of the risk analysis, stakeholders were also asked to consider to what extent the same risks would affect the baseline (reference) scenario as well.

2 Methodology and summary of survey responses

2.1 Objective of risk analysis

The aim of the risk analysis is to explore stakeholders' view concerning how potential technological, regulatory, societal and environmental, market, and economic developments might influence the implementation of pathways and prevent Estonia from reaching climate-neutral electricity generation by 2050. The analysis aims to weigh the likelihood and severity of different potential risks, and comment on risks that are highly likely to occur, or would be highly severe if they did occur. Ultimately, the risk analysis will recommend strategies for mitigating the most threatening risks in each category. The results of the analysis will feed into the development of policy action plans in Deliverable 7.

2.2 Stakeholders and how they were involved

The risk analysis questionnaire was sent to 62 stakeholders, who were all familiar with the ongoing project work, on November 29. 2021. Stakeholders from the following 37 organisations received an invitation to complete the questionnaire:

- AS Tootsi Turvas
- Association of Estonian Cities and Municipalities
- City of Tallinn
- Cleantech For Estonia
- EE Environmental Investment Centre
- Eesti Energia
- Eesti Gaas
- Elering
- Estonian Association of Hydrogen Technologies
- Estonian Cell
- Estonian Electricity Association
- Estonian Environmental Research Centre
- Estonian Forestry and Wood Association
- Estonian Gas Association
- Estonian Green Movement
- Estonian Heat Pump Union

- Estonian Investment Agency
- Estonian Power and Heat Association
- Estonian Private Forest Centre
- Estonian Renewable Energy Association
- Estonian Solar Association
- Estonian University of Life Sciences
- Estonian Wind Power Association
- Fermi Energy
- KPMG
- LHV
- National Audit Office of Estonia
- Nomine Consult
- Permanent Representation of Estonia to the EU
- Port of Tallinn
- PwC
- TalTech
- Tartu Regional Energy Agency
- University of Tartu
- Utilitas
- Viru Keemia Grupp
- World Energy Council Estonia

Stakeholders who participated in the project's December 2 workshop were reminded that they could provide feedback via the survey before December 10. Ultimately, 8 responses from 7 organisations were submitted by this deadline, from the following organisations:

- Eesti Linnade ja Valdade Liit
- MKM (Estonian Ministry of Economic Affairs and Communications)
- Eesti Roheline Liikumine (Estonian Green Movement)
- Estonian Renewable Energy Association
- Eesti Energia AS
- Siseministeerium
- Elering AS

2.3 Method of analysis

To process and analyse the responses to the questionnaire, a standardised methodology has been developed. First, a data cleaning exercise is conducted to identify and correct any data errors. Questions are also categorised as closed-ended questions (i.e. questions that limit the number of options for selection), and open-ended questions (i.e. questions that would require more elaboration).

2.3.1 Data cleaning

The survey received a total of 12 responses, but four responses were removed for various reasons (blanks, duplicate[1] etc.). Three stakeholders were excluded as they have provided no answer to any of the questions (only providing personal data without completing the survey). Given the low number of respondents, the survey's conclusions should be considered as having limited robustness.

Stakeholders were asked to provide both the severity and likelihood of specific risks. Where a response only provides one of the scores and not both, the score provided is ignored.

2.3.2 Closed-ended questions

There are two kinds of closed-ended questions:

1. *Severity/Likelihood score*: questions which ask the respondent to provide a score from 1 to 5 on the severity and likelihood of various risks; and
2. *Ranking*: questions which ask the respondent to rank their support for the implementation of the various pathways.

Severity/Likelihood score

The analysis of severity/likelihood of various risks focusses on the average score for each risk per pathway. The severity and likelihood scores are based on a scale from 1 to 5. Table 2-1 provides the definition of the rankings provided to the survey respondents.

Table 2-1 Severity and Likelihood of risks ranking scale

Ranking	Severity	Likelihood
1	Minimal/no impact on pathway implementation	Not at all likely to impact pathway
2	Might cause minor delays in pathway implementation	Minimal but non-zero likelihood of impacting pathway
3	Might stall pathway implementation by a few years	Somewhat likely to impact pathway

[1] Duplicate responses are made by the same person (based on name and email provided)

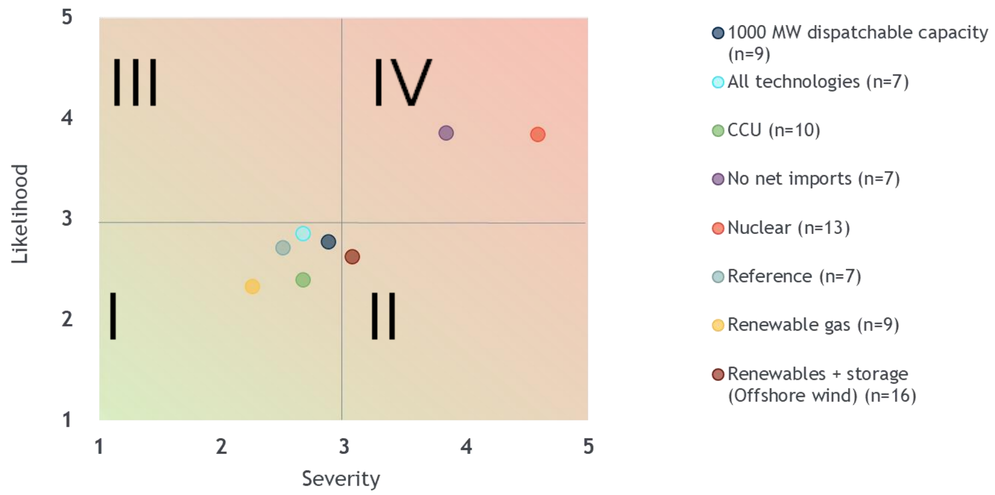
Ranking	Severity	Likelihood
4	Could delay pathway implementation indefinitely	Very likely to impact pathway
5	Would essentially prevent effective pathway implementation	Certain to impact pathway

Figure 2-1 provides an example of how data concerning the average likelihood/severity of a certain risks is presented. The figure is divided into quadrants:

I. *Low probability* to occur and potentially *minor impact* of implementation;
II. *Low probability* to occur but potentially *major impact* on implementation;
III. *High probability* to occur but potentially *minor impact* on implementation; and
IV. *High probability* to occur and potentially *major impact* on implementation.

For each pathway, the size of the sample (n) is provided. This is the number of analysed responses corresponding to the relevant question.

Figure 2-1 Example of average likelihood/severity map



Note: n is the total number of responses to the severity AND likelihood of the related risks

The risks are split into five categories: technological, regulatory, societal and environmental, energy market and economic risks. The analysis summarises the pathway's perceived risk for each of these five risk categories by averaging the ranking scores of respondents on the severity and likelihood of risks within each category.

Ranking

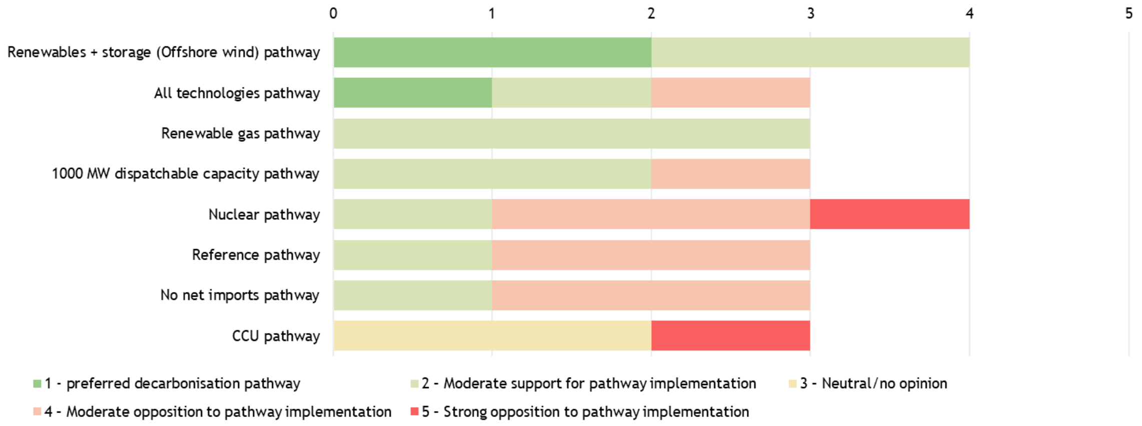
At the end of the survey, respondents were asked to rank how supportive they were of the various pathways based on a scale from 1 to 5. Table 2-2 provides the descriptions of the rankings provided to the survey respondents.

Table 2-2 Ranking of support scale

Ranking	Support for pathway
1	Highest level of support for pathway implementation: preferred decarbonisation pathway
2	Moderate support for pathway implementation
3	Neutral/no opinion
4	Moderate opposition to pathway implementation
5	Strong opposition to pathway implementation

The analysis of the ranking was carried out based on the total number of responses with the highest ranking for each pathway. Figure 2-2 illustrates how the ranking is presented.

Figure 2-2 Example of pathway ranking visualisation



2.3.3 Open-ended questions

As the sample size for the survey is relatively small, each open answer is analysed and summarised in this report. When possible, similar viewpoints provided by different respondents are condensed.

2.3.4 Commentary

When commenting on the chart, we use a series of terms to characterise the numerical result. We use the following convention to describe the risk levels:

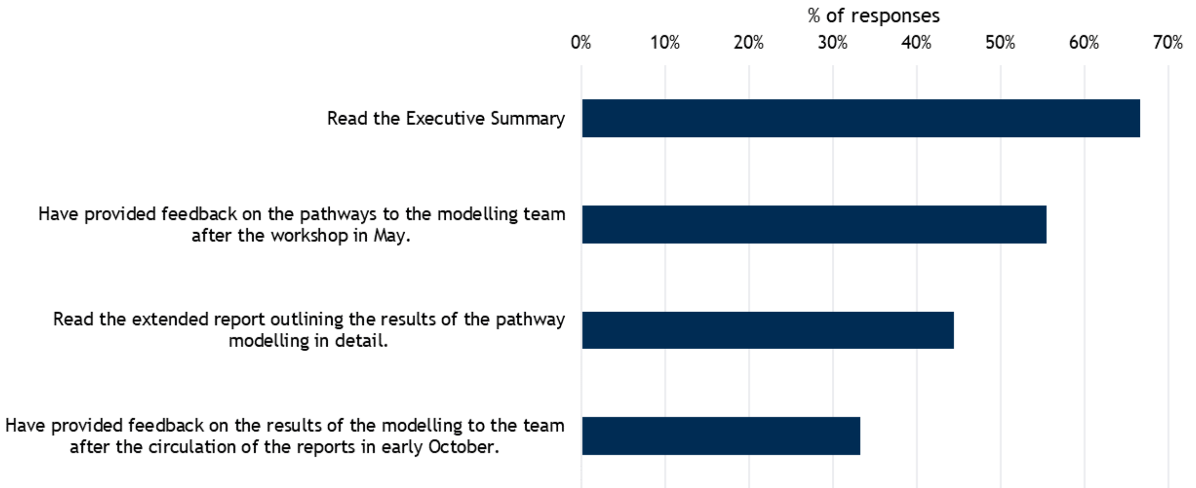
- When *both* likelihood and severity score are:
  - Above 4.5: very high/very severe risk;
  - Between 3.5 and 4.5: high/severe/significant risk;
  - Between 2.5 and 3.5: medium/moderate risk;
  - Below 2.5: low risk;
- When likelihood *or* severity fall in a different category than the ones set above, these are indicated separately (e.g. high severity but low likelihood).

2.4 Analysis of participating stakeholders

The first section of the questionnaire asked respondents to provide general details about themselves, including their name, in what capacity they are providing their contributions, the name of the organisation they are representing (if applicable), language and city/country of origin. The survey received a total of eight sufficiently complete responses. All but one of the respondents originate from Estonia, with one respondent coming from Denmark. Four of the respondents represent the public sector, followed by three from the Energy sector and one NGO.

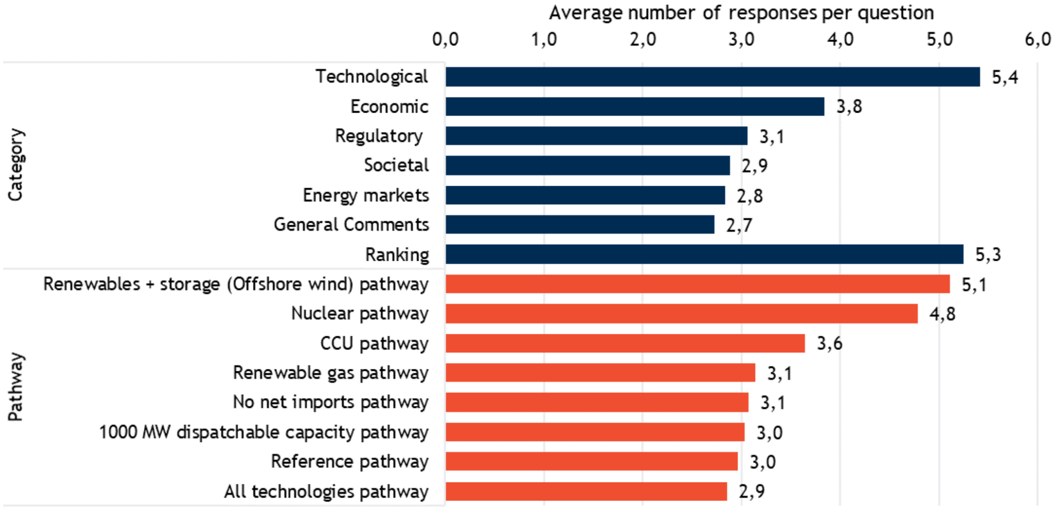
Further, respondents were asked about their familiarity with the pathway modelling results (see results in Figure 2-3). The majority (67%) of respondents have read the executive summary. 56% have provided feedback to the modelling team during the workshop in May 2021 and 44% have also read the extended report. Only a third (33%) provided feedback after the report was circulated in early October 2021.

Figure 2-3 Stakeholder familiarity with the results



The questionnaire comprises seven parts, which allowed respondents to assess the five risk categories, to provide general comments and to rank the seven pathways. Figure 2-4 provides an overview of the average number of responses received by each question in the given topics. For the risk assessment section, questions concerning the *technological* and *economic* risks were the most answered on average. The ranking section, where stakeholders were asked to rank their support for the implementation of the different pathways, received the second highest number of responses on average. In terms of surveying the likelihood and severity of various risks on different pathways, the questions concerning the *Renewables + storage* and *Nuclear* pathways received the most responses on average.

Figure 2-4 Average number of responses per question topic



3 Survey results

3.1 General views of respondents on risks of pursuing climate neutrality in Estonia

At the beginning of the survey, respondents were asked two open-ended questions so that they could provide their non-structured opinion over the risks of pursuing climate neutrality in Estonia, and the factors that may prevent the achievement of carbon neutrality in the long term. A summary of responses received is presented in Box 3-1 and Box 3-2.

Box 3-1 Stakeholder views on the risks of pursuing climate neutrality objectives in Estonia

How do you view the risks of pursuing a climate neutrality objective in Estonia? What are the principal risks associated with decarbonisation in the short, medium, and long term?

- **Regulatory risks:** Estonia already offers a less attractive investment environment compared to neighbouring countries. Further regulation to pursue decarbonisation may negatively affect investments.
- **Security of supply (SoS) risks**: There is a trade off with energy cost that has to be considered, but SoS is achievable if the right choices are pursued.
- **Electricity prices**: In order to prevent price increase and high volatility, the right conditions have to be set up: sufficient production capacity must be in place; investment in storage and demand-side management (DSM); energy efficiency; power-to-X etc.

- **Regulation/legislative risks**: policies have to be carefully designed to incentivise investments in buildings energy efficiency, including incentivising householders' investments.
- **Social acceptance/ Low awareness: w**hile there are plenty of promising solutions to achieve decarbonisation, Estonia lags behind in public understanding of these issues, which means there is a risk of taking the wrong decisions.
- The **risks of no decarbonisation are considerably larger than the risks of decarbonisation.**
- Concerning the pathways:
  - the main risk of renewables and storage is the need for sector integration and system balancing;
  - the risks of nuclear or CCU are tied to the technologies being unproven, too complex to work at scale or extremely costly. If these risks materialise, the consequences will be severe and will jeopardize the implementation of the whole pathway.
- **National security risks:** Given Estonia's current situation, economic risks are important both in the short and long term. This is because being so dependent on import means being at the mercy of other nations, and this poses a risk to Estonia's sovereignty.

Box 3-2 Stakeholder views on the risks preventing climate-neutral electricity in Estonia

What are the risks that might prevent Estonia from achieving climate-neutral electricity generation in the long-run?

- **Regulatory risks**, such as nature protection and other restrictions. A clear example is the difficulty of obtaining permission for new wind parks from municipalities.
- **Dependency risks:** neighbouring countries are pursuing more aggressive renewable policies, which creates a dependency situation that is difficult to break.
- **High costs**: cleaner technologies appear too expensive for investors. However, in the long term, energy scarcity may place an increased economic burden on final consumers.
- **NIMBYism**[2]: local resistance to wind energy remains high.
- **Political and social risks**, related to poor awareness and a lack of political consensus, which also leads investors to stay away from new technologies.
- **Energy efficiency**: existing building stock needs to be entirely renovated.

[2] NIMBY stands for 'Not in my backyard'

- **Just Transition**: insufficient compensations related to oil shale sector employees. Current lock-in to oil shale only increases future phase-out costs and Government has not provided a clear signal about the future of the energy system.

The rest of the chapter presents the responses to the closed-ended questions and the free comments respondents provided to support the closed-ended answers.

3.2 Technological risks

Stakeholders were asked to rank the likelihood and severity of three technological risks for each climate-neutral pathway. Table 3-1 lists the three technological risks provided and examples of how the risks may materialise.

Table 3-1 Types of technological risks

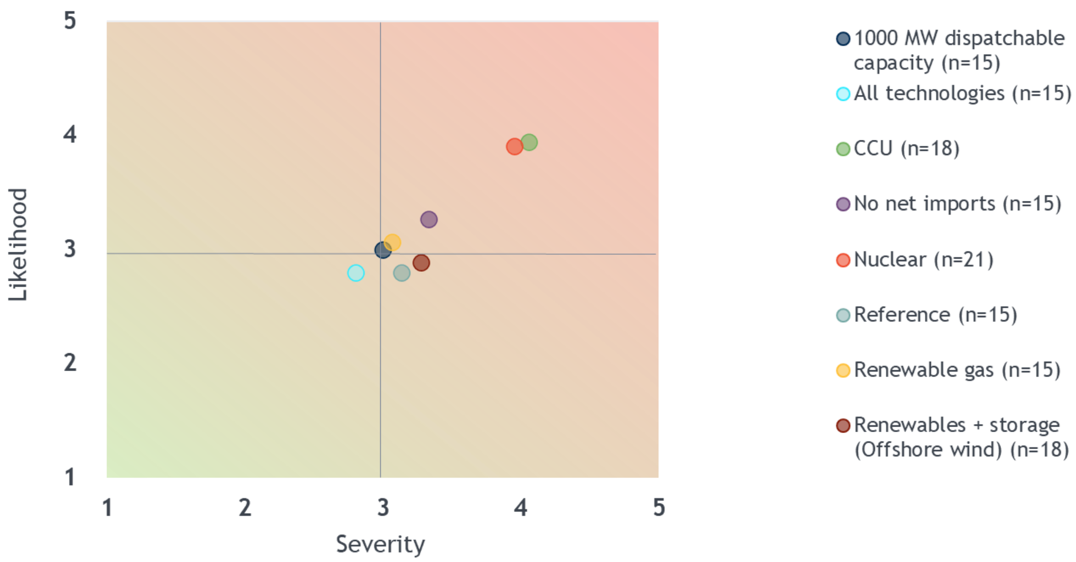
Technological risks	Selected examples of relevance to pathways
Delayed technological development of key decarbonisation technologies	• Hydrogen fuel cells are insufficiently developed for use as long-term storage, limiting implementation options for pathway 2
Key decarbonisation technologies do not reach economies of scale, such that their costs remain higher than projected	• Lithium ion batteries remain prohibitively expensive, limiting the role they can play as a storage solution in pathways 2, 3 and 4 • Small modular reactors remain niche and expensive, limiting options for concentrated carbon neutral generation in pathway 3
Delayed infrastructural development, preventing integration of key decarbonisation technologies	• Electricity grid is insufficiently upgraded/expanded, preventing the use of additional electricity produced by wind turbines or solar panels and blocking the realisation of pathway 2 • Long-term/seasonal (power to gas [P2G], pumped hydro, hydrogen) storage infrastructure development delayed, preventing implementation of pathways 2, 3 and 4 • Lack of carbon storage infrastructure stalls the use of CCS at oil shale plants and blocks realisation of pathway 4

3.2.1 Severity and likelihood of technological risks

All risks

Overall, on average, respondents consider all of the pathways to have relatively high chances of being affected in a significant way by the three technological risks considered. Respondents consider the *CCU pathway* and *Nuclear pathway* to have the highest technological risks. All other pathways were, on average, ranked around 3 out of 5 for both severity and likelihood (Figure 3-1). The *All technologies pathway* is expected to be less likely to be impacted by technological risks, and those risks are considered marginally less severe, compared to the other pathways.

Figure 3-1 Average likelihood/severity map for all technological risks considered

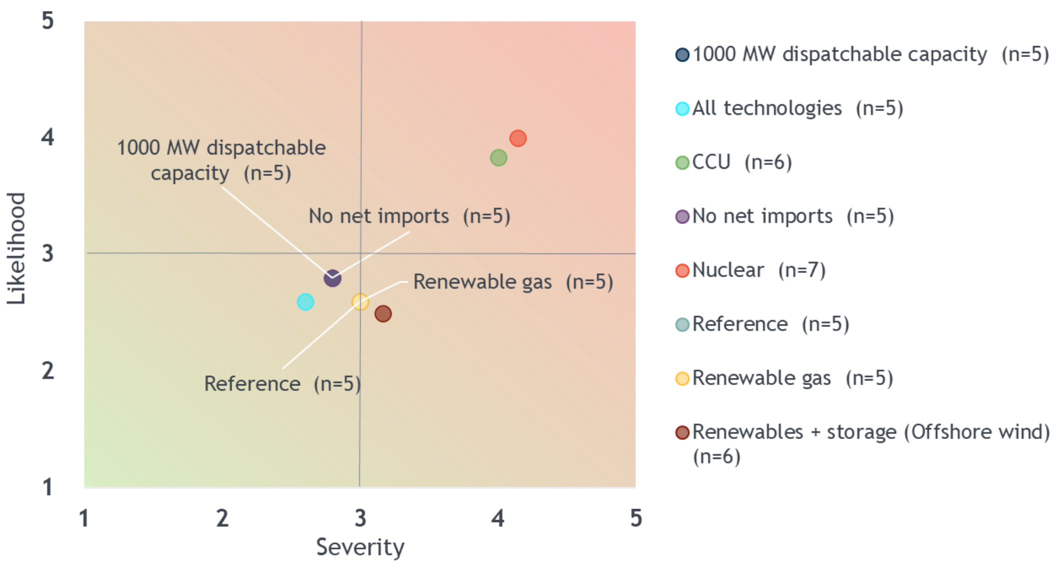


Note: n is the total number of responses that provided both severity AND likelihood of the related risks

Technological risk 1 - delays

According to respondents, on average, it is very likely that the *CCU and Nuclear pathways* will be impacted by delayed technological development of key decarbonisation technologies; the other pathways are less likely to be impacted, and the impacts will be less severe (Figure 3-2). Respondents also suggested in their open responses that delayed technological development would delay indefinitely or essentially prevent the implementation of the *CCU* and *Nuclear pathway*. On the other hand, the *All technologies, Renewables + storage, Renewable gas* and *No net imports pathways* are perceived as being generally the less risky pathways in this sense.

Figure 3-2 Average likelihood/severity map for risk of delayed technological development for key decarbonisation technologies

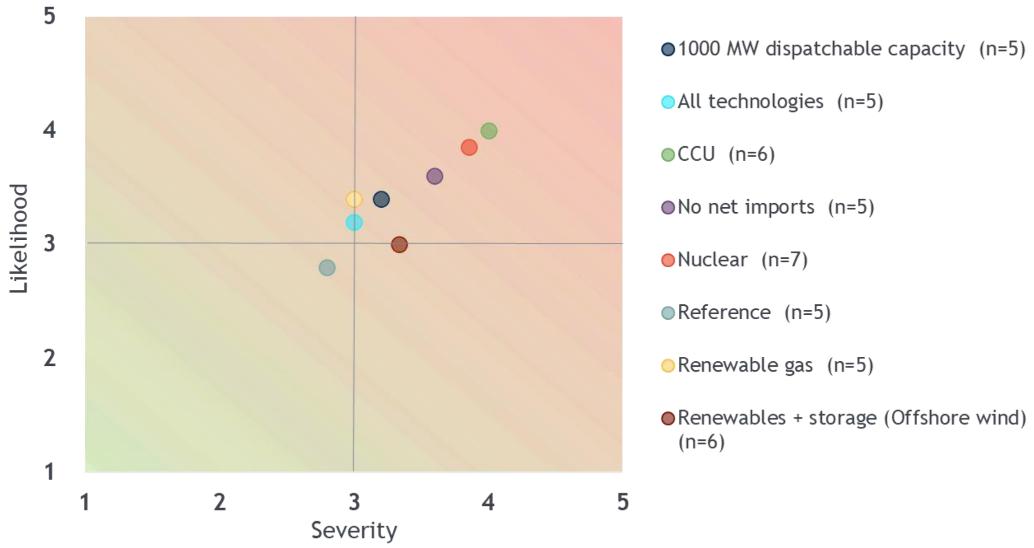


Note: n is the total number of responses to the severity AND likelihood of the related risks

Technological risk 2 - economies of scale

The *CCU pathway*, on average, is expected to be most likely impacted by key decarbonisation technologies not reaching economies of scale and this type of risk is expected to potentially delay this pathway implementation significantly (Figure 3-3). The *Nuclear* and *No net imports pathways* also have a relatively high average likelihood and severity ranking (severe risk). The *All technologies* and *Renewables + storage pathways* are the least likely pathways to be impacted, though still considered to be somewhat likely to be impacted. The *Reference pathway* is the least severely impacted pathway by this risk.

Figure 3-3 Average likelihood/severity map for risk that key decarbonisation technologies do not reach economies of scale, such that their costs remain higher than projected

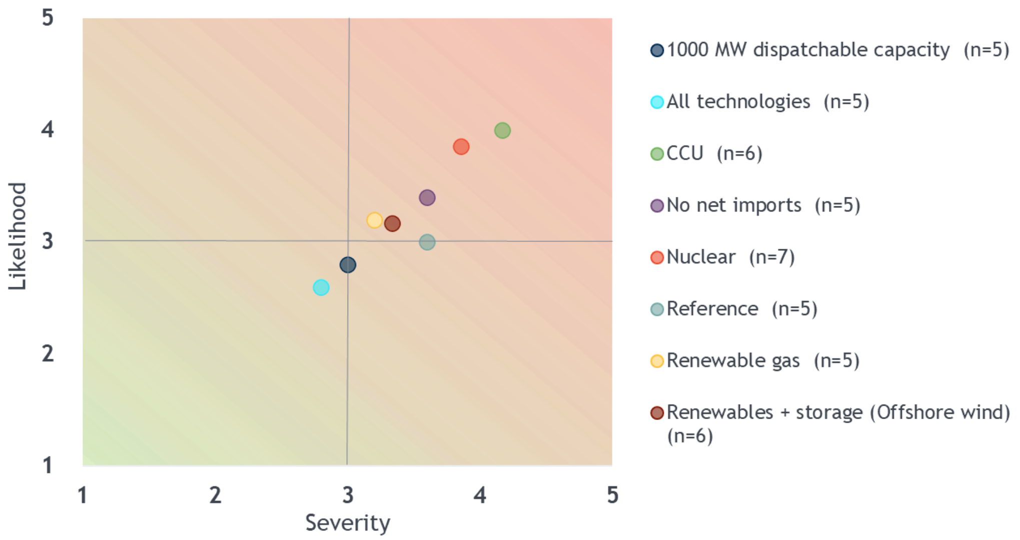


Note: n is the total number of responses to the severity AND likelihood of the related risks

Technological risk 3 - infrastructure development

All pathways are expected be vulnerable, by varying degrees, to delays in infrastructural development, which would prevent integration and the use of key decarbonisation technologies (Figure 3-4). Of all of the pathways, the *CCU, Nuclear* and *No net imports pathways* have the highest average severity and likelihood. On the other hand, the *All technologies* and the *1000 MW pathways* have the lowest average severity and likelihood rankings.

Figure 3-4 Average likelihood/severity map for risk that delayed infrastructural development prevents integration and use of key decarbonisation technologies



Note: n is the total number of responses to the severity AND likelihood of the related risks

3.2.2 Other risks and proposed mitigation of technological risks

Survey respondents also suggested additional technological risks that might impact the pathways. These include:

- Risk of scarcity of resources needed to produce key decarbonisation technologies, which will affect the price and real usage of a technology; and
- Risk of strategic dependency, due to need of specific technologies produced outside of Estonia, which could harm national security.

Three respondents provided suggestions on how to mitigate technological risks, including:

- Implementing strong legislation;
- Focusing on technologies that have a strong track record and are reaching economies of scale, such as renewables and storage;
- Implementing the energy efficiency first principle, to control power consumption and related dependency on technological innovation; and
- Decentralising the power system to disperse risks.

Table 3-2 provides the additional comments received in full.

Table 3-2 Other comments by respondents concerning technological risk[3]

Question	Answers provided (in verbatim)
If you wish, please add any comments on your ranking of the likelihood/severity of relevant technological risks.	1-You foresee power generation from oil shale until 2050 in rather significant amounts. We don't see that it could remain economical until that time. Power generation from oil shale could be feasible after 2030 only in very small amounts. Application of CCU in power plants does not seem to be realistic either. 3- It would be easier to assess risks if we would have already actions plans with cost calculations for pathways, at the moment it is a guess which pathways are more realistic. 5- CCU and the required nuclear generations (III+, modular, IV gen) provide the most relevant technological risks for pathway feasibility.
Please describe any additional (missed) technological risks that might impact	1-There is significant risk that CCU will never gain technological maturity. Given the previous track record, healthy scepticism on outlook for nuclear (SMR) development seems to be justified. As regards off-shore developments, our part of Baltic Sea could become icy during wintertime, hence impacting sustainability of off-shore parks (if ice starts to move).

[3] The numbers next to the answers identify the respondent

Question	Answers provided (in verbatim)
the implementation of the pathways.	3- Resources to produce technologies could be at risk as well which will affect a price and real usage of a technology. 5- I have to say, I am slightly surprised by the overall capacity and uptake of batteries in every scenario. As I see the sector moving forward, I envisage some amount of H2 or similar P2X capacity leading up to 2050. 8- from national security perspective, it is important, who's technologies are used and what are the consequences to that. For example: there could exist technologies but we can't integrate it because of the security risk of the producer and potential danger to countries national security. With specific technologies there are risk for strategic dependencies, that might harm national security.
How would you recommend mitigating the technological risks that might block pathway(s) implementation?	1-Exploit proven technologies only. 3- Implementation of energy efficiency first principle could help to control power consumption and related dependency on technological innovation. In addition risks could be minimized using well proofed solutions instead of testing them first. Decentralised power system (no very big single units) could disperse risks as well. 4- Powerful legislation 5- Some technological risks are not ours to manage (e.g. development of IV gen nuclear reactors), however, it is essential to push the development of energy grids, relevant regulation, etc. 7- Focus on technologies that have a track record of maturation and reaching economies of scale such as renewables and storage.

3.3 Regulatory risks

Stakeholders were asked to rank the likelihood and severity of three regulatory risks for each climate-neutral pathway. Table 3-3 provides the list of possible regulatory risks respondents were asked to rank, and examples of how the risks may materialise.

Table 3-3 Types of regulatory risks

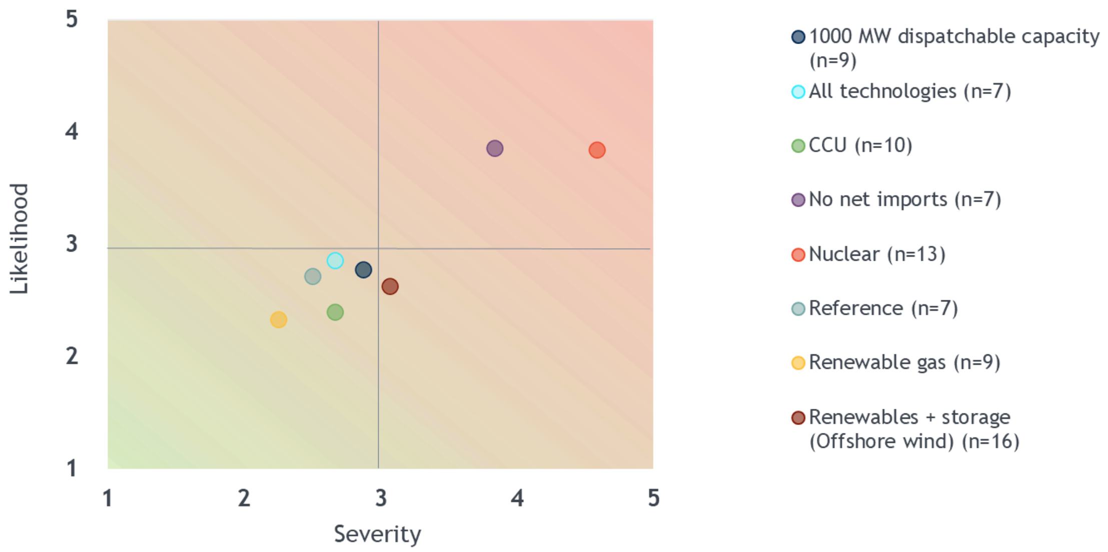
Regulatory risks	Select examples of relevance to pathways
Local policies present barriers to implementation	• Local permitting requirements in the regions Hiju maakond or Saare maakond prevent installation of offshore wind turbines integral to pathway 2 • Local regulations in the region Ida-Viru prevent the installation of CCS/U infrastructure at oil shale plants necessary for pathway 4
National policies present barriers to implementation	• Estonian policy restricts additional charges on electricity consumers, limiting funding options for the development of storage infrastructure vital to pathways 2, 3, and 4

Regulatory risks	Select examples of relevance to pathways
EU or international policies present barriers to implementation	• Compliance with nuclear safety requirements cumbersome enough to stall development of SMRs integral to pathway 3 • Agreements with neighbouring countries like Russia prevent redevelopment of the electricity grid, stalling the integration of renewable power essential for pathway 2 • Scandinavian policies on the use of the Baltic Sea limit opportunities for offshore wind development that could play a role in pathway 2

3.3.1 Severity and likelihood of regulatory risks

Survey respondents consider all pathways, except *No net imports* and *nuclear* pathway , to have relatively high likelihood of being impacted in a significant way by the four regulatory risks considered (Figure 3-5). Respondents consider the *No net imports* and the *Nuclear pathways* to have a very high likelihood to be significantly impacted by regulatory risks. According to respondents, the other pathways are less likely to be impacted by regulatory risks, and are clustered around the middle of the distribution (i.e. they broadly have the same medium likelihood to be affected by regulatory risks in a moderate manner). *Renewable gas* is the pathway that averaged the lowest risk score.

Figure 3-5 Average likelihood/severity map for regulatory risks

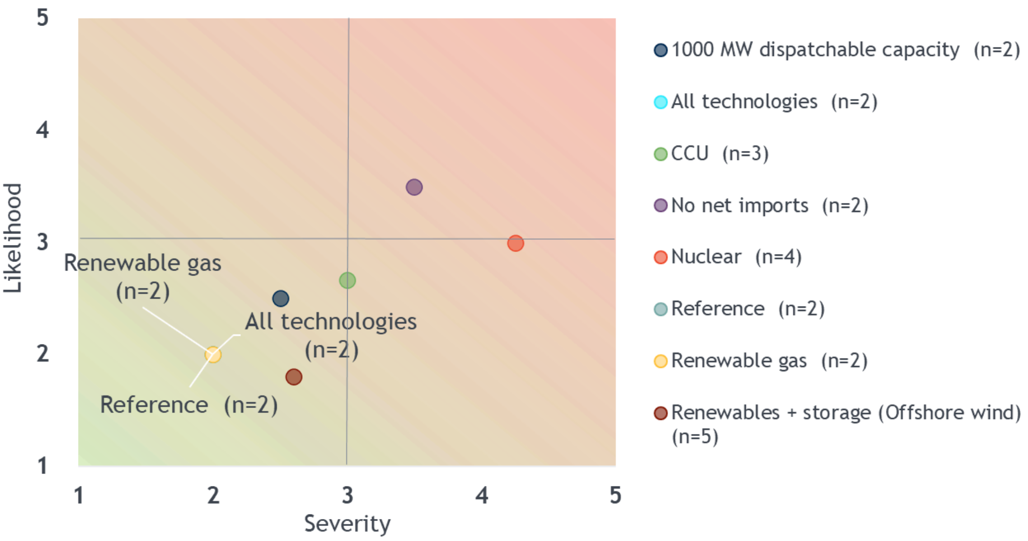


Note: n is the total number of responses to the severity AND likelihood of the related risks

Regulatory risk 1 - EU/international policies

Respondents consider the *No net imports* and the *Nuclear pathways* to be most at risk of being affected by EU/international policies (Figure 3-6). *Renewable gas* is the pathway considered the least risky.

Figure 3-6 Average likelihood/severity map for risk of EU/international policies presenting barriers to implementation

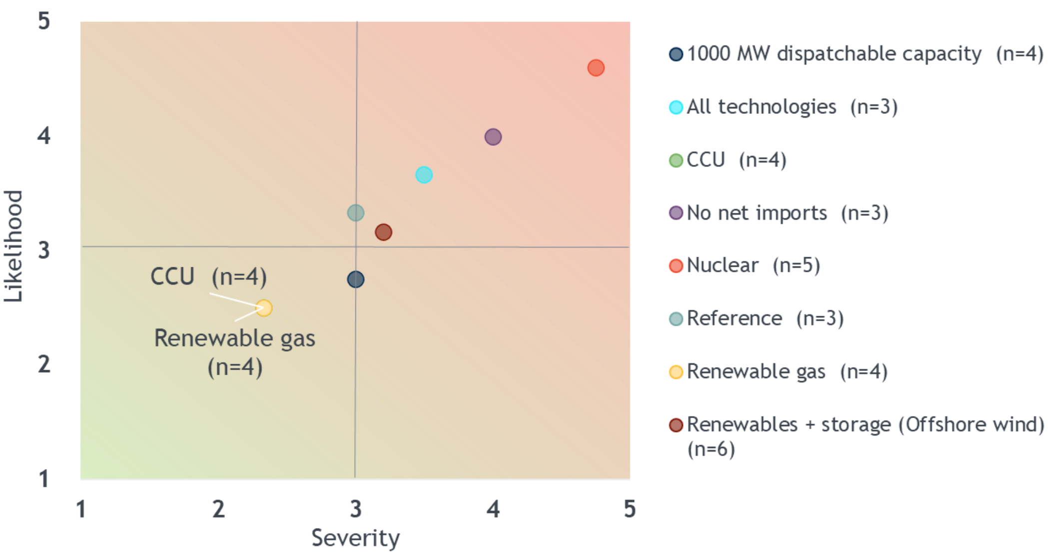


Note: n is the total number of responses to the severity AND likelihood of the related risks

Regulatory risk 2 - local policies

Barriers created by local policies are considered a moderate or significant risk (in terms of likelihood and severity) for most pathways excluding *renewable gas* and *CCU*, which scored significantly below average (Figure 3-7). The *Nuclear pathway* is considered at very high risk both for severity and likelihood, followed by the *No net imports pathway*. The probability and severity of barriers from local policies is also relatively high for the *All technologies pathway*, while the other pathways cluster around the middle.

Figure 3-7 Average likelihood/severity map for risk of local policies presenting barriers to implementation

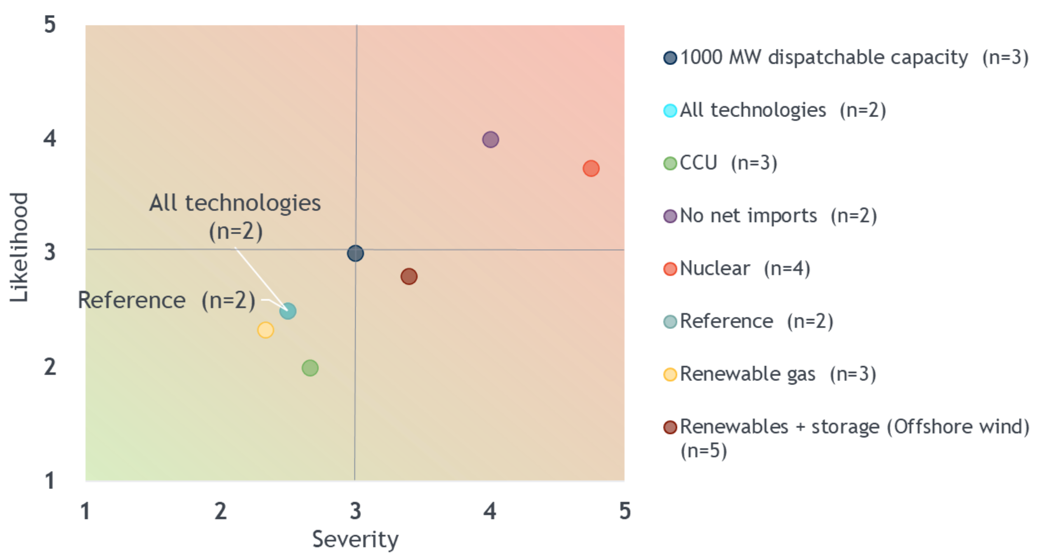


Note: n is the total number of responses to the severity AND likelihood of the related risks

Regulatory risk 3 - national policies

According to the survey respondents, the *No net imports* and *Nuclear pathways* are also the most likely to be severely impacted by barriers created by national policy (Figure 3-8), although the likelihood of national policies obstructing the *No net imports pathway* is marginally higher. The *CCU*, *Reference*, *Renewable gas* and *All technologies pathways* are considered less at risk of being negatively affected by national policies.

Figure 3-8 Average likelihood/severity map for risk of national policies presenting barriers to implementation



Note: n is the total number of responses to the severity AND likelihood of the related risks

3.3.2 Other risks and proposed mitigation of regulatory risks

Respondents provided the following additional regulatory risks:

- Given new technologies required by the pathways, not all important elements and requirements are comprehensively considered; and
- Regulation regarding energy storage and DSM do not sufficiently support the uptake of technologies.

To help mitigate regulatory risks, respondents recommend the following:

- Allow for sufficient time for testing and piloting new technologies to provide valuable input; and
- Establish a national level agreement on 100% renewable energy and remove obstacles in national legislation.

Table 3-4 provides the additional comments received in full.

Table 3-4 Other comments concerning regulatory risk

Question	Answers provided (in verbatim)
If you wish, please add any comments on your ranking of the likelihood/severity of relevant regulatory risks.	1-NIMBY factor on local level could (in fact have) become major problem. 3- Estonian regulation is highly based on EU's regulation, risks are mainly related to implementation side
Please describe any additional (missed) regulatory risks that might impact the implementation of the pathways.	3- Since new technologies are in line there might be risks that not all important aspects are considered and related requirements comprehensively considered. 5- This accounts for every pathway: it is essential that the regulation regarding energy storage and DSM support the uptake of these technologies, which also has a crucial impact on the share of variable renewables in the grid.
How would you recommend mitigating the regulatory risks that might block pathway(s) implementation?	1-All the usual stuff for persuading people 3- Sufficient time for testing and piloting new solutions (hydrogen, nuclear, CCU, offshore, storage etc) in Estonia could give valuable input into regulations. 5- There is no guarantee for good policy 7- Establish a national level agreement on 100% renewable energy and remove obstacles in national legislation. Refrain from the prevailing discourse of a "market based transition" when in fact the market is dominated by a state owned monopoly receiving government subsidies in order to invest into oil shale.

3.4 Societal and environmental risks

Stakeholders were asked to rank the likelihood and severity of three societal and environmental risks for each climate-neutral pathway. Table 3-5 provides the list of possible societal and environmental risks respondents were asked to rate, and examples of how the risks may materialise.

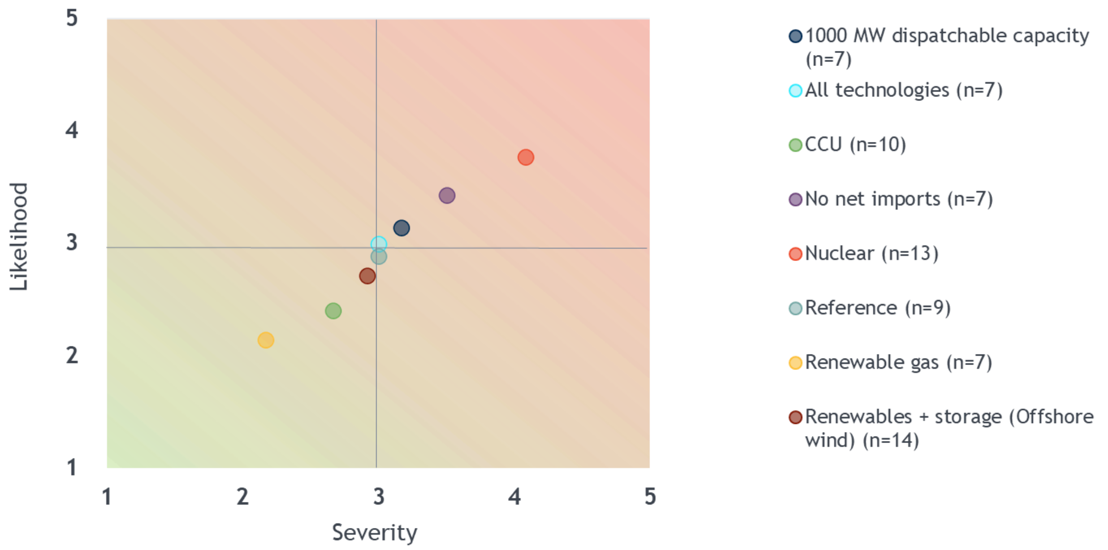
Table 3-5 Types of societal and environmental risks

Societal and environmental risks	Select examples of relevance to pathways
Local opposition to new infrastructure/"NIMBY-ism"	• NIMBY-ism flares in regions where solar panels or onshore wind turbines are slated for development, blocking their installation and the realisation of pathway 2
Lack of widespread public acceptance of new infrastructure	• Anti-nuclear sentiment prevents the development of any new nuclear reactors, limiting options for carbon neutral concentrated generation in pathway 3

3.4.1 Severity and likelihood of societal and environmental risks

Respondents find the *Nuclear pathway* to have the highest societal and environmental risks, followed by the *No net imports* and *1000 MW pathways* (Figure 3-9). The other pathways, with exception to the *Renewable gas pathway*, are also considered to be at a moderate risk of possibly being impacted by societal and environmental risks.

Figure 3-9 Average likelihood/severity map for societal and environmental risks

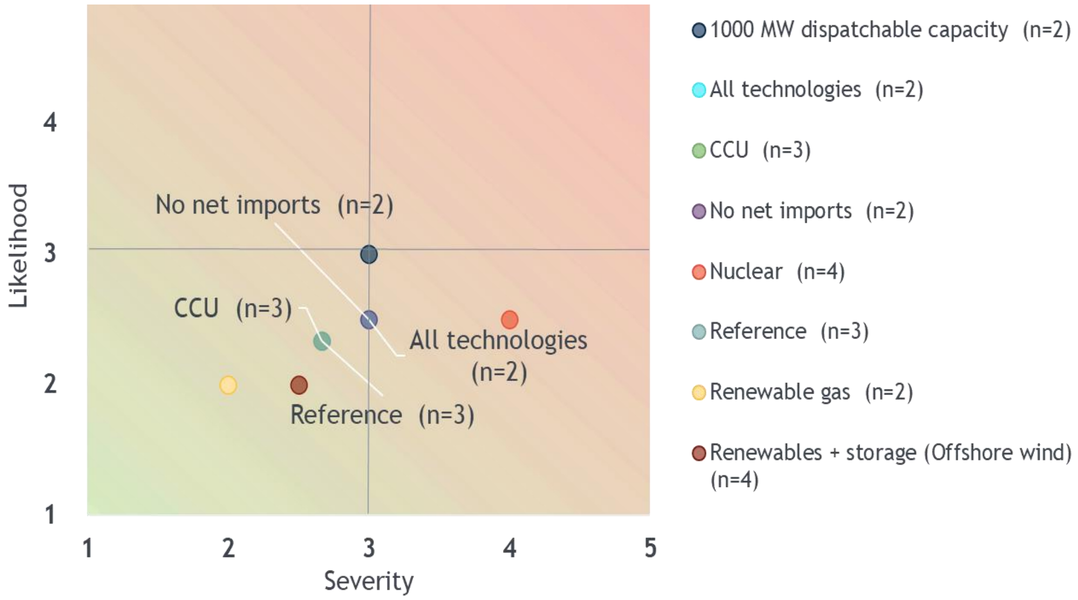


Note: n is the total number of responses to the severity AND likelihood of the related risks

Societal/environmental risk 1 - adverse environmental impacts

All pathways are expected to have an adverse impact on the environment, but the perceived likelihood and severity are moderate with most pathways, with exception of the low risk associated with the *Renewable gas pathway*, and the significant risks associated with the *Nuclear pathway* (Figure 3-10).

Figure 3-10 Average likelihood/severity map for risk that pathway implementation results in adverse environmental impacts on air, soil, water or biodiversity

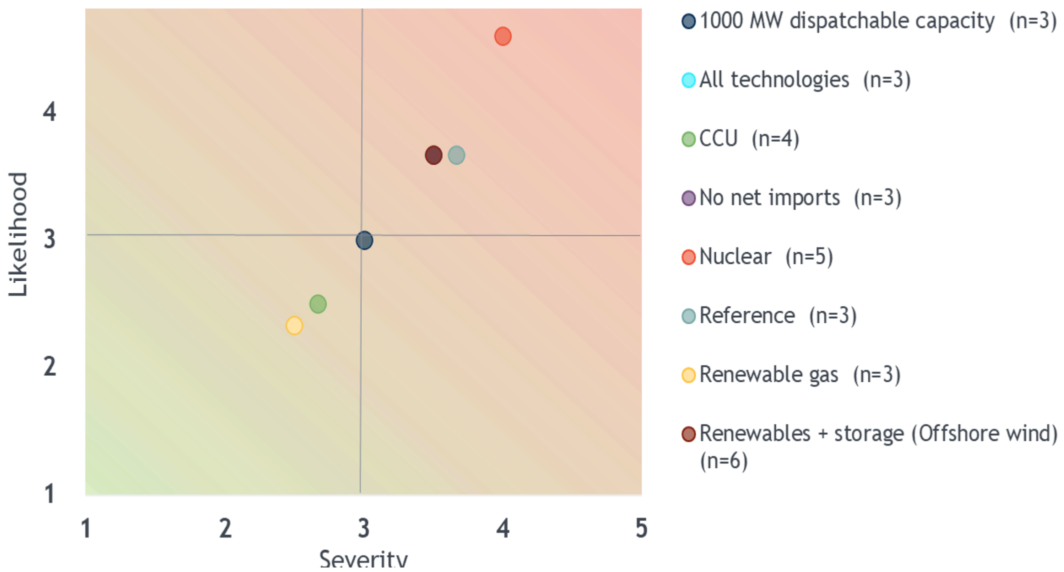


Note: n is the total number of responses to the severity AND likelihood of the related risks

Societal/environmental risk 2 - local opposition

According to respondents, the implementation of the *Nuclear pathway* has the highest chance of being hindered by local opposition to new infrastructure and this risk is viewed as very severe (Figure 3-11). *The No net imports, All technologies, Reference* and *Renewables + storage pathways* are also at moderate risk of facing local opposition to new infrastructure, but of a lesser degree. The *Renewable gas* and *CCU pathways* are viewed to be at moderate risk.

Figure 3-11 Average likelihood/severity map for risk that there is local opposition to new infrastructure, i.e., "NIMBY-ism"

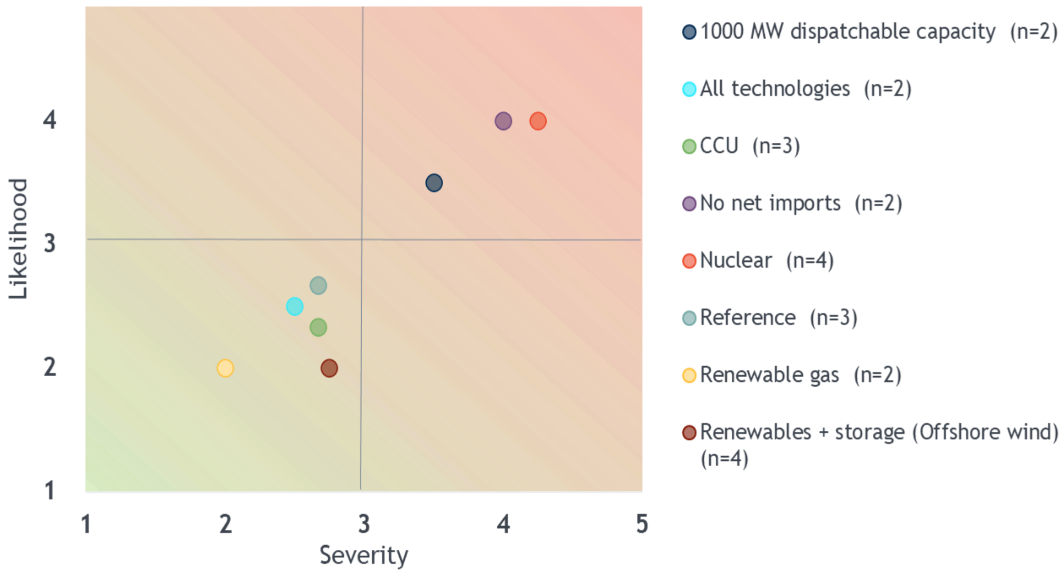


Note: n is the total number of responses to the severity AND likelihood of the related risks

Societal/environmental risk 3 - opposition to infrastructure

The likelihood and severity of the inability to gather widespread public acceptance of new infrastructure to impact implementation is considered to be the greatest for the *Nuclear pathway*, followed by the *No net imports* and *1000 MW dispatchable capacity pathways* (Figure 3-12). Comparatively, the risk is low for the *Renewable Gas pathway* and moderate for the remaining pathways.

Figure 3-12 Average likelihood/severity map for risk that widespread public acceptance of new infrastructure cannot be achieved



Note: n is the total number of responses to the severity AND likelihood of the related risks

3.4.2 Other risks and proposed mitigation of societal and environmental risks

Respondents provided the following additional societal and environmental risks that could create opposition to climate policy and the green transition:

- High energy prices; and
- General lack of understanding/awareness of the energy sector.

To help mitigate societal and environmental risks, respondents recommend the following:

- Risks for different social groups should be addressed distinctively;
- Risks should be address with ‘well thought-out’ regulation; and
- Increase awareness amongst municipalities to reach climate neutrality via innovative schemes, agreements and/or ownership models.

Table 3-6 provides the additional comments received in full.

Table 3-6 Other comments concerning societal and environmental risk

Question	Answers provided (in verbatim)
If you wish, please add any comments on your ranking of the likelihood/severity of relevant societal and environmental risks.	3- It depends on costs of pathway action plan, is it affordable and understandable, communicated enough, which technologies prevail considering environmental impacts. 5- I ranked the risks only for 2 pathways with higher renewables/nuclear content, which in turn can be taken into account for other pathways with similar content.
Please describe any additional (missed) societal and environmental risks that might impact the implementation of the pathways.	3- Current high energy prices could add opposition to climate policy and green transition if not communicated properly. 5- The price for electricity, energy subsidies, societal general understanding of the energy sector etc.
How would you recommend mitigating the societal and environmental risks that might block pathway(s) implementation?	3- Risks for different social groups should be precisely assessed, introduced and communicated to policy makers as well as to related social groups for example via associations, social media. 5- With well thought-out regulation to some extent. 7- Increase the motivation, knowledge and capacity of municipalities for reaching climate neutrality. Develop and establish innovative schemes, agreements and/or ownership models that would increase the benefits to the local community in the process.

3.5 Energy market risks

Stakeholders were asked to rank the likelihood and severity of various energy market risks for each climate-neutral pathway. Table 3-7 provides the list of possible energy market risks provided and examples of how the risk may materialise.

Table 3-7 Types of energy market risks

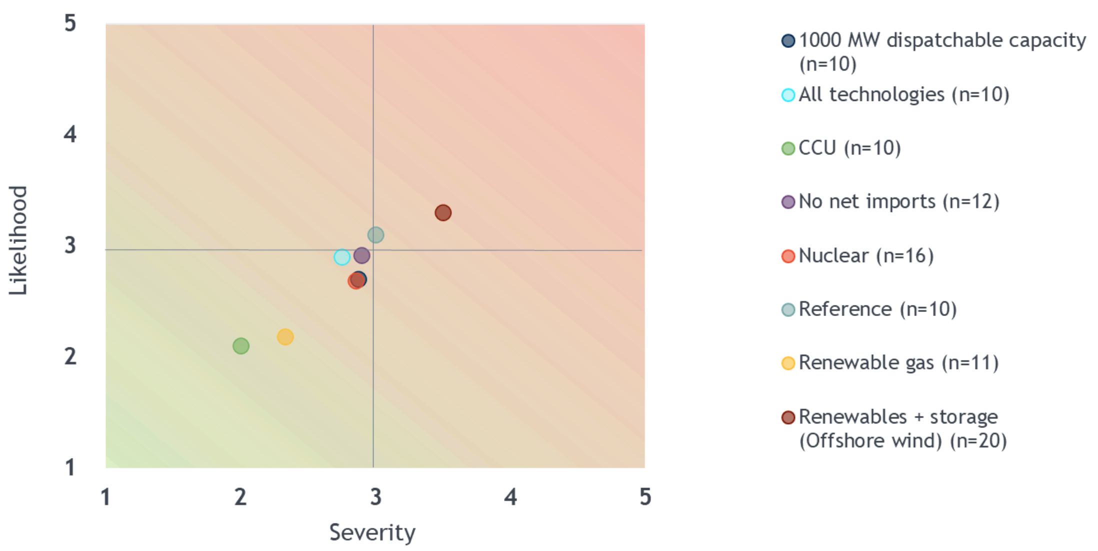
Energy market risks	Select examples of relevance to pathways
Inability to fund necessary grid infrastructural development	• Estonian TSO and DSO unable to fund expansion of electricity grid capacities necessary to accommodate renewable power, hindering pathway 2

Energy market risks	Select examples of relevance to pathways
Security of energy supply threatened due to electricity system instabilities	• Increasing reliance on intermittent technologies in pathway 2 spikes security of supply concerns and continued reliance on oil shale, delaying carbon emission reduction
Unexpected developments in global fossil energy markets	• Consistently falling oil prices render new investments in oil shale plants unappealing, preventing realisation of pathway 4
Electricity system development plans stall in neighbouring countries	• Flexibility of markets and options for selling excess power generated decrease, potentially rendering implementation of pathways 2, 3 and 4 more expensive

3.5.1 Severity and likelihood of energy market risks

On average, energy market risks have a moderate chance of disrupting the implementation of all the pathways (Figure 3-13). Excluding the *Renewable Gas* and *CCU* pathways, that score as low risk, all other pathways cluster around a medium (3) score for both risks and severity. *Renewables + storage* appears to be the riskiest one from an energy market risk perspective.

Figure 3-13 Average likelihood/severity map for energy market risks

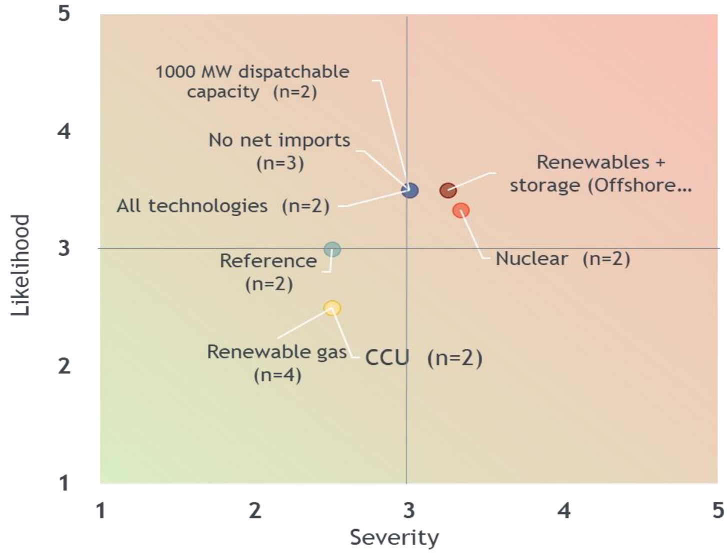


Note: n is the total number of responses to the severity AND likelihood of the related risks

Energy market risk 1 - global energy markets

The energy market risk considers the impact that an increase in oil and gas prices may have on the successful outcome for each pathway. There are a few overlaps in the risk scores obtained by the eight pathways examined in Figure 3-14, but all pathways score within the medium risk category. Among these, the pathways with higher risk from higher costs of fossil fuel usage are the *Renewables + storage* and the *Nuclear pathways*. On the other hand, *Renewables gas* and *CCU* are the pathways less affected – a result relatively surprising since the commercial viability of CCU is likely to be affected by high fossil fuel prices. Few answers were obtained in regard to this risk.

Figure 3-14 Average likelihood/severity map for risk that developments in global energy markets drive up the cost of fossil fuel use

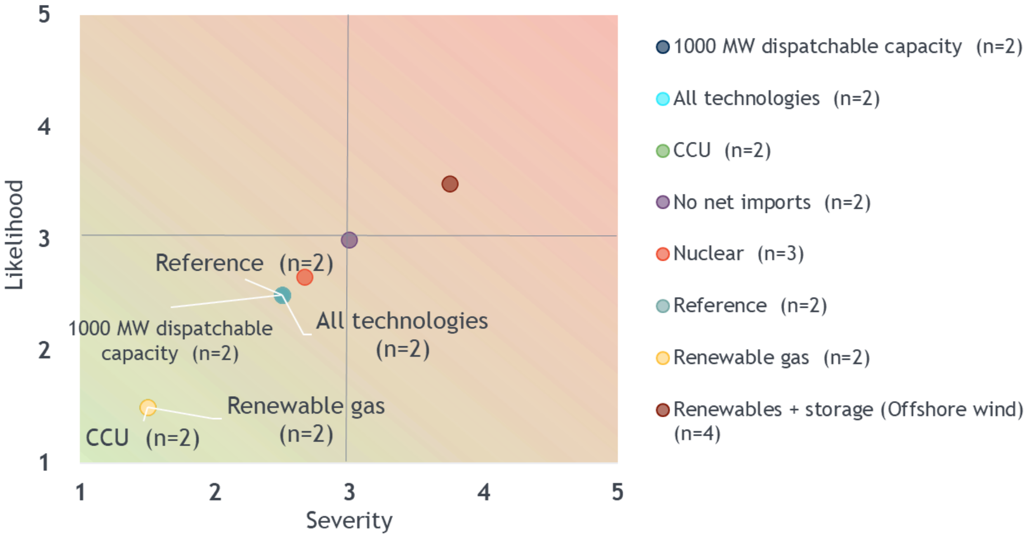


Note: n is the total number of responses to the severity AND likelihood of the related risks

Energy market risk 2 - neighbouring countries

Respondents provided more varied answers when assessing the risk that electricity system development plans stall in neighbouring countries. In this respect, the *Renewables + storage* pathway appears the riskiest pathway (in particular, high severity of impacts) while *Renewable gas* and *CCU pathways* are rated as very low risk.

Figure 3-15 Average likelihood/severity map for risk that electricity system development plans stall in neighbouring countries

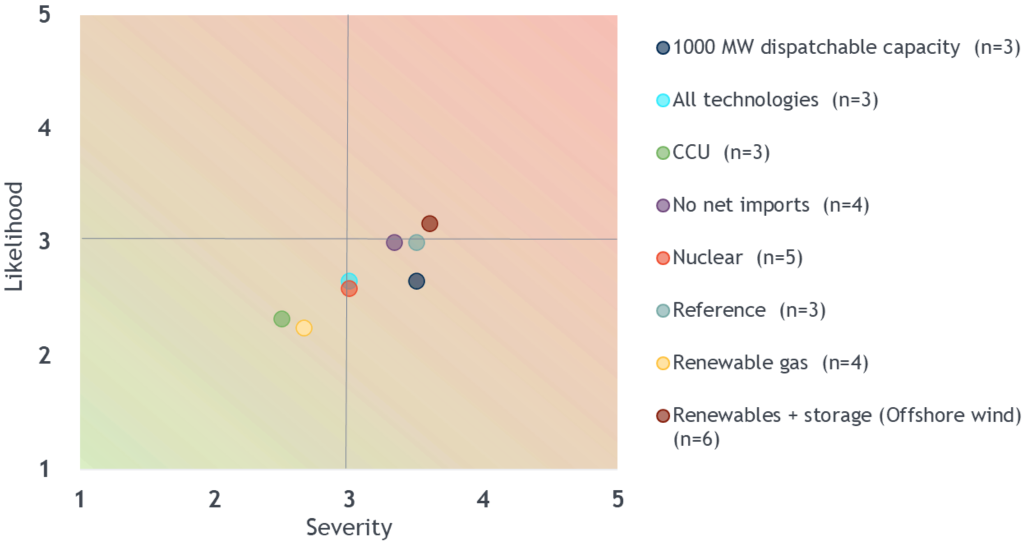


Note: n is the total number of responses to the severity AND likelihood of the related risks

Energy market risk 3 - funding grid infrastructure

For all pathways, the risk that necessary grid infrastructural development cannot be adequately funded is rated as medium. *Renewable gas* and *CCU pathways* appear again to be the less risky (just below the medium level) while most other pathways cluster towards the higher end of the medium risk, with *Renewables + storage* being again perceived as marginally riskier than other pathways.

Figure 3-16 Average likelihood/severity map for risk that necessary grid infrastructural development cannot be adequately funded

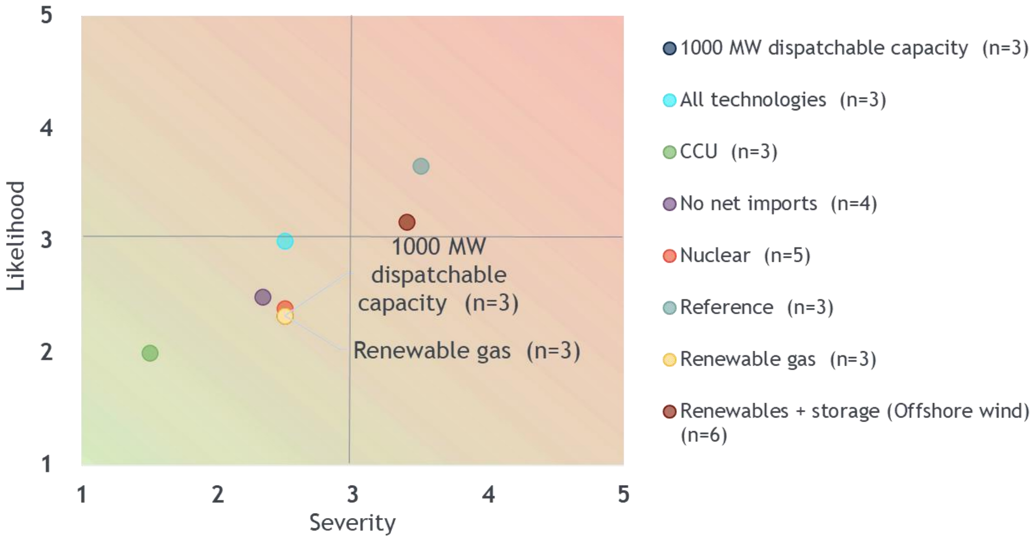


Note: n is the total number of responses to the severity AND likelihood of the related risks

Energy market risk 4 - system instabilities

Concerning risk that the security of energy supply in Estonia is threatened due to electricity system instabilities, there is a significant disparity among scenarios. The *Reference* scenario appear the most critical one, while the *CCU pathway* appears to be the less risky one. All the other pathways have a medium level of risk.

Figure 3-17 Average likelihood/severity map for risk that the security of energy supply in Estonia is threatened due to electricity system instabilities



Note: n is the total number of responses to the severity AND likelihood of the related risks

3.5.2 *Other risks and proposed mitigation of energy market risks*

Respondents also suggested additional potential energy market risks. These include:

- Risks related to the increasing complexity and size of power systems;
- Risks related to the development of an international transmission grid; and
- Risks of crises could stop market-based models from working.

Respondents provide the following recommendations to mitigate energy market risks:

- Sufficient preparation of system operators in order to be flexible and find new solutions to manage and inform increasing number of market participants in a decentralised power system; and
- Good foresight, modelling and quality assumptions for developing necessary infrastructure.

Table 3-8 provides additional comments received in full.

Table 3-8 Other comments concerning energy market risk

Question	Answers provided (in verbatim)
If you wish, please add any comments on your ranking of the likelihood/severity of relevant energy market risks.	1-Key risks are related to very long-term and capital intensive projects like off-shore and nuclear 3- Technologies and fuels development in transportation, heating and cooling would have impact on electricity demand and market making it more dependent on digital solutions. Cyber security would have rising importance. 5- I could not comment on the likelihood of developments in other countries, however, the severity of such developments is dependent on the necessary energy imports for each pathway respectively.
Please describe any additional (missed) energy market risks that might impact the implementation of the pathways.	3- Bigger and more complicated power system will have additional risks. Producers, consumers and prosumers, different market participants will be connected via web, but in real situation (in specific climate conditions or any technical failures) more devices depend on real action of distribution companies. 5- The developments regarding international transmission grids - Baltic Sea offshore grid initiative, Hydrogen backbone. Relevant for import/export scenarios and the potential uptake of variable renewables, P2X. 8- Market based models could stop working in crisis scenarios. Stakeholders put their national interest before market interest. For import based country there could be strategic deficit that can lead to serious consequences.
How would you recommend mitigating the energy market risks that might block pathway(s) implementation?	3- System operators should be well prepared, flexible and find new solutions to manage and inform rising number of market participants in decentralised power system 5- Good foresight, modelling and quality assumptions are necessary for such developments regarding e.g. necessary infrastructure.

3.6 Economic risks

Stakeholders were asked to rank the likelihood and severity of the main economic risks identified for each climate-neutral pathway. Table 3-9 provides the list of possible economic risk provided and examples of how the risk may materialise.

Table 3-9 Types of economic risks

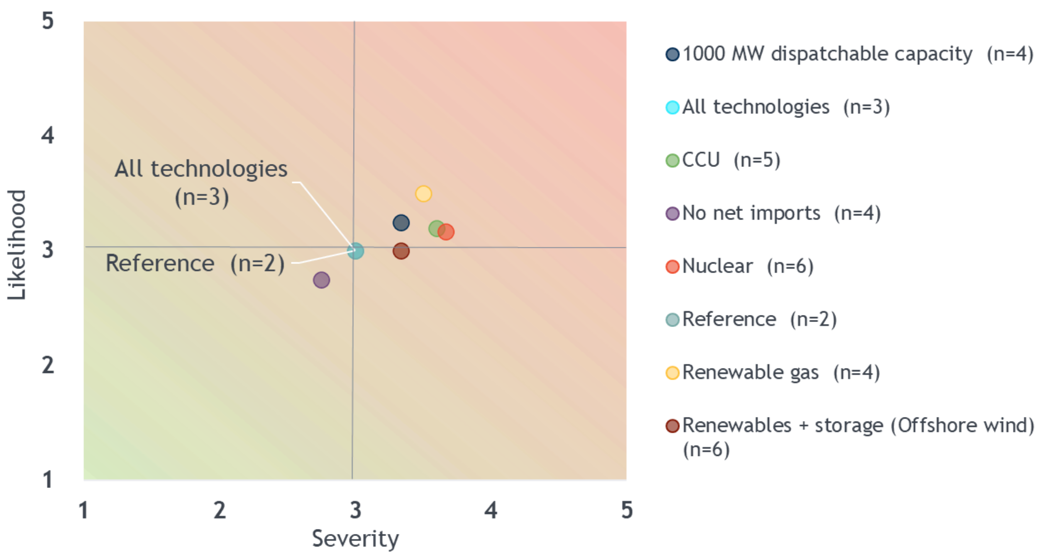
Economic risks	Select examples of relevance to pathways
EU or global economic crisis results in market volatility and limited spending potential	• Volatile electricity prices render short- and medium-term storage options more valuable in pathways 2, 3 and 4 • Costs of new renewables, storage, and grid infrastructure required for pathway 2 or new nuclear infrastructure required for pathway 3 deemed preventively high

3.6.1 Severity and likelihood of economic risks

Energy market risk 1 - economic crises

All pathways have been rated as being at moderate risk to be affected by EU or global economic crises which may result in market volatility and limit spending potential. Towards the high severity level are the *Renewable gas*, *Nuclear* and *CCU pathway*; towards the lower end, is the *No net imports pathway*.

Figure 3-18 Average likelihood/severity map for risk that EU or global economic crisis results in market volatility and limits spending potential



Note: n is the total number of responses to the severity AND likelihood of the related risks

3.6.2 Other risks and proposed mitigation of economic risks

One respondent expressed concern for the impact of the development of other sectors with high energy consumption on changing system stability. To mitigate economic risks, respondents recommend an analysis of different market participants and to focus on one sector at a time.

Table 3-10 provides additional comments received in full.

Table 3-10 Other comments concerning economic risk

Question	Answers provided (in verbatim)
If you wish, please add any comments on your ranking of the likelihood/severity of relevant economic risks.	3- More common technologies are probably available also in crisis situation, but development of new solutions might be stopped 5- The market instabilities in the recent ca 15 years (Covid-19, financial crisis) have shown little impact on energy sector investments
Please describe any additional (missed) economic risks that might impact the implementation of the pathways.	3- Development of other sectors with high energy consumption need will be mostly affected changing system stability. 5- Maybe it is not the most relevant here, but it is necessary to understand the dependency of investments and uptake of variable renewables on regional developments due to grid saturation (i.e. the more wind capacity in the NordPool market already reaches Estonia during windy hours, the less incentive there is for local investments). Therefore, it is necessary to move ahead with necessary prerequisites for the energy sector development in a timely manner to ensure a better socio-economical position in the region
How would you recommend mitigating the economic risks that might block pathway(s) implementation?	3- Analysis of different market participants is needed. Risks related with big consumers should be assessed separately, including proportion of big consumers in the system and, as an alternative their ability and readiness to produce electricity for self consumption. 4- Focus on one area at the time

3.7 Other comments

Respondents were asked to provide further comment to elaborate on one of the pathways or further risks (Table 3-11).

Table 3-11 Other comments

Pathway specific comments (in verbatim)	
Reference pathway	1-Oil shale electricity is not sustainable 3- Highly power-to-X dependent scenario stresses need for power generation. Rising need for energy.

Pathway specific comments (in verbatim)	
Renewables + storage (Offshore wind) pathway	1-Expensive 3- Clearest way to climate neutrality. 8- not stable, questionable liability.
Nuclear pathway	1-No proven technology which is suitable for Estonia 3- No suitable functioning solutions existing today. Question of managing radioactive waste remains. 8- cost and environmental problems.
CCU pathway	1-No proven technology 3- If a company is able to invest into these solutions it should be considered as a temporary solution until emission free production.
Renewable gas pathway	1-Expensive 2- We are neutral towards all pathways, while prefer the pathways with higher security of supply. 3- No functioning solutions yet but if there will be it should be used. 8- strategic dependences.
All technologies pathway	1-Oil shale electricity is not sustainable 3- It seams safest way to have a diverse generation.
1000 MW dispatchable capacity pathway	3- Hereby main question might be cost of keeping these capacities
No net imports pathway:	1-Expensive 3- Most unrealistic scenario since we have developed connections to participate in electricity market. However in current high energy prices situations maybe if we would have own generation capacities we would be able to keep more stable prices than in market. It might be longer term pathway when we have local generation capacities and storage enough.
Other questions	
Please describe the key steps the Estonian government could take to ensure the pathway is implemented successfully	1-Create attractive business environment in comparison to neighbouring countries. Facilitate planning process, develop required infrastructure, promote PPAs and fight NIMBY. 3- Local communities and local governments need more support and communication regarding importance and implementation options of renewables and storage. Potential producers and developers should be supported and communicated as well. 4- Põhjalik ja kiire keskkonna-ja ohutusriski analüüsi läbiviimine.
In the next 1-5 years, what are the "no regret" actions that should be prioritised to ensure the pathway can be implemented successfully	1-Create attractive business environment in comparison to neighbouring countries. Facilitate planning process, develop required infrastructure, promote PPAs and fight NIMBY. 3- Preparation of necessary developments of existing power system to reach consistency with future demands and requirements. Therefor present study should describe in its action plans most urgent steps as well regarding whole power system (not only generation but as well distribution). 4- Strateegi kinnitamine, sedusandluse ülevaatamine ja korrigeerimne

4 Stakeholders interviews

4.1 Interviews

In January 2022, the project team interviewed a number of stakeholders representing different views from the power generation sector. The list of interviewees are listed in Table 4-1 below.

Table 4-1 Interviewees

Organisation	Representative
Renewables Association	Mihkel Annus
Wind Association	Terje Talv
Nuclear Energy interested company Fermi OÜ (also representing Power Industry Association)	Kalev Kallemets
Biofuels Association	Ülo Kask
Chamber of environmental organisations	Johanna Maarja Tiik and Ingrid Nielsen (Estonian Nature Fund), Silver Sillak (Estonian Green Movement)
Sunly (renewable energy developer/investor)	Priit Lepasepp
Axela	Marti Hääl

Interviewees were provided with a short PowerPoint presentation summarising the results of the outcomes of the risks survey, and the topic of the interview is stated as follows:

- **How different risks may affect the chances of success of the different pathways and barriers that must be overcome.** We would like to discuss with you the outcomes of the survey and elaborate on the most significant risks identified. While the risks are largely "future oriented" we would like to integrate this analysis with a discussion over the currently existing barriers.

- **Actions that Government and other stakeholders could put in place to ensure the pathway is successfully implemented.** At this regard, we would like to explore issues such as: governance; financing issues (sources of funding, financing model, risk allocation…); regulatory reforms; new policies and programmes; investments in infrastructure; social policies. While exploring these measures, we would like to gather your views also in terms of government budgets, timing, and responsibilities.

The individual conversations focussed primarily on the four main pathways (**renewables + storage**; **nuclear + renewables + storage**; **CCS/CCU + renewables + storage**; **all technologies**) but also touched on the secondary ones (renewable gas; no net imports; 1000 MW dispatchable capacity). A summary of barriers and actions discussed with stakeholders is provided as part of Deliverable 7.

4.2 Summary of interviews responses

4.2.1 On the risk analysis

From stakeholders' answers the following conclusions can be drawn:

- Most stakeholders, excluding the nuclear industry, broadly agreed with the overall picture emerging from the risks survey. However, stakeholders were surprised that nearly all pathways converge towards a medium level of risk (they expected wider differences).

Renewable gas

- A few stakeholders understood why, in general, the renewable gas pathway was seen as less risky (mainly because of limited change compared to current system), but some brought up additional risks associated with the scenario:
    - They are unsure whether carbon neutrality could realistically be achieved under this scenario;
    - The exploitation of forest biomass that this pathway may entail is not necessarily a desirable option;
    - For the production on synthetic fuels and green hydrogen from unutilised renewable generation, it would be necessary the deployment of a substantial renewable capacity first. So an increased deployment of wind and solar has to be achieved in any case;
    - Waste gas (from food and agriculture) could be much better exploited and realistically generate 1.2-1.5 TWh per year. However, Estonia is very far from being able to exploit this potential;
    - Hydrogen in district heating is not a smart solution.

Nuclear

- Investors and proponent of renewables in general stated that the main risk of nuclear is the fact that the chosen nuclear technology (SMR) is not available and will not be for several years, and that Estonia lacks the administrative capability and skills to run a successful nuclear programme. Nuclear also poses a risk of creating a monopoly, given the small size of the market and the size of nuclear plants.
- Representative of the nuclear industry instead stated that risks for the nuclear pathway are much lower than the rankings made by survey respondents. The representative expressed that the risk perception presented by the survey may be skewed as most respondents are from industries that oppose to nuclear a priori. According to supporters of the nuclear options, the main risks for the success of the nuclear pathways are:

- Subsidies for renewables may jeopardise the business case for nuclear (which will need no subsidies, but only some form of investment risk reduction support, such as risk transfer or guarantees);
- Government decides in the future to tax excessively the profits made by investors in nuclear;

- Disagreement on public perception of nuclear: while the nuclear industry states that regular polls show a good support from nuclear among Estonian citizens, other stakeholders suggest any pathway that involves nuclear should be accompanied by a strong public relations campaign. NYMBY-ism would also affect this scenario.

Wind and solar focussed scenarios

- Overall, while the risks for scenarios with high wind and solar are low due to the ever decreasing development costs (according to many, wind and solar are already cost competitive and only need minimal government support because banks demand it), batteries may pose a substantial problem. In particular, they are a problem because of scarcity that will emerge later in the 2020s, due to the worldwide demand for rare metals and other raw materials used in batteries.
- There are substantial energy security challenges of integrating renewables above 25%, in particular related to peak shaving and long-term storage. Without properly addressing these risks, citizens are more likely to go against renewables if prices spike or if there are supply constraints, and this may fuel further NIMBY-ism. The government has so far relied on the System Operator (with its own backup capacity) and on the emergence of market solutions, but this is unlikely to be sufficient. The requirement to build storage should have been associated with the first auctions, and it could be done for the next actions (although this may create some backlash). However, the primary cause of this risk is the fact that there is no clear strategy on how these issues will be dealt with.

CCU

- Most stakeholders were also sceptical of the CCU scenario, due to costs and unproven technology. However, CCU is a strategy worth pursuing, especially if it targets relatively low investments. Fossil fuel plants will, with CCU, be able to support renewables during peak times and at low generation/high demand events.

Financing

- Overall, most new technologies are (and will continue to be) affected by financing difficulties due to the length of the planning process, the lack of appropriate instruments to lower risks (guarantees, green bonds, minority stakes…) and the lack of clear government commitment to one strategy. How to lower financing risks is something that should be considered in every pathway.

Other risks

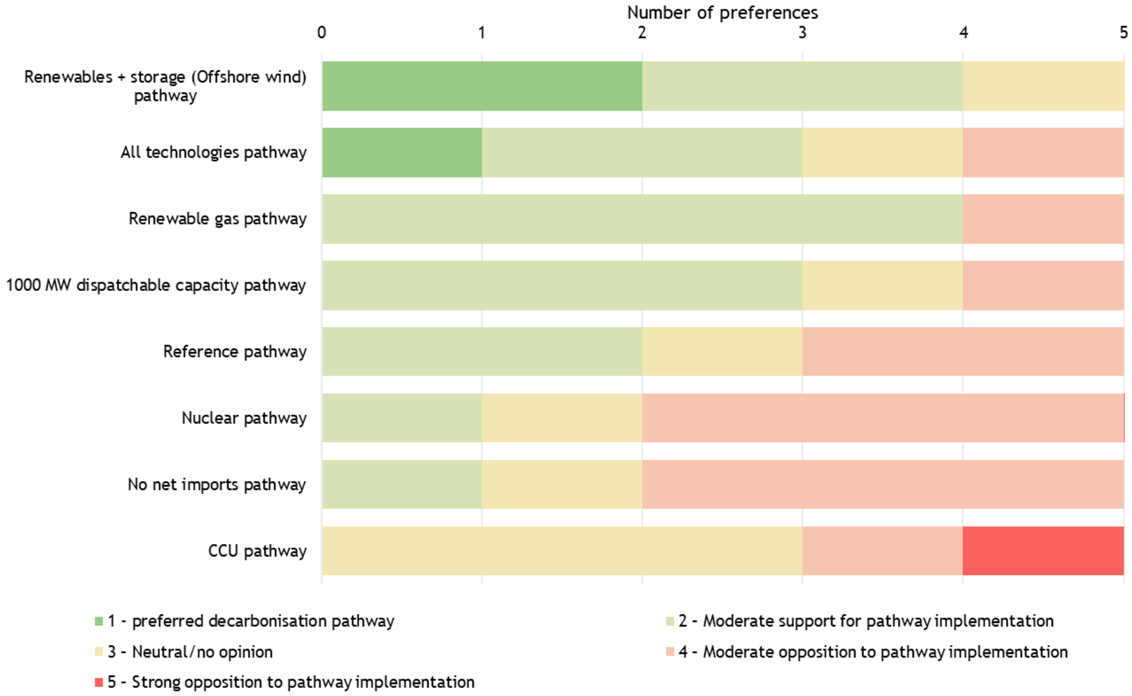
- Risks associated with a lack of government commitment: opting for pathways that rely too much on technology neutrality (all technologies) or on perspective technologies (nuclear, CCU) would give an ambiguous message to citizens and investors. This would discourage investments and extends local administrations' reluctance to commit to local renewable installations.
- The choice of best pathways for the power sector depends on other sectors as well, especially the heating and transport sectors. For example, while pathways with high deployment of renewables and batteries may be preferable to some stakeholders, these may be in direct competition with scenarios that see a high electrification of heating and transport. In this case, a renewable gas scenario may be preferable, so as to avoid competition for batteries among sectors.
- The end-of-life costs of different technologies are not fully considered when choosing among technologies. If life-cycle costs were considered, nuclear would come up better and other technologies worse, as at the moment, it is unclear how the decommissioning of wind and solar parks will be paid for.
- Decarbonisation in general and some pathways in particular may put substantial pressure on energy bills. This may in turn affect citizens' support for strong actions to decarbonise.

5 Conclusions and next steps

5.1 Ranking

Survey respondents were asked to rank pathways in terms of their support or opposition using a scale of 1 to 5, with 1 being the preferred pathway and 5 being the most opposed pathway. *Renewables + storage is* the pathway that attracted the highest support, followed by the *All technologies pathway*. These are followed by the *Renewable gas pathway*, that received several votes as "moderate support". The *CCU pathway* is the one with the lowest support and the only one for which a stakeholder came out as clearly opposing it.

Figure 5-1 Pathway by preference



5.2 Comparison of key risks across pathways

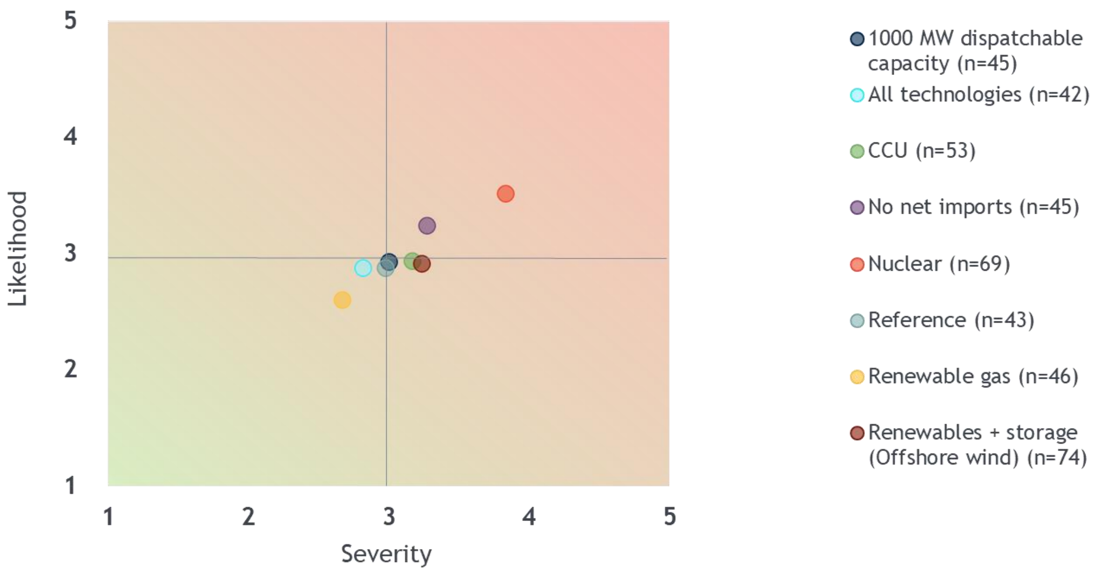
Table 5-1 and Figure 5-2 show the average score across all risks considered across the eight pathways. The risk in not weighted by category, which means the risk categories for which more risks were identified will have a bigger weight on the score.

Across the eight pathways, the *Renewable gas pathway* is deemed as least risky, followed by the *All technologies*, the *Reference scenario* and the *1000 MW dispatchable capacity pathways*. *Nuclear* and *No net imports* are considered the riskiest.

Table 5-1 Average risk score by pathway (all risks)

	Likelihood	Severity	Grand Total
Renewable gas	2.61	2.67	2.64
All technologies	2.88	2.82	2.85
Reference	2.88	2.98	2.93
1000 MW dispatchable capacity	2.93	3.00	2.96
CCU	2.94	3.16	3.05
Renewables + storage (Offshore wind)	2.92	3.23	3.07
No net imports	3.24	3.27	3.26
Nuclear	3.52	3.83	3.67
Grand Total	3.02	3.17	3.09

Figure 5-2 Average risk score by pathway (all risks)



Comparing the preferences expressed by survey respondents (Figure 5-1), it can be noted that, even though *Renewables + storage* is the preferred pathway, it seems to have relatively high perceived risks; the next preferred pathway, i.e. the *All technologies pathway* is perceived as being the second less risky option.

However, considering the views of stakeholders who were interviews, the *Renewables + storage pathway* appears as the least risky because:

- The technology is available today at competitive cost;
- The actions required to mitigate risks are relatively straightforward (for example, issues with the planning process and local opposition appear solvable with few

targeted actions, while other risks affecting other scenarios such as technology availability are more complex);

- It will be a pathway in line with the course taken by other nordic countries that are showing strong progress towards their decarbonisation targets (Germany, Denmark, Sweden, Finaland..);
- It is a clear strategy which is easy to follow and with strong experience at the EU level.

Several stakeholders also expressed during the interviews that risks associated with high renewable deployment pathways would be lower if actions to promote renewable gases and limited CCU will be undertaken.

Annex - All results

Average Likelihood/severity score for all specific risks rated (L = Likelihood, S = Severity)

Risk	L / S	Reference pathway	1000 MW dispatchable capacity	All technologies	CCU pathway	No net imports pathway	Nuclear pathway	Renewable gas pathway	Renewables + storage
Technological									
of delayed technological development for key decarbonisation technologies	L	2,60	2,80	2,60	3,83	2,80	4,00	2,60	2,50
	S	3,00	2,80	2,60	4,00	2,80	4,14	3,00	3,17
that delayed infrastructural development prevents integration and use of key decarbonisation technologies	L	3,00	2,80	2,60	4,00	3,40	3,86	3,20	3,17
	S	3,60	3,00	2,80	4,17	3,60	3,86	3,20	3,33
that key decarbonisation technologies do not reach economies of scale, such that their costs remain higher than projected	L	2,80	3,40	3,20	4,00	3,60	3,86	3,40	3,00
	S	2,80	3,20	3,00	4,00	3,60	3,86	3,00	3,33
Economic									
that EU or global economic crisis results in market volatility and limits spending potential	L	3,00	3,25	3,00	3,20	2,75	3,17	3,50	3,00
	S	3,00	3,33	3,00	3,60	2,75	3,67	3,50	3,33
Societal									
that pathway implementation results in adverse environmental impacts on air, soil, water or biodiversity	L	2,33	3,00	2,50	2,33	2,50	2,50	2,00	2,00
	S	2,67	3,00	3,00	2,67	3,00	4,00	2,00	2,50
that there is local opposition to new infrastructure, i.e., "NIMBY-ism"	L	3,67	3,00	3,67	2,50	3,67	4,60	2,33	3,67
	S	3,67	3,00	3,50	2,67	3,50	4,00	2,50	3,50
that widespread public acceptance	L	2,67	3,50	2,50	2,33	4,00	4,00	2,00	2,00

Risk	L / S	Reference pathway	1000 MW dispatchab le capacity	All technologi es	CCU pathway	No net imports pathway	Nuclear pathway	Renewabl e gas pathway	Renewabl es + storage
of new infrastructure cannot be achieved	S	2,67	3,50	2,50	2,67	4,00	4,25	2,00	2,75
Regulatory									
of EU/international policies presenting barriers to implementation	L	2,00	2,50	2,00	2,67	3,50	3,00	2,00	1,80
	S	2,00	2,50	2,00	3,00	3,50	4,25	2,00	2,60
of local policies presenting barriers to implementation	L	3,33	2,75	3,67	2,50	4,00	4,60	2,50	3,17
	S	3,00	3,00	3,50	2,33	4,00	4,75	2,33	3,20
of national policies presenting barriers to implementation	L	2,50	3,00	2,50	2,00	4,00	3,75	2,33	2,80
	S	2,50	3,00	2,50	2,67	4,00	4,75	2,33	3,40
Energy markets									
that developments in global energy markets drive up the cost of fossil fuel use	L	3,00	3,50	3,50	2,50	3,50	3,33	2,50	3,50
	S	2,50	3,00	3,00	2,50	3,00	3,33	2,50	3,25
that electricity system development plans stall in neighbouring countries	L	2,50	2,50	2,50	1,50	3,00	2,67	1,50	3,50
	S	2,50	2,50	2,50	1,50	3,00	2,67	1,50	3,75
that necessary grid infrastructural development cannot be adequately funded	L	3,00	2,67	2,67	2,33	3,00	2,60	2,25	3,17
	S	3,50	3,50	3,00	2,50	3,33	3,00	2,67	3,60
that the security of energy supply in Estonia is threatened due to electricity system instabilities	L	3,67	2,33	3,00	2,00	2,50	2,40	2,33	3,17
	S	3,50	2,50	2,50	1,50	2,33	2,50	2,50	3,40

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