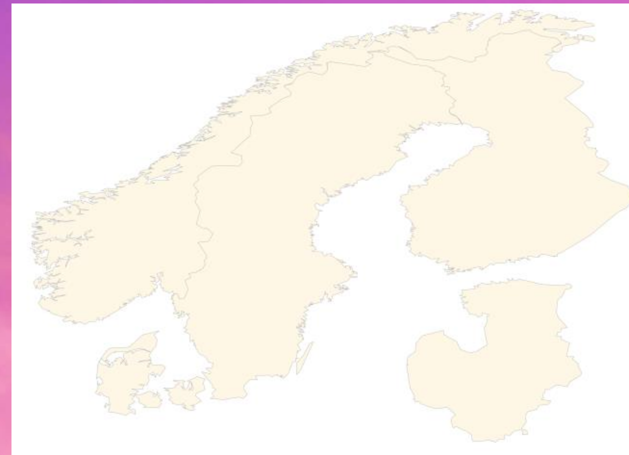

THE BALTICS – THE FIRST REGION IN THE EU TO BECOME 100% RES

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Highlights

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- A 100% renewable energy system with energy storage solutions can provide reliable, sustainable energy services before 2050
- A 100% renewable energy system is lower in cost than the current system based on nuclear and fossil fuels
- Interconnections between Baltic countries can result in further cost savings
- A well-designed 100% renewable energy system with energy storage solutions can provide power system stability in all 8760 hours of the year

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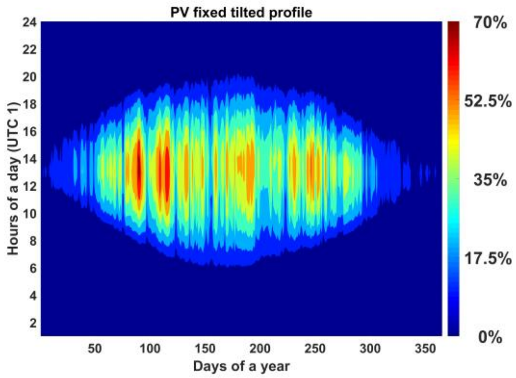
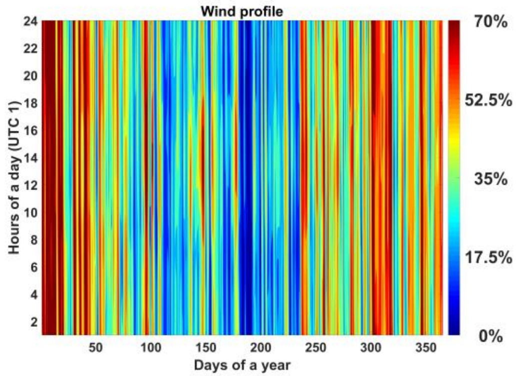
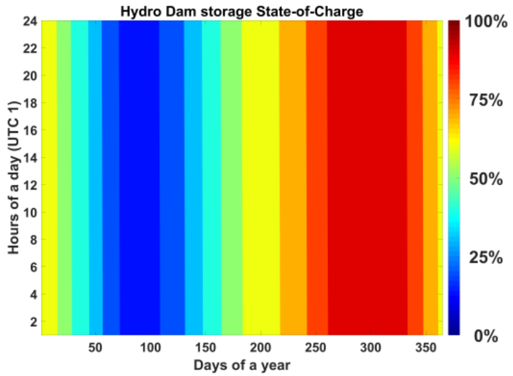
Abundant Renewable Resource Potentials







Resource	Units	Norway	Denmark	Sweden	Finland	Estonia	Latvia	Lithuania	Total	2050 Utilisation
Solar PV	GW	1457	194	2026	1522	204	290	294	5987	<1%
Onshore wind	GW	109	14	151	114	15	22	22	447	11 %
Hydro dams	GW	30	0	17	0	0	0	0	47	79 %
Hydro RoR	GW	14	0	8	5	0	1	1	29	67 %
Waste	TWh	1	2	2	3	0.5	0.7	0.8	10	100 %
Biomass waste	TWh	2	1	70	58	6	4	11	152	100 %
Biomass residues	TWh	8	15	48	37	4	8	13	133	0 %
Biogas	TWh	1	28	7	13	0.5	0.5	4	54	100 %
Biomass total	TWh	12	46	127	111	11	13	29	349	62 %

Comment on biomass potential:
in a full energy system consideration the total biomass potential is also used for heating purposes and for biofuels in the transport sector

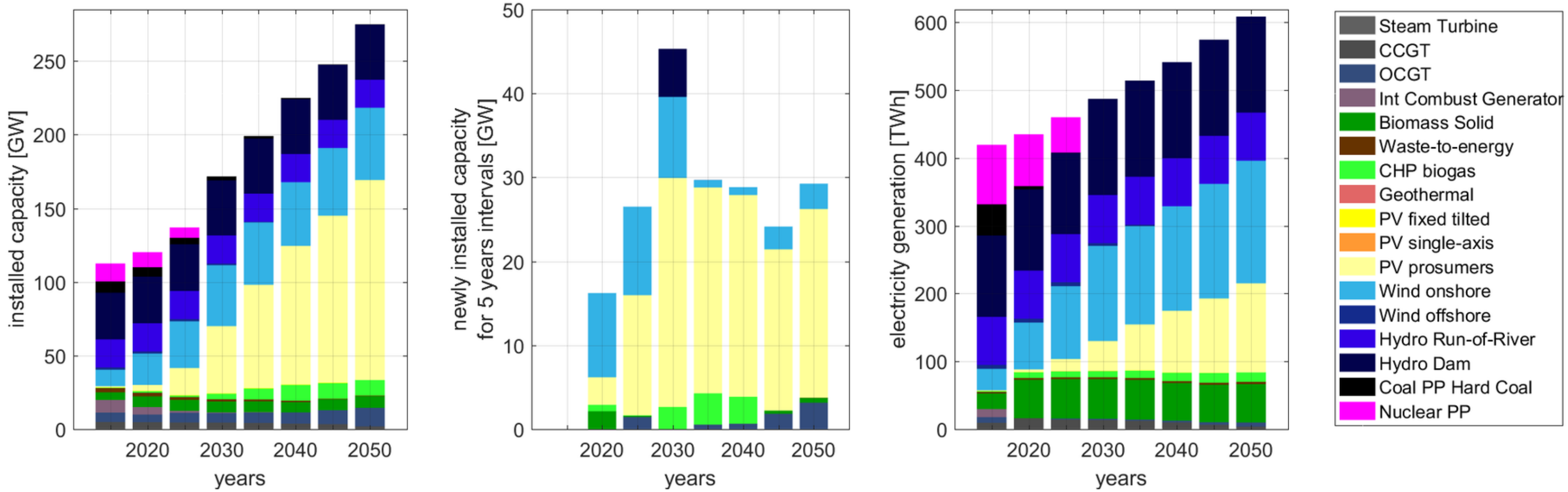
Important Steps to Reach 100% RES

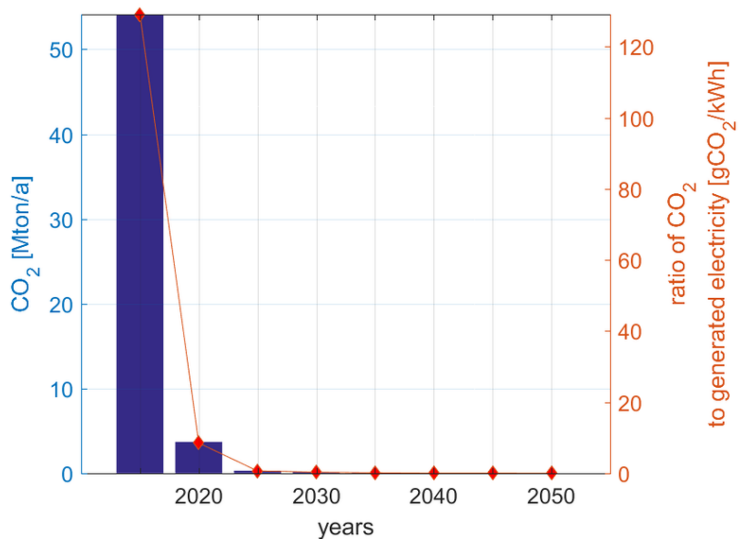
1. **Eliminate subsidies for fossil fuel and nuclear power generation**
   - Account real costs of CO_2 emissions, heavy metal emissions, and socialization of risks associated with nuclear power (e.g. limited liability insurance)
2. **No new investments in coal and nuclear power**
3. **Substitute natural gas with sustainable biogas/biomethane/Power-to-Gas over time**
   - Gas infrastructure and conversion technologies remain important
4. **Avoid extra taxation for RES (good example from Sweden)**
5. **Promote solar PV prosumerism (e.g. missing 3-phase balancing in Finland)**
6. **Electrify transportation as much as possible**
   - Biofuels for shipping, aviation and sectors where electrification is difficult
7. **Improve energy efficiency in buildings**
   - Expand use of electric heat pumps and bio-based CHP
8. **Promote regional interconnections and sharing of grid solutions**
9. **Set clear targets to achieve a fully sustainable energy system (e.g. DK, NO, SE)**

Outcomes and Impacts of 100% RES

1. **Achieving a more sustainable and resilient energy sytem**
2. **Reduction of CO_2 emissions and associated costs**
3. **Job creation associated with RES**
4. **Improved health of people and environment**
5. **Improved trade balances through no imports of fossil and nuclear fuels**
6. **Elimination of unfair sharing of risks and rewards related to nuclear power**
7. **Reduction of heavy metal emissions**
8. **Challenges associated with grid reinforcement (HV, MV and LV) are manageable**
9. **By achieving high shares of RES before other EU member states, the Baltic region can become a showcase and blueprint for the rest of Europe**
    - Possibilities to export solutions

Key Findings 100RES – Capacities, Generation, CO_2





Main insights

- RE generation already reached 61% in 2015
- Increasing relevance of electricity
- Phase out of coal by 2025 and nuclear plants by 2030
- Increasing levels of solar PV prosumers and onshore wind
- Fossil natural gas replaced over time by sustainable biogas/ biomethane and SNG
- Decarbonisation of power sector by 2035
- Bioenergy to be used in all energy sectors

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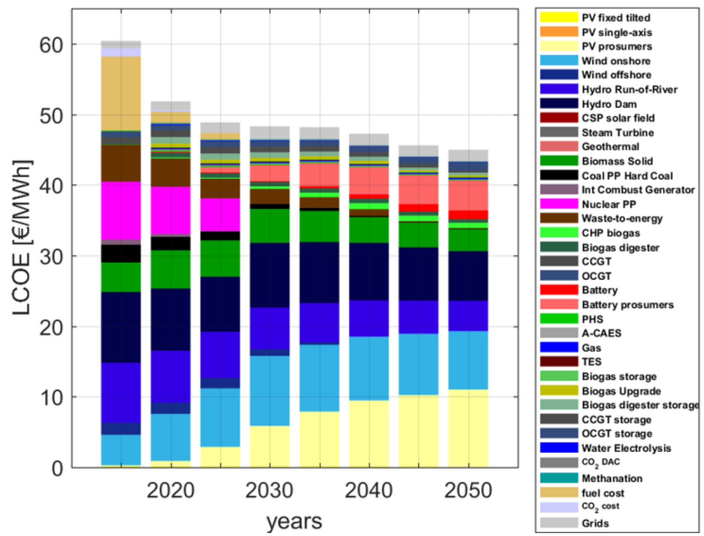
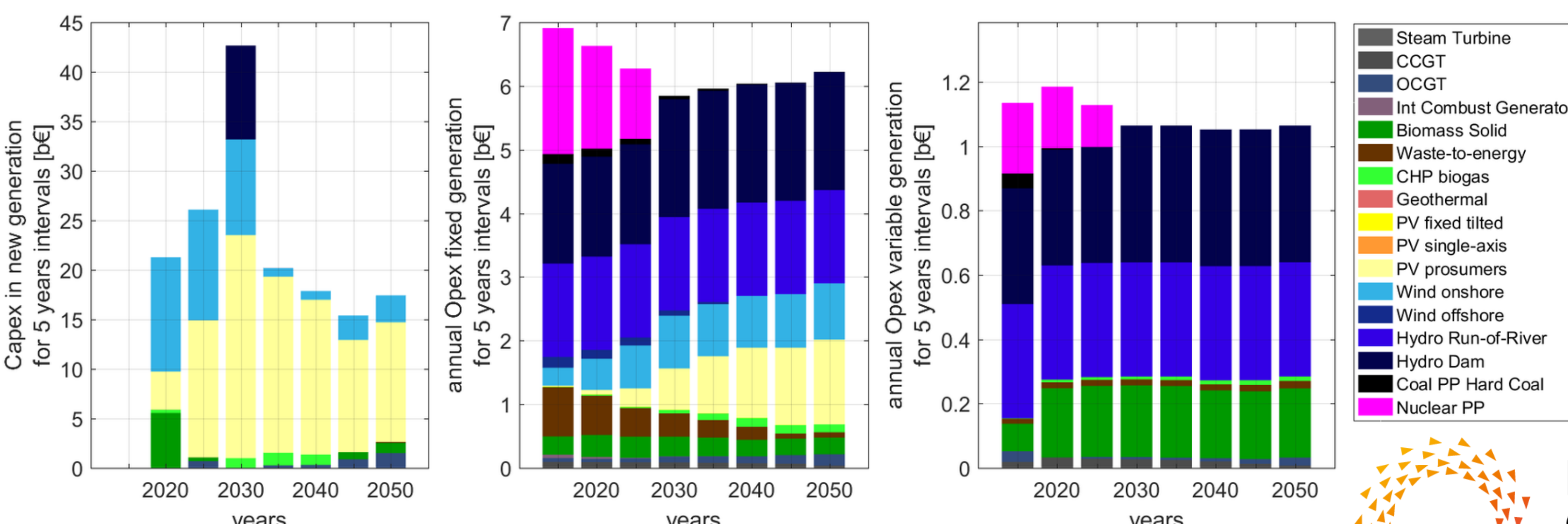
Key Findings 100RES – Investments, Cost



Main insights

- Decreasing LCOE over time (from 60 to 45 €/MWh)
- Decreasing fossil fuel and CO_2 costs
- New investments in solar PV and onshore wind
- Relevance of storage increases over time
- Curtailment of excess electricity low due to interconnections
- Other low carbon technologies (nuclear and fossil CCS) are (substantially) more expensive and risky



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Key Findings 100RES – Interconnections, Storage

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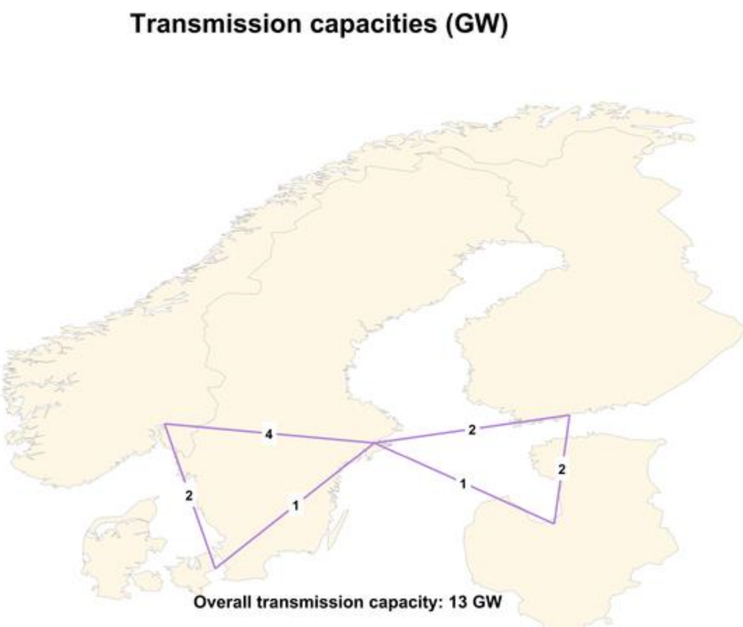
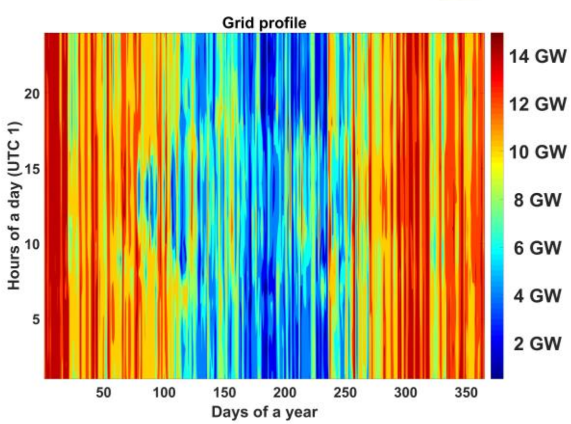
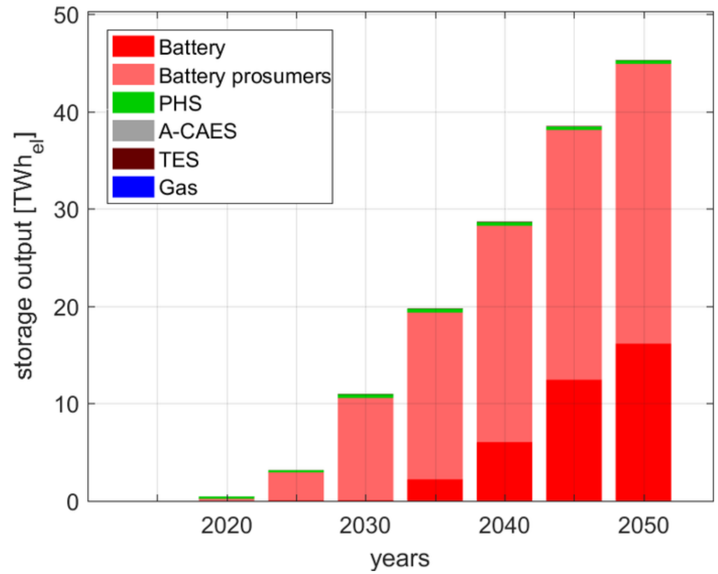
2050







Main insights

- Storage becomes increasingly relevant as source of flexibility
- Current interconnections amount to approximately 12 GW
- Simulation results do not show significant need for expansion (+1 GW between Finland and Estonia)
- 15% of total generation of 587 TWh is traded to other Baltic regions and not consumed in the region of origin
- Strengthening of interconnections between Estonia, Latvia and Lithuania may also be needed

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Key Findings – 100% RES is Possible

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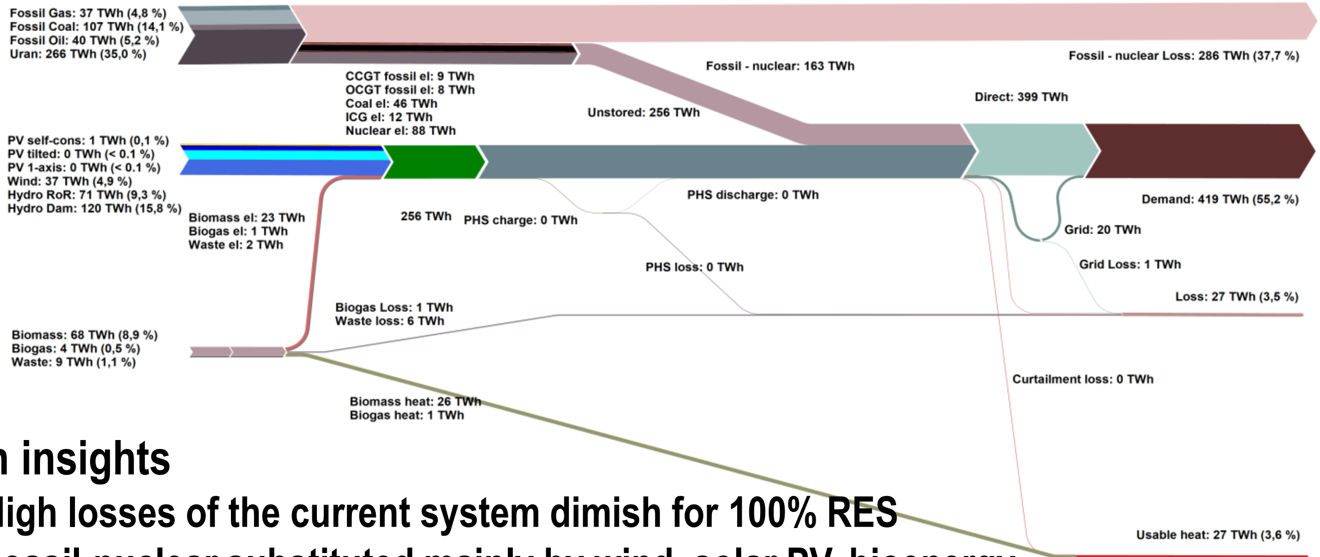
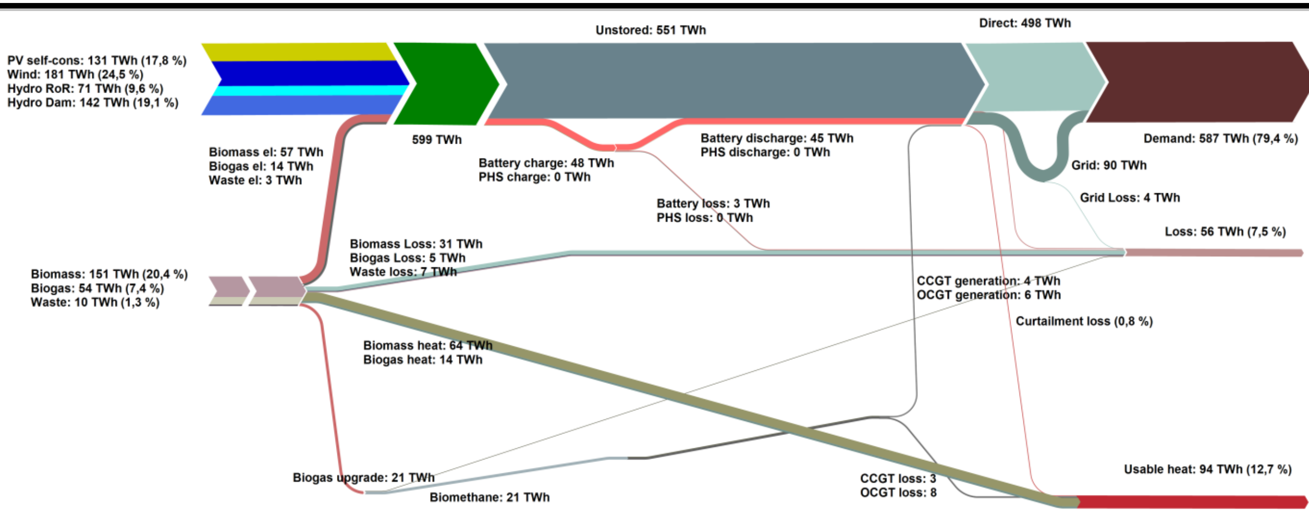
2015

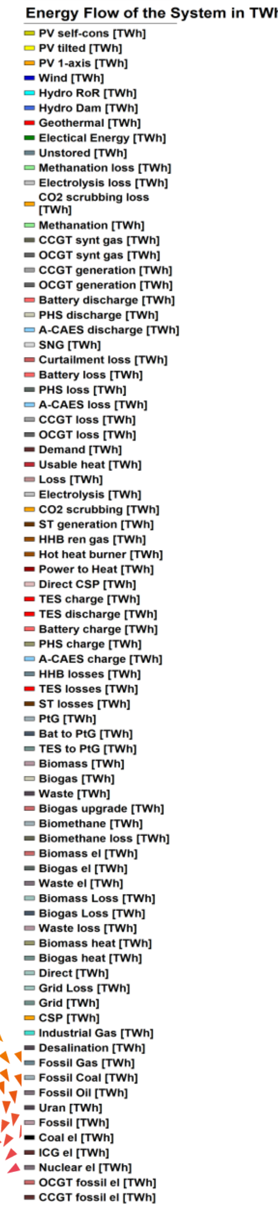


Main insights

- ➤ **High losses of the current system dimish for 100% RES**
- ➤ **Fossil-nuclear substituted mainly by wind, solar PV, bioenergy**

2050





Barriers and Solutions to 100% RES

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Barriers	Possible solutions
Technological barriers: • Lack of energy storage solutions • Inefficiency	• Lessons to be learned from solutions available in Germany, R&D allocated to storage solutions, electrification of transport and use of EV batteries may offer significant potential for storage • Reduce transmission and distribution losses, improve access for small-scale producers, reduce inefficiencies in production as RE generation replaces older nuclear and fossil plants
Economical barriers: • Competitiveness • A need for new kinds of electricity markets and rules • Inefficient markets for storage systems • Support and high subsidies for conventional energy system • Current dominance by large monopolies and oligopolies	• Solar PV has already reached grid parity in some market segments and will become more competitive on in the future • Storage solutions are available at least in Germany – a need to import solutions • Ideally there should be no support systems in the long run distorting markets • Subsidies for harmful emissions of conventional energy production need to be eliminated • Feed-in tariff, net metering and privileged grid access in the begining for renewables • Creating a fair, low risk investment landscape is essential to ensure future growth

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Barriers and Solutions to 100% RES

Barriers	Possible solutions
Institutional and political barriers: • Fossil fuels lobbying • Vested interests • Path dependency and technological lock-in • Incumbent electricity companies • Lack of support policy • Lack of powerful advocacy coalitions • Failure to overcome existing subsidies • Misleading energy scenarios (e.g. Nordic Energy Technology Perspectives 2016)	• No new investments in nuclear or fossil plants • Maintain and expand gas infrastructure • Only need to switch fuel from NG to biogas or SNG • A possibility to build a more distributed energy regime • New business models arising, but more needed • Incentives for wide range of efficiency improvements • Some support policy for renewables and storage seems to be needed in the beginning (to balance subsidies for fossil-nuclear) • Feed-in tariff law should be based on German model and non-tendering models (more players and lower cost of capital) • Promote more solar, wind and bioenergy energy advocacy • Develop more sustainable and resilient energy scenarios
Behavioral barriers: • General attitudes • Psychological resistance • Political will	• Promote greater public awareness of renewable energy and energy efficiency • Provide more information and practical examples of successful installations • Maintain strong political will for change, fairness, sustainability and energy independence • Further develop education and training programs at universities and vocational schools

Summary – 100% RES is Possible and Feasible

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- A 100% renewable energy system is a least cost option for the Baltic region (given the high cost of new nuclear and fossil-CCS alternatives)
- 100% RES can result in job creation and improved trade balances
- 100% RES also represents lower health and economic risks, and higher overall energy system resilience beyond CO_2 emission reductions
- Current barriers to high shares of RES can effectively be overcome through effective policy and planning
- The Baltics can become the first region in the EU to achieve 100% RES
  - almost complete decarbonisation of power sector by 2035
  - this can serve as a showcase for other member states

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Thank you for your attention!

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NEO-CARBON Energy project is one of the Tekes strategy research openings and the project is carried out in cooperation with Technical Research Centre of Finland VTT Ltd, Lappeenranta University of Technology (LUT) and University of Turku, Finland Futures Research Centre.