The visionary report on Estonian-Norwegian cooperation in renewable energy and green transition

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DISCLAIMER

The report expresses solely the opinions and positions of the authors in making the selections and prioritisations.

The report is not intended to be comprehensive of all possible renewable energy sector topics neither at all possible cooperation domains or options.

Products or service providers lists brought as examples are not exhaustive and are serving as examples to allow the reader to explore a use case.

Authors:
Margit Kull, Irina Oleinikova, Ulrika Hurt, Elisabeth Skarsbo Moen, Rutt Hints, Allan Niidu, Jaan Kers

Acknowledgments:
Pål Runde, CEO Battery Norway, Trine Kopstad, Berentsen, CEO The Norwegian Solar Energy Cluster, Bjørn Ottar Elseth, CEO H2 Cluster Norway, Daniel Miravalles, Energy Valley, Norway, Veiko Karu, TalTech, Estonia, Riina Aav, TalTech, Estonia

TalTech Tallinn University of Technology. Tallinn, ESTONIA
Sustainable Value Chains Unit www.taltech.ee/sbg
Circular Economy Core Lab, www.taltech.ee/ringmajandus www.taltech.ee/circular

EnergyValley. Fornebu, NORWAY www.energyvalley.no

Key contacts:
Margit Kull margit.kull@taltech.ee, Ulrika Hurt ulrika.hurt@taltech.ee

EXECUTIVE SUMMARY

The current report aims to recommend best policy practices, untapped cooperation and business and joint research collaboration in the fields of renewable energy and green transition.

The Norwegian and Estonian industries, academia and authorities have **complementary competences, strengths and abilities** that reinforce each other in speeding up the much-needed energy transition and in safeguarding European energy security in the Nordic-Baltic region. Uptake of existing top technologies and innovating on technology in the uncovered domains will be contributing to the **Nordic-Baltic region sustainability and economic growth** matching the expectations of industries and governments. Reaching out for further national and international funding and investments to develop joint cost- and energy-efficient power and energy production, storage and distribution solutions is considered highly potential.

The green energy transition and technology uptake as well as evolution are based on foundations of the already existing ties and the mutual readiness to seek joint work streams, innovation, investments, and technology evolution as well as application.

The report maps the standpoint, suggests fields of priority cooperation, and recommends joint actions for the roadmap of Estonia-Norway cooperation. For actions and results, stakeholders from industry and research institutions are encouraged to be included to strategic cooperation agenda-setting.

SUGGESTED PRIORITY DOMAINS:

- **grid integration and development,**
- **offshore and onshore wind,**
- **energy storage,**
- **hydrogen and ammonia,**
- **solar energy technologies,**
- **carbon capture** alongside its storage and utilisation,
- **biomass,**
- **geothermal energy,**
- **technologies allowing industrial energy efficiency**.

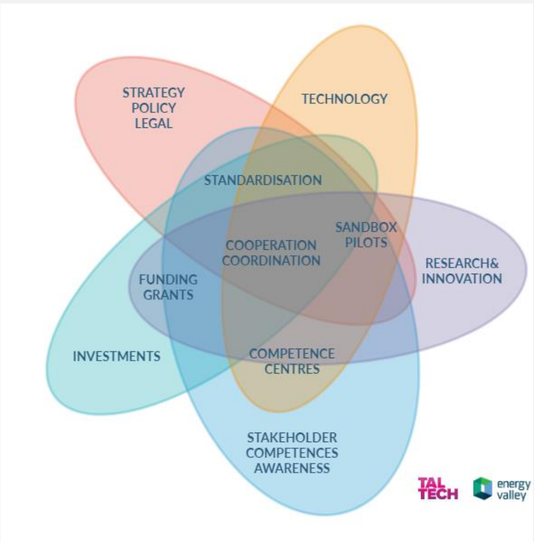

Figure 1. Proposed Collaboration Activities

SUGGESTED COOPERATION ACTIVITIES:

- Policy and strategy for setting the scene for cooperation and political and administrative decisions,
- **Stakeholder engagement and motivation** to work with new Estonia-Norway cooperation pathways,
- **Competence development** to grow the potential number of people and businesses that could engage to technology but also political and business level cooperation,
- **Technology implementation and scaling** both between the two counties and beyond,
- **Economic aspects and discovery of business models** in green transition that have not been mapped before,
- **Investment guidance** to both sides' investors and funding institutions as a solid strong background,
- **Research and innovation actions** to be prioritised, whilst both start-up and academic community to be included into developing and scaling new solutions,
- **Pooling the sandbox and running pilots** via the already established frameworks and using the flexibility and accessibility of the testbeds and skilled workforce,
- **Legislation and standards**, also intellectual property rights affairs to be addressed with a strong position on renewables to be given priority, guaranteeing safety, but safeguarding progress over conservation,
- **Channelling funding** – both private and public – to renewable energy and green transition also being courageous on the high-risk/high-potential scale.

CONTENT

INTRODUCTION

In the light of global aspirations towards green transition – the Paris agreement[1], European Green Deal[2], Sustainable and Smart Mobility Strategy[3], the European Union and EEA member states are not only seeking energy and resources optimisation, but also to put stronger effort on the evolution of new technologies. Russia's war in Ukraine, has created a strong need for European energy independence from Russia, and has speeded up the energy transition and to further strengthen European cyber security.

Norway and Estonia have demonstrated important capabilities on a global scene in the energy transition. Estonia is a dynamic reformer with the use of digital technologies, and modern Norway built on natural resources and the knowledge to refine these into energy, while distributing the wealth and investing in education and research. Both countries share a culture of fast adaptability. Also, there is a huge trust and investment history already existing in Norwegian-Estonian cooperation and in the context of global trends and disruptions, it is even more important to coordinate and support the steps towards green transition and necessary steps of industry and innovation leading to an economy which is based on sustainable and climate-neutral energy.

The report provides an insight to the basis of the cooperation between the countries, proposes eight energy technology domains for joint work, application and evolution and suggest roadmap actions for collaboration to foster the prioritised domains. The report is based on the expertise of the clusters, universities and experts from both countries and key stakeholders including ministries, government agencies, business associations and research institutions. Independent analysis and suggestions for the decision makers are performed from the different perspectives: system users and stakeholders, operational and environmental perspectives considering legal, technological, and related market aspects.

The intended audience of this report are ministries responsible for energy and innovation, energy and industrial sector decision makers, industry, and academia, who might contribute to the technologies and uptake allowing the transition. Synthesised key messages for ministers are highlighted at the beginning of the report in the executive summary.

The project has been completed between September-December 2022. The report falls into series of visionary reports initiated between the Estonia and Nordic countries - between Finland and Estonia[4,5,6,7] and Sweden and Estonia** and is the first one between Norway and Estonia.

This report has been compiled on the motivation to deliver content input and deliverables based on the joint initiative of Norway and Estonia's prime ministers on the 6th of April 2022[8] to map the possibilities for closer cooperation between businesses on green energy projects. Though such priorities would have been highlighted before, the changed security situation in Europe due to 2022 early spring events have reinforced the importance of even closer cooperation on the green energy shift.

The initiative was assigned by the departments of foreign affairs of both countries — Estonia and Norway.

[1] Paris Agreement, LINK
[2] The European Union Green Deal, LINK
[3] European Commission, LINK
[4] Embassy of Estonia in Helsinki (2022) LINK
[5] Report link – LINK
[6] Ministry for Foreign Affairs of Finland, LINK
[7] Ministry of Foreign Affairs, Estonia, LINK
[8] Regjeringen.no, LINK and Vabariigi Valitsus, LINK

1. TECHNOLOGY DOMAINS PROPOSED FOR COOPERATION

In this chapter the prioritised technologies and areas are listed based on the discussions held and as a result mapped as the most relevant for cooperation on political, industrial and research levels.

The suggested domains are: grid integration and development, offshore and onshore wind, energy storage, hydrogen, and ammonia, solar, carbon capture, storage and utilisation, biomass technologies and other technologies supporting energy efficiency and industrial symbiosis.

1.1. GRID INTEGRATION AND DEVELOPMENT

Massive renewable energy integration must maintain cost efficiency, dynamic security, and resilience of energy infrastructure. This requires new planning strategies and methods for flexibility solutions and system services, as well as flexibility markets solutions for innovative ancillary services provided by VRE and storage. Also, aspects related to cyber-security threats must be included in studies related to energy infrastructure.

Experience on land and in sea areas shows that technology uptake can run aground on insufficient anchoring with stakeholders. It is therefore important to have knowledge of measures such as contributing to stakeholder's involvement and to effective technology uptake in various markets and society in general. Considering the emergency of the situation, solutions should be available and implemented now, for example, there must be technology to reduce the market price, the development of national pilot projects with related feasibility studies/CBA and laboratory tests can be included.

Areas of cooperation:

- **Competence in grid development**. Grid development across Nordic-Baltic facilitates power exchange, which entails new interconnectors and/or new technologies, supporting power system balancing of which both countries are part.
- **Cross-sectoral coordination**. Including generation and grid, transport and grid, industry, and grid, including DER integrating (also via Demand Response) and Public-Private sector initiatives. Share experience from Business Models development and implementation.
- **Social impact, social acceptance of innovative technologies and requirements of behaviour change.** Consumers and prosumers are representing a key player defining a combined strategy for consumption through the Business Models development.
- Create enabling environment zero-emission **legislative initiatives.**

Areas for mutual learning:

- **Dedicated public workshops** can be organised from both sides throughout 2023 and 2024 to share best practices, lessons learned including external stakeholders, also consumers. This could also build a connection to the regulatory aspects and standardisation.
- To improve **sector-integrated services** and increase **energy system flexibility**, including heating sector, their benefits and opportunities, the necessary knowledge, and tools, also ICT, must be in place to increase consumer engagement and reinforce their social acceptance as a preliminary step for further empowerment.
- **Decision-making process.** Dedicated outreach and engagement with energy democracy forms, such as Energy Cooperatives and Communities, aggregators, and associations of energy players will facilitate outreach to this target.

Standardisation supports the translation of the RD&I findings into marketable solutions. Building upon existing standards ensures compatibility with market conditions and increases transparency for prospective customers.

1.2. WIND

Norway needs more **onshore and offshore** wind to keep up with growing energy demand. Norway is set to install 1GW of onshore wind, bringing it to almost 5GW — up from only 1.5 GW 3 years ago. It's going to need still more onshore wind to help meet its expected rise in electricity consumption (from 140 TWh today to up to 220 TWh by 2050). But the first need here is to open a new round of licensing for new onshore wind farms. As well as there will need to develop a new approach to community benefits and engagement. Norway's Planning and Buildings Act now also covers onshore wind, so municipalities can be more involved in permitting than before[9].

Since 2002 there have been installed approximately 150 *windmills*, with total output over 700 GW[10]. Although the goal is to increase the number of wind parks there are certain limits which slow down the overall process: limits for heights and nature conservations, lack of supporting measures and confrontation with civil society (*not in my backyard*). To pass the issues it is important to create an environment where nature and wind parks can exist together as well as to create supportive measures for local authorities and locals, e.g., *windmill* fee. [11]

The Norwegian offshore wind industry is fast growing, and the government has an ambition for building up to 30 GW on the Norwegian coastline by 2040, but the potential could be much bigger, suggesting up to 160 GW in 2050. EU ambition is 500 GW in 2050. Technology from the oil and gas sector over many years, gives Norway a global lead in floating offshore wind. For the moment two licences have been announced in Norway, with new ones coming out every other year after 2023. Due to the lack of projects in Norway many Norwegian companies have developed their projects in areas outside the UK and USA and are looking for new projects abroad. The Baltic Sea is one area of interest.

The advanced state of Norwegian industry and Estonia's interest in developing offshore wind make this an area for cooperation, which should be investigated further. Energy Valley, NCE Energy Technology, presented a timeline[12] for offshore wind in August 2022 for the Norwegian minister of oil and gas, with the industry present in Arendal. This timeline has received great support from industry and governmental authorities. The timeline presents recommended actions to be taken for succeeding in offshore wind, that can be useful for both countries.

Areas of cooperation:

- Manufacturing, installation, and servicing capacity. For industry and related stakeholders, **identify and share best practices (also policy), untapped business opportunities** or possible bottlenecks, and cooperation potential in the fields of green energy.
- **Joint innovation** and development supporting fast kick-off of sustainable rare earth industry along the whole value chain, including recycling permanent magnets from wind turbines.
- Initiate the cooperation to support geological surveys.
- Define/support innovation priorities under which to concentrate efforts towards the objective of innovative solutions.
- **Share best practices** contributing to knowledge, capacity building and know-how exchange.

Areas for mutual learning:

- **Streamlining the licensing process to cut lead time.**
- **Integrate holistic approach to sustainability from the start.** To avoid delays and avoidable damage to onshore and offshore ecosystems, impact assessments should be initiated now and financed by the government, taking a holistic approach to sustainability and coexistence considerations.
- **Develop licensing roadmap and strategy.** It is important to follow other EU countries' experience like the UK, Belgium, and Denmark, establishing a well-defined roadmap with short-term and long-term vision. Establish a financial support scheme.

[9]Wind Europe. LINK
[10] Estonian Wind Power Association (Eesti Tuuleenergia Assotsiatsioon) LINK
[11] Enerhack Academy. LINK
[12] Cap Gemini, LINK

1.3. ENERGY STORAGE

Development and application of electric battery technology is crucial for the decarbonization of transportation and an important tool to stabilise the grid. At the same time, it represents an opportunity for the development of a new green industry. Norway already has an established process industry producing materials essential for the battery industry and world-leading manufacturers of battery packs for the maritime sector. In addition, several players have implemented plans for large-scale battery cell production in Norway. Development of a more complete battery value chain will require additional investment in education, competence building, development of advanced battery materials, access to international markets as well as strengthening of the cooperation with the other European countries. The new strategic partnership between EU and Norway on raw materials and batteries is a good foundation for such development.

In order to better utilise intermittent renewable energy sources, such as solar and wind energy, hydro pumped storage can also be used. Pumped storage is a new developing area in Estonia that started 10-12 years ago and should be ready by 2030. This is one of the most promising technologies to ensure a volatile wind resource, for instance. Hydro pumped-storage project is still under development and needs extra investments. [13]

Areas of cooperation:

- **Competence building.** Starting with R&D and continuing with a large-scale battery cell production including local access to the materials & raw-materials and concepts for increased performance and safety, reuse, and recycling. Natural and environmental impacts and battery value chain, including digitization, robotization and automatization[14][15].
- **Decarbonization of the transport sector**: road transport, maritime transport, aviation.
- **Technology adoption** and power peak reduction, participation in system balancing, services, and contributions to the security of supply.

Areas for mutual learning:

- **Dedicated public workshops** can be organised from both sides throughout 2023 and 2024 to share best practices, lessons learned including external stakeholders. This could also build a connection to the regulatory aspects and standardisation.
- Public workshops how primary resources companies can be turned as circular companies. Examples from Estonia and Norway.
- Standardisation supports the **translation of the RD&I findings into marketable solutions.**

[13] Energiasalv. LINK
[14] Energiasalv LINK
[15] Veldeas LINK

1.4. HYDROGEN AND AMMONIA

In the near future hydrogen would need to meet around 15% of world energy demand by mid-century.[16] DNV forecast that global hydrogen uptake is very low - reaching 0.5% of global final energy mix in 2030 and 5% in 2050. Estonia and Norway are two countries that can internationally contribute to faster development of the market.

The Norwegian government has launched an external investigation into how the state can contribute to building up a coherent value chain for hydrogen produced with low or no emissions, where production, distribution and use are developed in parallel[17]. The research is performed by NTNU, SINTEF, Greensight and Oslo Economics. Also, the Norwegian Hydrogen Cluster, the H2Cluster, has recently made a report mapping the large potential for growth and export in the emerging hydrogen economy.

Potential of using hydrogen in Estonia is also found in sectors of transport, energy supply for buildings, chemistry industry and energy sectors. Biggest investment potential is in shipping and in rail transportation.[18] In Estonia an ongoing Hydrogen Valley Estonia project is aiming at developing the hydrogen value chain throughout Estonia and connecting it to nearby regions and wider Europe in the future. Steering committee of the Valley includes most of the biggest stakeholders in Estonian energy and transportation landscape (Eesti Energia, Alexela, Terminal, Tallinna Sadam, Tartu municipality, Taru University etc.) and supporting group TalTech and many smaller companies, municipalities, and educational institutions.[19]

Estonian national energy grid operator is a partner in Nordic-Baltic hydrogen corridor cooperation agreement. The consortium aims at connecting Nordic countries to central Europe via a hydrogen pipeline network. In the north the hydrogen network would be connected to the Nordic Hydrogen Route around Bothnian Bay.[20]

A good example of existing cooperation is the informal collaboration network "Northern European Alliance for Sustainable Energy" where Norway (through Energy Valley) and Estonia (through Estonian Hydrogen Cluster[21]) are active members. One of the first results of the collaboration is the delivery of an application to build a Baltic Hydrogen Valley under the Horizon Europe grant scheme, connecting Estonia, Finland, Sweden, Denmark, and Norway.

Estonia has the opportunity to choose how hydrogen is produced, either it could be done onshore, or the production should be done together with off-shore wind parks, which is new technology and shouldn't be brought in with first off-shore wind parks. The expensiveness of hydrogen production pushes the action to the future, also the immediate need is to fill the energy needs rather than storing[22]. Therefore, supporting measures are urgent. In November 2022, Estonia has established a committee on Hydrogen Technologies was established by the Estonian Centre for Standardisation and Accreditation[23], with TalTech professor Allan Niidu as its chairman[24].

Alongside, the European Commission has declared hydrogen as the key priority for the Green Deal energy challenges[25]. There are possibilities how to store hydrogen after production, either to transform it into electricity energy with fuel cells, transform it into green methane, green methanol, or ammonia to store it either in gas network or in fuel tanks[26]. Producing ammonia from hydrogen for export has huge positive impact potential in Estonia[27]. The use of Hydrogen raises safety issues amongst

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[16] DNV Energy Outlook 2022 Forecast Hydrogen 2022
[17] Hirth ML, Janzen D, Hove KU (2019). Hydrogen i Kvinnherrad — En mulighetsstudie. Greensight (2019) rapport nr. 30035
[18] Sei LINK
[19] Hydrogen Valley Estonia, LINK
[20] Nordic Baltic Hydrogen corridor, LINK
[21] Estonian Hydrogen Cluster (Eesti Vesinikuklaster), LINK
[22] Enerhack Academy. LINK
[23] Estonian Centre for Standardisation and Accreditation, LINK
[24] TalTech news, LINK EVS website LINK
[25] H2-View- LINK
[26] Estonian LINK
[27] SEI, LINK

consumers, and this must be properly addressed to avoid losses for the investors and society. Norway has long experience from the oil- and gas industry that is applicable to the hydrogen industry.

Another type of production is related to ammonia. Ammonia is a far more developed energy barer than Hydrogen, and with an already mature and growing market. This innovation gives a lot of advantages with minimal costs for onshore infrastructure. The vessel is designed according to pre-defined classification standards to ease regulatory requirements. The vessel can relocate if circumstances regarding the power source should change.

Areas for cooperation:

- **Technology adoption** and participation in the energy system and contributing to the security of supply.
- **Transport systems and infrastructure**. Contributing to a reliable energy carrier with transport and storage properties that offer system flexibility and thus security of supply, and emission-free energy.
- **Health Environment and Security (HSI).** Knowledge sharing within HSI and development of key technologies and standards.
- **Value chain for Hydrogen. We recommend the two governments** to analyse their strongholds but also their weaknesses in the different parts of the value chain in order to position their industry in the parts of the market where they can succeed. As such the countries can help to develop a robust and cost-efficient hydrogen value chain benefitting both countries.
- We recommend the two governments to specialise in different parts of the value chain to move things in parallel and mature the market faster together.

Areas for mutual learning:

- **Dedicated public workshops** can be organised from both sides throughout 2023 and 2024 to share best practices, lessons learned including stakeholders and consumers. This could also build a connection to the regulatory aspects and standardisation.
- Standardisation supports the **translation of the RD&I findings into marketable solutions.**

CASE EXAMPLE:

The Norwegian company H2 Carrier has developed the P2XFloater, which is the world's first floating production system for ammonia green ammonia, using renewable energy for ammonia and hydrogen production[28]. One of the pioneering companies in hydrogen fuel cell production, Elcogen, has its roots and corporate headquarters in Estonia and supports Estonia-based hydrogen fuel cell research. [29]

Figure 2. Hydrogen carrier example

[28] H2Carrier, LINK
[29] Elcogen, LINK

1.5 SOLAR

Solar energy was the second largest sector after offshore wind of the renewable energy sectors in Norway, measured by export turnover in 2020, and growing. [30]

The EU is an especially interesting market, due to the ambitions presented in the EU solar strategy of bringing home the full industrial value chain to Europe. Norway already produces the silicon for solar panels, ingots and wafers with the world's lowest carbon footprint, and the demand is expected to increase in the coming years.

Developed solar power in Norway today only makes up a small part of power production in Norway. The potential is however large. Results from a survey conducted by the Norwegian Solar Cluster estimates the technical potential for solar power on buildings of 87,1GW, which corresponds to an annual power production of approximately 65,6 TWh/year. In comparison developed hydropower makes up 138,3 TWh/year. The Norwegian market is in growth and research and innovation needs are linked to the integration of solar energy into the energy system[31]. In addition, Norwegian players are involved in the development of new solutions for floating and building-integrated solar power.

To fulfil the goals of increasing renewable energy production in Estonia, solar still plays an important role, although the supporting measures are concentrated more to offshore wind energy[32].

Area for cooperation:

- Solar energy has an attractive contribution to decarbonisation in the form of distributed solutions for power and heat, also in areas with a weak grid.
- **Development of** competitive renewable power and heat production and to give consumers ownership over power and heat production.
- **Further value creatio**n in the Norwegian process industry aimed at a growing solar market that emphasises low-emission materials and for the development of new concepts such as floating solar power and building, infrastructure-integrated solar energy, and solar energy as a service.

Areas for mutual learning:

- Solar energy in the system and digitization — local solutions solar power and heat, flexibility and storage solutions for solar energy and smart management of solar systems.
- New concepts and technologies — floating solar power plants, building-integrated solar energy concepts and hybrid power plants.
- Society and environment - framework conditions for local energy solutions, waste management, circular economy aspects and industrial production.

[30] Market report, Norwegian Solar Cluster, 2022
[31] B. D. Dimd, S. Völler, O. -M. Midtgård and T. M. Zenebe, "Ultra-Short-term Photovoltaic Output Power Forecasting using Deep Learning Algorithms," *2022 IEEE 21st Mediterranean Electrotechnical Conference (MELECON)*, 2022, pp. 837-842, doi: 10.1109/MELECON53508.2022.9843113.
[32] Enerhack Academy. LINK

1.6. CARBON CAPTURE STORAGE AND UTILISATION

Norway is a global frontrunner within CCUS, due to an early joint initiative between the Norwegian government and the industry, Longskip/Longship[33] project.

Possibilities for CCU and CCS in Estonia have been researched on the example of oil shale industry as its environmental impact on greenhouse gases is the biggest and needs decreasing amounts. Research of TalTech "Climate change mitigation with CCS and CCU technologies"[34] brought out that there are two technologies (absorption and oxyfuel combustion) that would fit the Estonian oil shale industry. Valorisation plant mineralizing captured CO_2 with oil shale ash to ultra-pure calcium carbonate is projected to be operational in 2028, but other technologies such as carbonation of mine wastes also hold promise for local utilisation of the CO_2 produced[35]. For CCU strong political statements, long-term policies, funding, and clear climate goals are needed. For CCS policy measures to decrease the costs are needed, as well as built-out infrastructure, funding, legal organisation, and storage locations need full clarity[36]. For CCS the possibility is to transport collected carbon to Norway as there is the only possibility for storage under the North Sea. Though it must be analysed either captured CO2 needs pipelines to the storage place or sea transport is preferred. [37]

The topic has recently[38] gained further attention due to success story presentation and intention to broaden the options of the technology uptake[39],[40].

Area for cooperation:

- Materials and raw materials - materials and concepts for further developments, today's li-ion batteries and increased performance and safety and for competing battery chemistries.
- Efficient battery cell production, battery utilisation
- Energy efficiency, all related environmental issues. Automated production and process design, and related services.

Areas for mutual learning:

- Safety, reuse, and recycling. Natural and environmental impacts in the value chains.
- Societal and environmental challenges. Waste management, CO2 storage, circular and industrial production.

To overcome some of the barriers in the early-stage market for CCUS, the Norwegian company Aker Carbon Capture, has developed the concept of carbon capture as a service. The company offers financing, commissions the carbon capture plant, operates the plant and handles the transportation and storage value chain[41]. The service is flexible which means the carbon capture capacity can expand by adding additional modules to the installations. The customer pays per tonne CO2 captured. The company works with local suppliers. This is a model that opens possibilities for cooperation between Estonian and Norwegian industry.

[33] Longship project - LINK
[34] ETAG. LINK
[35] Ragn-Sells. LINK
[36] Ministry of Economic Affairs and Communications, LINK
[37] Estonian Research Agency LINK
[38] Genius Portal, LINK
[39] Battery Retur, LINK
[40] Hyrdovolt LINK
[41] Eco Stor, LINK

1.7 BIOMASS

Biomass is mainly used to produce either electricity, heat energy or biogas. Biodegradable and agricultural waste, low value leftovers from woods, but also wastewater and sludge are used as input material, giving the possibility to use own and close resource materials.

Estonia previously based on the development plan of the use of biomass and bioenergy for the years 2007-2013 and plays the biggest role in renewable energy usage in Estonia. Estonia was also one of the main biomass energy consumers in 2018, together with neighbouring countries like Sweden, Finland, and Latvia. [42] According to the prognoses, 11TWh of all needed heat comes from biomass by 2030. Estonia also has 17 biogas stations, in which 2 biomethane is produced.[43] According to The Association of Estonian Biogas the field makes tight cooperation with universities as the thesis of final works in different degrees are open to read and brought to front for everyone[44]. Estonia has possibilities to change biomass to be producible for industries or producing more biomethane for transportation (which is already in use). In the future more (liquid) biofuels could be produced for aviation. [45]

Significant quantities of biofuels are produced in Norway, approximately 350 GWh/year, therefore the market is growing well. Here the customer groups are forest industry, wood processing (wood chips and wood briquettes), waste and other industries. It is also contributing to the heating systems throughout the country that ensure environmentally friendly heating of buildings as well as industrial heat that is not covered by the district heating network.[46]

Areas for cooperation:

- Share the know-how of using biomass as a renewable energy resource.

Areas of mutual learning:

- Giving extra value for biomass before changing it into energy.

[42] The European Commission's Knowledge Centre for Bioeconomy. Link
[43] REKK 2030. Link
[44] Eesti Biogaasi Assotsiatsioon. Link
[45] ADDVAL-BIOEC: Lisandväärtuse tõstmine ja toorme tõhusam kasutamine Eesti biomajanduses. Link
[46] ERGON, Link

1.8 GEOTHERMAL ENERGY

Geothermal energy, which is a local and permanently available renewable energy, is able to supply more than 25% of the heating and cooling demand in Europe47. As geothermal gradients and heat flow in Norway and Estonia are generally low, heat pumps utilising shallow geothermal energy dominate the current usage, while deeper drill core-based high-temperature installations have been considered uneconomic until recently. Geothermal energy, however, provides a sustainable alternative to natural gas-based district heating systems.

In Estonia, pilot-scale middle-deep geothermal potential studies are currently run by the Geological Survey of Estonia48. Also, a few geothermal district heating projects are in the early preparatory phase. Geothermal energy is added as a focus area in a new national research, development, and innovation roadmap (in preparation)49. Local geothermal energy potential is expected to be similar to that of southern Finland, where a number of geothermal district-scale projects are under development.

Norway, with its extensive drilling industry and related technical knowledge, could provide innovative, tailored, and cost-efficient solutions for drilling geothermal cores[50].

Areas for cooperation:

- Share the know-how of low-temperature geothermal technology implementations. Pilot operations. Innovative drilling and well technologies.

Areas of mutual learning:

- Lowering cost and securing longevity of district-scale geothermal heating systems. Integrating geothermal heating into existing heating systems and with other renewable energy solutions.

[47] EGEC Annual Report 2021. Link
[48] The Geological Survey of Estonia. Link
[49] TAIE action plan 2021—2035. Link
[50] EA Geothermal 2021 Norway Country report. Link

1.9 OTHER TECHNOLOGIES ALLOWING ENERGY EFFICIENCY AND INDUSTRIAL SYMBIOSIS

The abovementioned list of technologies is not exhaustive on the possible cooperation domains. New opportunities for cooperation can be found from disciplines where industries are seeking for sustainable and circular business models, aim at production process energy savings and prepare for general uptake of new technologies on site and within their supply chains. Such trends are to be supported by public sector either by motivation, financial support, promotion, research provision or legislation. Examples of work on suggestions and support to SMEs have already been initiated for example by TalTech in preparing relevant mapping studies[51] on enablers and motivational factors of industries in regard to circular business models, the studies having been financed by the Estonian ministries and agencies.

Also, the countries might strongly benefit from collaboration on new technologies for the abovementioned fields and seeking joint technology and product development to obtain new intellectual property rights and scalable results that attract wider European and international customers.

Norway and Estonia have strong potential to become major players in the European sustainable value chain of rare earths containing permanent magnets, regarded as critical compounds for offshore wind instalments[52]. Countries held Europe's biggest Rare Earth Elements (REE), which prospective exploitation is currently addressed under various R&D schemas[53],[54]. Estonia has the only operational REE separation plant in the region, and recently ensured investment from Europe's Just Transition Fund for constructing a novel permanent magnet plant in Estonia[55].

Areas for cooperation:

- Research and studies performed on business models by universities and research institutions.
- Mapping of enablers and barriers, technology options for energy efficiency and support or motivational measures for industries to implement circular business models.
- Joint evolution and funding of priority technologies in collaboration to benefit the priority industries, supply chains and value chains.

[51] TalTech 2021 and 2023, Link
[52] Rare Earth Magnets and Motors: A European Call for Action. LINK
[53] EURARE. LINK
[54] The Geological Survey of Estonia. LINK
[55] NEO. LINK

2. ROADMAP FOR JOINT ACTIONS

This chapter summarise suggested actions for further collaboration.

DOMAIN(S)	KEY ACTIONS	KEY STAKE-HOLDERS	TIMEFRAME
POLICY AND STRATEGY	-To set up a cooperation strategy on energy based on report and selected priorities -Work on a Memorandum of Understanding -Set both policy domains and key priority domains for energy technologies	Policy makers Ministries Key associations Major industries	Immediate, long-term
STAKEHOLDER ENGAGEMENT	-Stakeholders in energy sector, but also industries are to be included in priority domains as beneficiaries, users, and partners -Investors and financiers (banks) are to be engaged in the process -Academia and research institutions to be engaged -Use and engagement of clusters for coordination and dissemination	Associations Industry Academia Foundations Financers	Immediate, long-term
COMPETENCE DEVELOPMENT	-Knowledge and awareness raising -New technologies Technology readiness assessment knowledge	Education institutions Academia Key associations	long-term
TECHNOLOGY IMPLEMENTATION AND SCALING	-Allow new technologies to be explored	Private sector Ministries Key associations	Immediate, long-term
ECONOMIC ASPECTS AND BUSINESS MODEL	-Business model(s) development and share of best practices	Academia Education institutions Private sector Ministries Industries	Immediate, long-term
INVESTMENT GUIDANCE	-Investment coordination, information -Legislative support for investment	Policy makers Investors Financers Ministries	Long-term
RESEARCH AND INNOVATION	-Allocation of coordination to the innovation and technology component evolution/research in the energy technology domains	Education institutions Academia Key associations Finances	Long-term

SANDBOX AND PILOTS	-Support the setup of pilots and sandboxing -Use the maximum of start-up-minded	Policy makers Clusters Technology parks Education institutions Research centres	Immediate, long-term
LEGISLATION AND STANDARDS	-Addressing of standards in the energy technology domains	Ministries Key associations Industries R&D institutions	long-term
FUNDING	-Support schemes/initiatives	Financers Ministries Investors	Immediate, long-term

3. ENABLERS: RESOURCES AND LEGAL ASPECTS

The purpose of this chapter is to prepare recommendations to the research and innovation-driven business development that contributes to increased value creation and in safe, cost-effective, and sustainable utilisation of energy resources in Estonia and Norway. The approach towards the ownership and benefitting from natural resources is rather similar between Estonia and Norway. It is expected by the community/society and is backed up by the constitution and dedicated legislation.

Value chains, circular economy and energy efficiency are important and needed to be taken for further consideration in the natural resources management. It will allow the nations the reaping of benefits of digitalisation and technology transfer. The understanding, monitoring and analysis for best implementation should be backed with most recent applications and devices, and real-time information for businesses, consumers, and government.

It is also of utmost importance to align the use of natural resources with the general value chain approach and introduce the industrial symbiosis principles alongside circular economy ambitions.

3.1. MANAGEMENT OF NATURAL RESOURCES IN NORWAY

The principle that revenue from Norwegian natural energy resources belong to the Norwegian people to be used for common good, was established already with the development of hydropower alongside the industrialization late 1890 and start of 1900. Since then, there has been a resource rent tax, channelled back to the society on a state level, and to the communities where the natural resources are made available. From 2023, there will also be a base rate for onshore wind, based on the same principles.

From the 1960 and 70s Norway has managed to transform oil and gas resources into real and financial assets through resource management. Direct government participation in the oil and gas industry and an extraordinary tax rate on oil company profits. The government also has direct ownership stakes in the most profitable oil fields. The revenue is redistributed to all inhabitants in the form of investment in infrastructure and public services, such as education and health care. At the same time, revenues from oil and gas have been put aside in the Norwegian sovereign wealth fund, so that future generations will also benefit from petroleum revenues, as they are non-renewable. The idea behind the Norwegian sovereign wealth fund, known as the Government Pension Fund Global, is to view the revenue from natural resources as a transformation of wealth, from natural resources to financial assets. The fund's capital is invested abroad, mainly in equities, but also in bonds and real estate. Investments are spread across most markets, countries, and currencies to achieve broad exposure to global growth and value creation and ensure good risk diversification.

In 2001 a fiscal rule was established to prevent political pressure for higher spendings as the revenue grew. The aim is to phase petroleum revenues into the economy gradually. The fiscal limits average petroleum revenue spending over the cycle to the expected real return on the fund — currently estimated at 3 percent. The rule established a long-term petroleum revenue spending strategy. Together, the oil fund and the fiscal rule constitute a robust framework and enjoys cross-party support. When it comes to offshore wind, Norway grants licences which secures revenue from these natural resources back to the Norwegian society. However, politicians are not excluding base rate or other ways of taxation of offshore wind in the future.

3.2. MANAGEMENT OF NATURAL RESOURCES IN ESTONIA

In Estonia the management of natural resources is covered by the Earth Crust Act[56], adopted in 2016 with latest adaptations made in 2023.

Estonian earth crust policy states that management and the use of extractable land resources should be based on scientific knowledge whilst keeping in mind resource efficiency, eco-friendliness and human health. Public revenues from land resource extraction should be shared with local governments affected by environmental and social impacts. Full use of accompanying resources envisioned, e. g. rare earth metals should be extracted from argillite upon excavating the latter.

"National development plan for the use of oil shale 2016-2030". The main goals are to increase the usage of oil shale outside energy sector and to decrease negative environmental impact. To achieve the goals building cogeneration plants and decreasing the heat loss in central heating systems are important gaps to fill. Taxation for mining natural resources is higher to increase income of the state. There is also the importance of adding extra value for energetic mineral resource[57]. Main replacement for fossil fuels in Estonia is biomass (inputs from agriculture, industries, sewage sludge etc). Some industries are replacing oil shale heating systems with woodchips.[58] Locally produced biogas is mostly used in transportation.

Hydro, wind, solar, biomass and other renewable technologies are used to achieve climate goals, the-usage of most technologies is expected to grow to achieve consumption of renewable energy. Development of wind energy technologies plays the most important role. Consumption of solar energy is expected to grow four times in the years of 2020-2030. Consumption growth of hydro energy is prognosed to stay on the same level, yet two hydro energy plants are planned to be built by private sector funding (Paldiski and Estonia mining).[59] Pumped-hydro storage is one of the best-known storage possibilities at the moment, but only several can be built according to the high price. Technologies producing and storing hydrogen are yet expensive.[60]

According to The Nuclear Energy Research Group Final Report, Estonia would be ready to start using nuclear energy in 2032 at the earliest, using 3+ generation small reactor technology (2-4 reactors, firstly will be built in 2028). The report expects the oil shale industry to end by the time and to lower energy prices twice according to current prices. Total cost of the project is 2 billion euros[61].

During the years 2002-2020 in total 31 onshore wind parks have been built in Estonia with power of 319,96 MW with 145 generators[62]. During the years 2006-2021 6 offshore wind parks projects have been started with power of 9864 MW[63], but none of them have been built yet. Main issues are lack of production capacity, infrastructure, and storage possibilities.

In Estonia first generation biofuels (more than 6%) and second generation biomethane fuels (more than 1%) are used. Proportion of electric transport is less than 1%. To support green transition, few dozens of different measures have been created by Estonian Energy Development Plan and Estonian National Energy and Climate Plan Until 2030: "Increasing the use of alternative fuels in transport", "Decreasing the demand for motorised individual transport", "Purchase support for electric cars", "Development of railway infrastructure", "Electrification of ferries" etc. In the longer view the direction is towards carbon-reducing technologies and lower energy consumption. More closer is moving towards hydrogen carriers. Though, hydrogen usage needs building industrial ports while for delivery the existing natural gas network can be used[64].

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56 Earth Crust Act (Maapõueseadus), LINK
57 Estonian Ministry of Economics and Communication LINK
58 Estonian Ministry of Economics and Communication LINK
59 Estonian Ministry of Economics and Communication LINK
60 The Green Portal, LINK
61 Ministry of Environmental Affairs, LINK
62 Estonian Wind Energy Association, LINK
63 Estonian Wind Energy Association, LINK
64 Ministry of Economic Affairs and Communications, LINK

The prognosis shows that the amount of greenhouse gases is increasing in road transport, decreasing in sea transport, and staying at the same level in aviation and railway transport. To support green transition, according to the Ministry of Economic Affairs and Communication (MKM), supportive measures for start-ups and science and development should be offered. The best-known start-up on energy field from Estonia is Skeleton Technologies[65].

In the future, it is planned to create a long-term energy strategy and establish a task force growing a deeper priority action plan and formulating the structure of working groups or activity plans. For each activity line and policy domain decisions, more background work should be done, involving investors, private sector, and state as it would bring clarity for all parties. Especially with respect to novel high costs technologies, the profitability of which depends on CO_2 quota costs.[66]

[65] Ministry of Economic Affairs and Communications, LINK
[66] ETAG. LINK