Transitioning to a climate-neutral electricity generation
Concluding presentation

DG REFORM & Estonian Ministry of Economic Affairs and Communications

11 May 2022

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Agenda

I. Introduction + objectives
II. Key findings of the project
III. Sensitivity analysis
IV. Final action plans

Project objectives

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- Propose and analyse institutional, administrative and growth-sustaining reforms in Estonia that will enable the country to achieve climate-neutral electricity production by 2050 while addressing any adverse socio-economic impacts of decarbonisation

- Support the Estonian Ministry of Economic Affairs and Communications by:
  a) Defining pathways towards climate-neutral electricity production; and
  b) Proposing regulatory Action Plans on implementing decarbonisation measures and mitigating risks for eventual adoption.

Overview of deliverables

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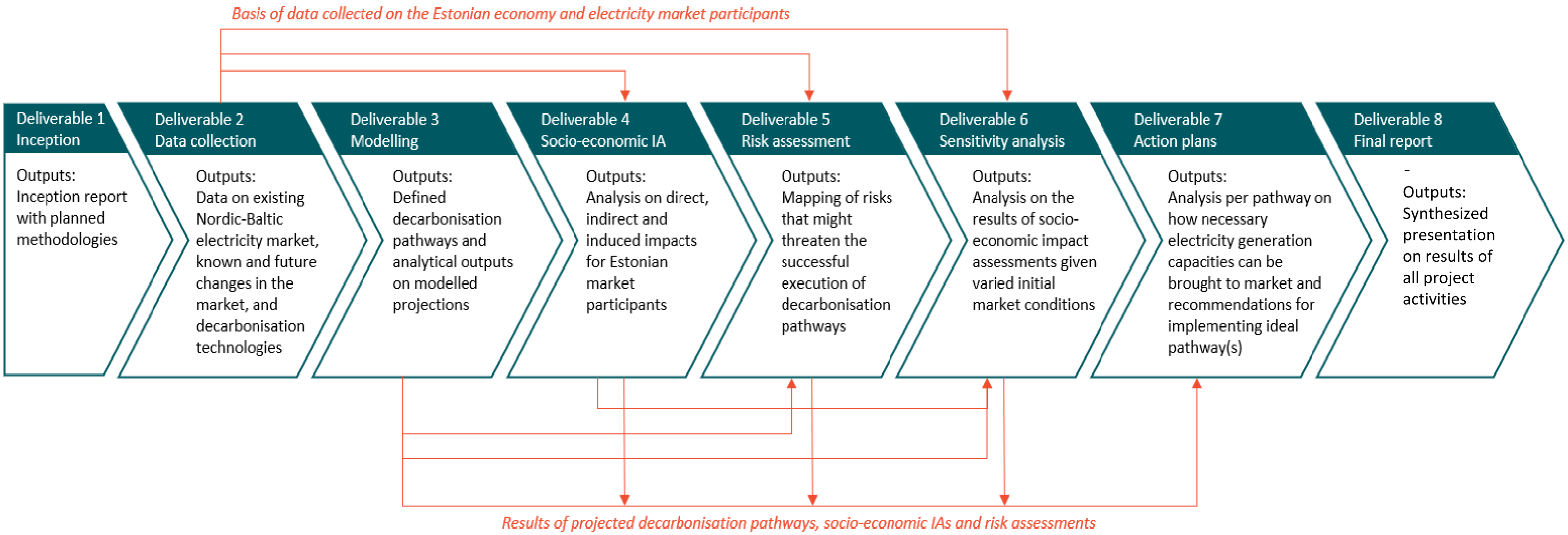

Deliverable leads:

TAL TECH

SEI Stockholm Environment Institute

SEI Stockholm Environment Institute

E3 Modelling Energy Economy Environment

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Pathways

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- BAU
- Reference
- RES+ Storage
- Nuclear
- CCUS
- All technologies
- AT+ 1000MW
- No net imports

Key findings / Conclusions

Main modelling results

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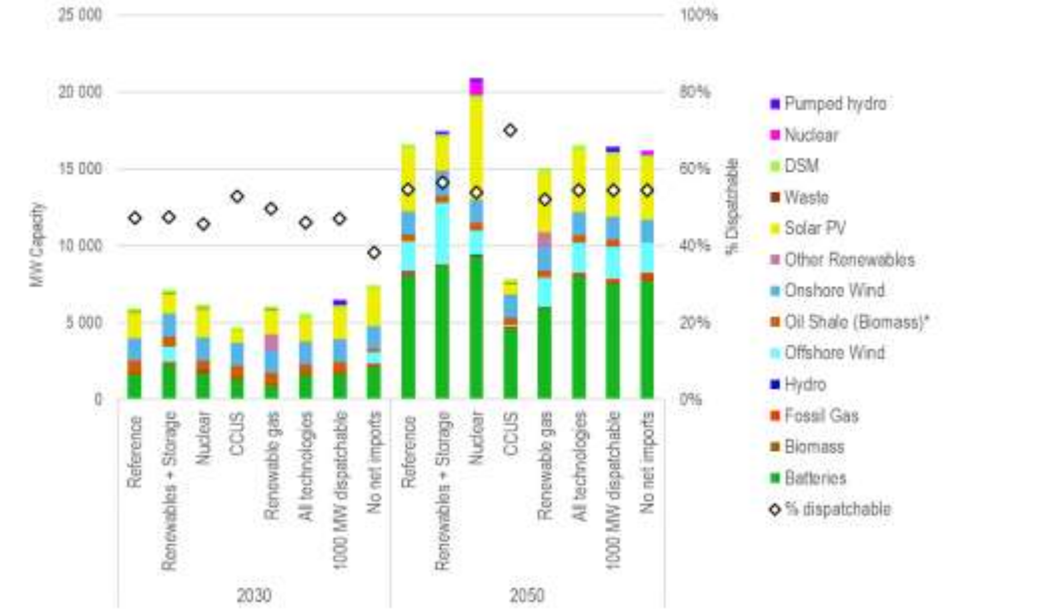
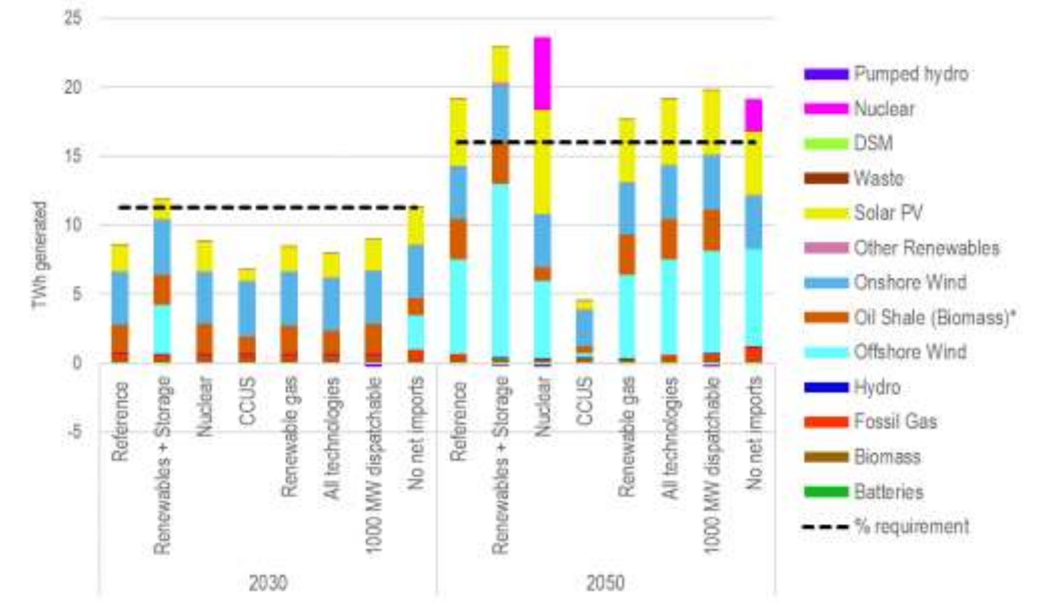
- In all climate-neutral pathways:
  - Estonian electricity production shifts from oil shale towards wind and solar (70-85% of domestic production)
  - Fluctuations balanced primarily by built-up dispatchable generation and storage, some demand-side management and electricity imports
- Batteries and DSM most cost-competitive across all pathways, and offers reliability to complement wind and solar resources
- Low technology costs drive significant build-up of batteries, solar PV and onshore wind across all pathways
- Limited / no potential to expand waste / biomass, and hydropower capacities (limited resource / not as cost-competitive)
- Net electricity imports are reduced over time in most climate-neutral pathways
  - Domestic generation ~60% of national electricity requirements by 2030; ≥85% by 2050
  - Net exporter in ‘*All technologies - No net electricity imports*’, ‘*Nuclear*’ and ‘*Renewables + storage*’ pathways; Most reliant on imports in ‘CCUS’ pathway
- Investments in generation capacity improve electricity import-export balance and reduce electricity prices
  - ‘*Renewables + storage*’ pathway see largest ↑ net electricity exports but second-highest long-run electricity prices
- Across pathways, projected prices are higher than prices today, ranging between 0.095 and 0.11 $€_{2020}$/kWh in the 2030-2050 period.

Main pathway results

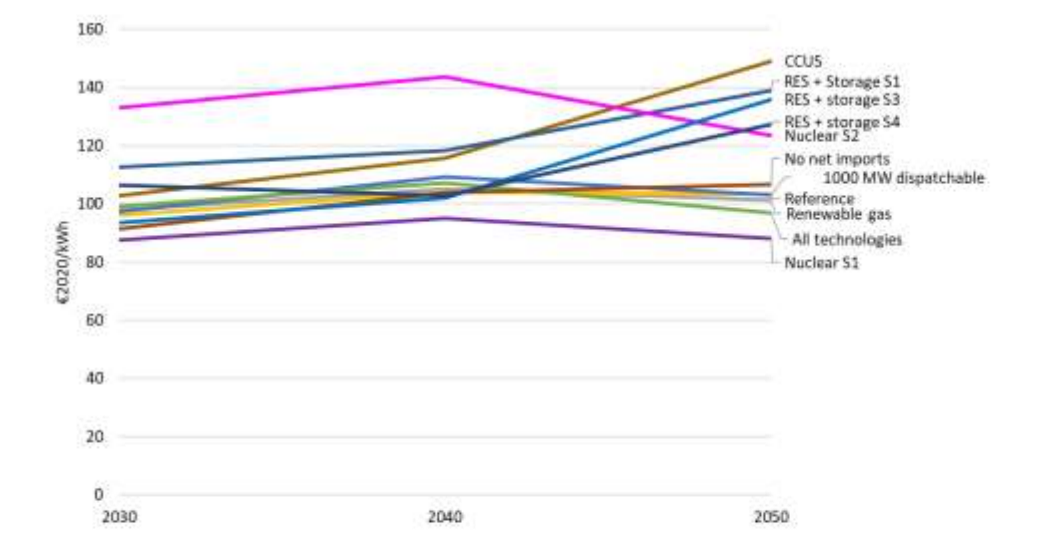
Capacity (MW)



Generation (TWh)



Prices (EUR/MWh)



Emissions (ktCO₂e)

GHG emissions	2020	2030	2040	2050	Total cumulative 2020-2050
Reference	2 667	763	98	187	24 306
RES+STORAGE	2 667	782	84	79	23 761
Nuclear	2 667	754	41	30	22 780
CCUS	2 667	493	-136	-147	17 430
RES-GAS	2 667	728	77	68	23 092
AT	2 667	722	77	167	23 572
AT+1000	2 667	787	213	199	25 764
AT-NIMP	2 667	766	784	324	31 950

Main results from socio-economic analysis

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- Modelling focused on quantifying the impacts on energy sector investment, on GDP, on employment, and on disposable income associated with each pathway
- To assess the importance of the cost of financing, two options were considered corresponding to tight and favourable conditions in financial markets.
  - self-financing – assumes that investments are fully financed by domestic/Estonian savings
  - loan-based financing – assumes investments are financed through loans that have a 10-year repayment period and an interest rate equal to 5%

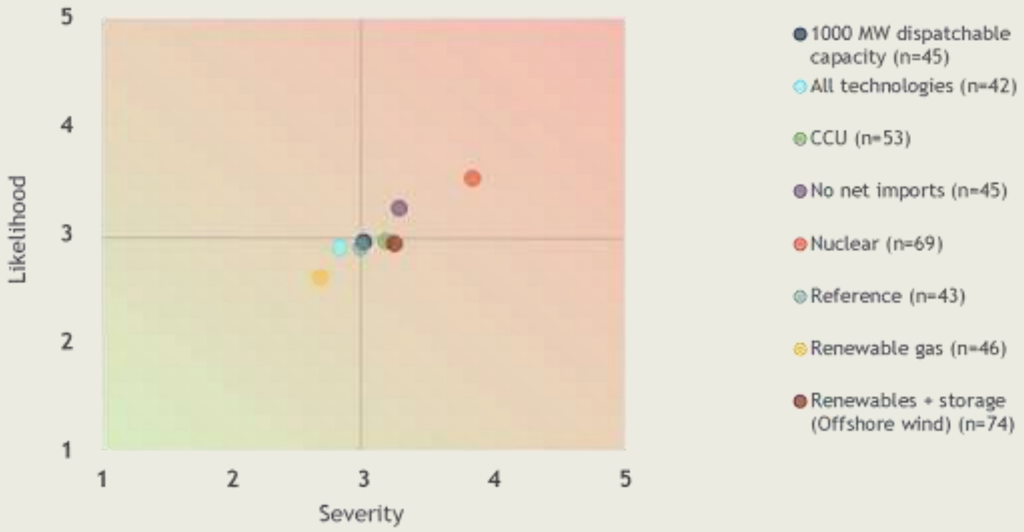
  → pathways result in **higher net benefits assuming loan-based rather than self-financing**, highlighting the importance of financial constraints in determining the macroeconomic performance of the alternative pathways.

		Loan-based financing	Self-financing
Compared to the reference pathway	Highest GDP gains (compared to ref. pathway)	‘*Renewables + storage*’ pathway	‘*All technologies - no net electricity imports*’ pathway
	Lowest GDP gains (GDP losses) (compared to ref. pathway)	‘*CCUS*’ pathway	‘*CCUS*’ pathway
Looking at the regional level	Highest socio-economic gains	Lääne-Eesti; ‘*Renewables + storage*’ pathway	Lõuna-Eesti; ‘*All technologies - no net electricity imports*’ pathway
	Lowest socio-economic gains	Lõuna-Eesti; ‘*CCUS*’ pathway	Lõuna-Eesti; ‘*CCUS*’ pathway

Main results from risk analysis

- The analysis focussed on 5 risk areas:
    - Regulatory risk
    - Technological Risk
    - Socio-environmental Risks
    - Energy Market risks
    - Economic risks
- Stakeholders were consulted through survey, and targeted interviews
- ‘Nuclear’ pathway as the riskiest (a medium-high level of risk)
- ‘Renewable gas’ pathway is the less risky one – although marginally less than all other pathways.

Figure 1 Average risk score by pathway (all risks)



Main results from sensitivity analysis

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Scenario	Assumptions used	Results
S1: Alternate wind availability curves in all pathways	Uses a more granular version of the wind variability profile that better represents variances in availability over a year	• ↑ capacity in most pathways, mainly via battery and solar PV capacities in 2030, and via offshore wind capacity in 2050 • Requires higher investments – delivering higher economic output and employment, but also prices
S2: Higher nuclear dispatch in the '*Nuclear*' pathway	Enforcing a dispatch rate of 90% on nuclear generation	• Reduced capacity, as higher nuclear generation reduces need and attractiveness of batteries and solar • Significantly higher avg. electricity prices
S3: Higher biomass prices in the '*Renewables + storage*' pathway	Assume a ↑ biomass price by 2050	• Reduces battery and Solar PV capacities, generation and prices • Higher biomass prices have little impact on biomass fuelled generation
S4: Higher battery costs and pumped hydro in the '*Renewables + storage*' pathway	Includes Higher battery costs, construction of Paldiski pumped hydro facility and all of the above	• Reduces battery and Solar PV capacities, generation and prices • Pumped hydro displaces some battery additions

Key results

- The *'Nuclear'* pathway provides the highest electricity generation potential by 2050, compared to all pathways (+23.4 TWh), and requires much less use of biomass and no fossil-related electricity (nearly carbon neutral).
- Only the *'Renewable + storage'* and the *'All technologies - No net electricity imports'* pathways exceed the electricity requirements for 2030, 2040 and 2050. This would mean that Estonia could export more, which could bring in extra revenues and increase energy independence.
- The investment costs are greatest for the *'Renewable + storage'*, 'Nuclear' and *'Renewable gas'* pathways; the least for the *'CCUS'* pathway.
- The *'Nuclear'* pathway has the lowest average electricity prices throughout the modelling timeline, whereas the *'CCUS'* pathway has the highest average prices.
- All of the pathways have GHG emissions below the Fit-for-55 trajectory.
- According to stakeholders, the riskiest pathway is the 'Nuclear' pathway and whereas the *'Renewable gas'*, *'All technology'*, *'1000 MW dispatchable capacity'*, *'CCUS'* and *'Renewable + storage'* pathways are considered less risky.
- The 'RES+storage' and 'All technologies' pathways offer the best overall outcomes based on socio-economic and sensitivity results. 'RES+gas' can also deliver good outcomes, however it would be recommended to significantly reduce the installed biogas capacity as it is not economical to use it.

Conclusions – Scenario selection

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Recommended

- **RES+storage:** scores positively on contributing to security of supply, limiting fossil fuel usage, socio-economic impacts and reducing CO2 emissions; aligns well with deployment in neighbouring countries; is based on proven technologies; the actions required are relatively straightforward
- **All Technologies:** achieves a positive or moderate score across most indicators;
- **Renewable gas (modified):** the pathways scores well across several indicators, but with some changes to total biogas deployment

Also viable

- **All Technologies – No Net Imports:** scores well across several criteria, but foresees extended use of fossil gas throughout the period considered (to 2050) and is likely to require high support to renewable generation installations
- **All technologies + 1000 MW:** overall this scenario achieves similar results to the base case AT – but the requirement to keep high reserve capacity (rather than relying on the market) is likely to result in unnecessary costs
- **Biogas (as modelled):** while the use of the 1 GW of biomass capacity is very limited, and investment costs in biogas quite high, building up high dispatchable capacity may reduce the risk on relying so extensively on batteries as in other scenarios

Not recommended

- **Nuclear:** this pathway is expected to have good outcomes (reducing the use of fossil fuel and keeping prices low in the long term). However, is too risky to rely on this technology to achieve the decarbonisation objectives *quickly*. Nuclear may be part of a balanced mix *in the long term* but cannot be the “core” of a decarbonisation strategy in the *near future, where the focus should be on mature and scalable solutions*.
- **CCUS:** opting for a technology for which only very limited investments are possible does not make sense. However, CCUS should be revaluated if new outlet channels are found

Summary assessment

	RES+Storage	Nuclear	CCUS	Renewable Gas	All technologies (AT)	No net imports	1000 MW dispatchable capacity
Security of supply (year power req. are met)	++	+	--	0	0	0	++
Limit of fossil use (fossil gas gen. in 2050)	++	++	--	++	-	--	-
Electricity from Biomass in 2050	--	0	++	--	--	++	--
CO2 emissions by 2050 (ktCO2)	0	0	++	0	0	-	0
Avg. electricity prices in 2050 (EUR/kWh)	-	++	--	+	+	+	+
Total cumulative investment costs (2022-2050)	--	--	++	--	0	0	0
Total network reinforcement costs	--	-	+	+	+	+	+
Renewable subsidies costs in 2030 (low-high est.)	--	0	++	0	0	--	0
Socioeconomic impacts	++	-	--	++	0	++	0
Risk analysis	0	--	--	++	++	--	++
Sensitivity analysis	++	++	--	++	0	++	0
Main implementation challenges	0	--	-	0	++	0	0

Conclusions – No regret actions (short term)

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Actions to **streamline the planning process**

- Tailored to preferred strategy e.g. small vs large projects; local vs national administrations, local vs national campaigns; skills quantity vs quality etc.

Actions to **reduce risks on renewable and low carbon investments**

- Feed-in premium/CfDs are recommended, with different budgets for the targeted deployment capacities and technology mix.
- For renewable gases, nuclear, and CCUS technologies, a more tailored, tech-specific risk reduction instrument is required

Setup a **market for reserve capacity, flexibility and ancillary services** that is open to different technologies, to nearby countries and to prosumers

- main instrument to drive deployment of battery / other storage solutions

Actions to **support the uptake of Demand Side Management** (DSM)

- In all scenarios, all available DSM capacity (261 MW) is available, with broadly similar utilisation levels in 2030 (between 25-29 GWh) and 2050 (between 21-27 GWH), excluding CCU in 2050.

Actions to facilitate the diffusion of **PPAs**

Increased funding and limits for Kredex **guarantees**

Actions to **support vulnerable households**, including economic, technical and informational support

Additional conclusions

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Need for clarity & commitment

- The Estonian government should publish a clear and unambiguous strategy for the decarbonization of the power sector.
- The strategy does not need to mirror any one of the pathways presented, but it must include a coherent set of objectives, actions and financial commitments
- Commitment from Ministry of Finance, Prime Minister, and as far as possible, the support of all major political parties
- Communicated to citizens and public administrators at all levels.

Need for further analysis

- To achieve decarbonisation targets at country level, the analysis here presented should be complemented with further analysis under **a system integration perspective**. This analysis should examine implications for other sectors of the trajectories and actions associated with the preferred pathway. Key sectors to consider are heating and cooling, buildings (energy efficiency) and transport
- The present analysis should also be **repeated regularly to ensure that the preferred technology mix is still the best way** to achieve the decarbonisation targets.

Sensitivity analysis

Introduction

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- In the modelling of the various decarbonization pathways that will help Estonia achieve a climate-neutral electricity generation, some underlying critical assumptions were used
- To explore the robustness of the pathways, a sensitive check on these critical assumptions is carried out
- This complements the socio-economic analysis carried out in Deliverable 4 which assesses the implications for the economy, employment and income in Estonia

Sensitivities investigated

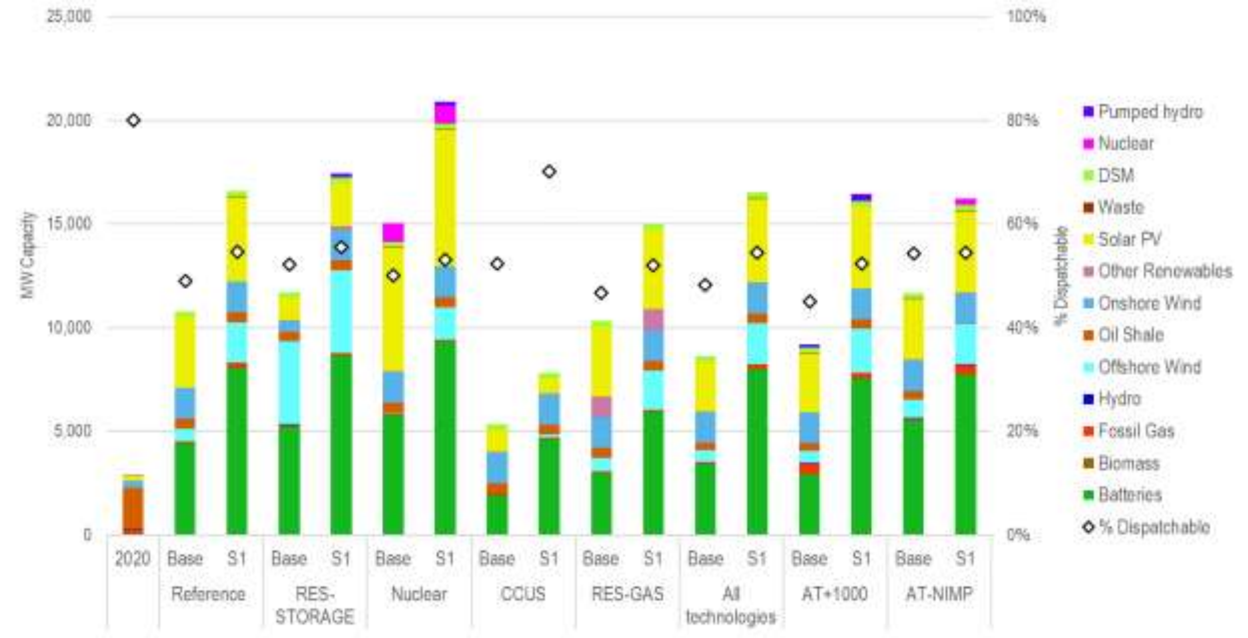
- Alternate wind availability curves in all pathways (S1)
  - Uses a more granular version of the wind variability profile for Estonia that better represents the variances in availability over a year
  - The pathways produced using this sensitivity **supersede the pathways produced in D3**
  - S1 is also used as the **basis for the following sensitivity analyses and as the new 'base case'**
- Higher nuclear dispatch in the '*Nuclear*' pathway (S2)
  - Enforces a dispatch rate of 90% on nuclear generation and comparing resulting outcomes to the '*Nuclear*' pathway
- Higher biomass prices in the '*Renewables + Storage*' pathway (S3)
  - Assume a rising price for biomass (that could reflect potential restrictions on harvesting, or a new definition of biomass's sustainability) by 2050
  - Compare resulting model outcomes to the '*Renewables + storage*' pathway
- Higher battery costs, pumped hydro facility in the '*RES + Storage*' pathway (S4)
  - '*Renewables + storage*' pathway has emerged as one of the most attractive options, however, storage plays a crucial role
  - S4 tests the impact of a 2.5 times higher battery capital costs and the impact if the Paldiski pumped hydro plant is constructed

S1: Alternate wind availability curves in all pathways

Main results:

- Significant impact on pathway outcomes, leads to additional battery and solar PV capacity up to 2040 and offshore wind after 2040
- ‘*RES GAS*’ pathway adds 1000 MW biogas capacity, but it is not used for power generation as it is too expensive

Comparison of MW capacity in 2050 for Base and S1 pathways



S1: Alternate wind availability curves in all pathways

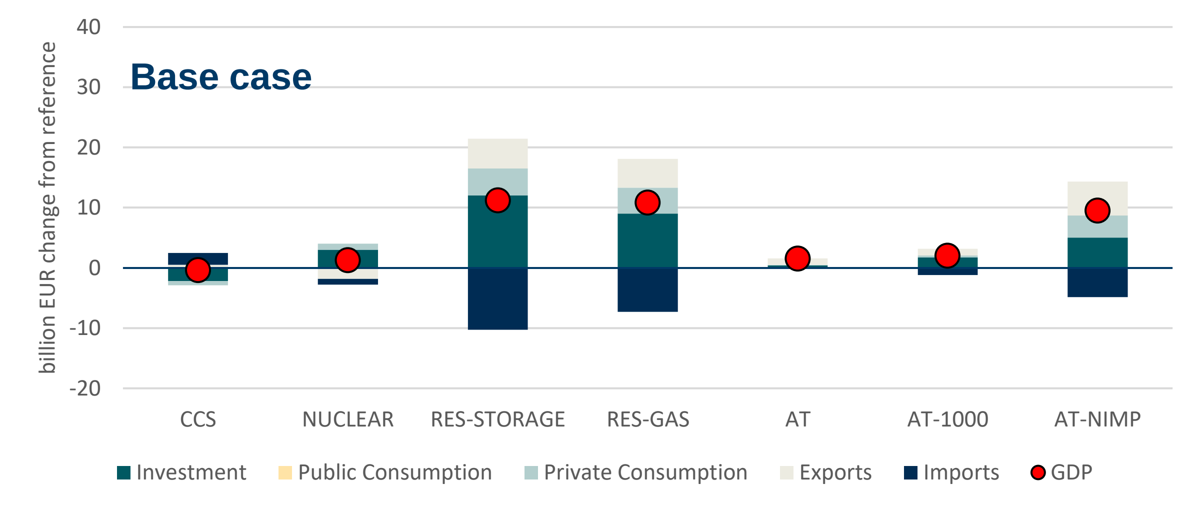
Main socio-economic impact results:

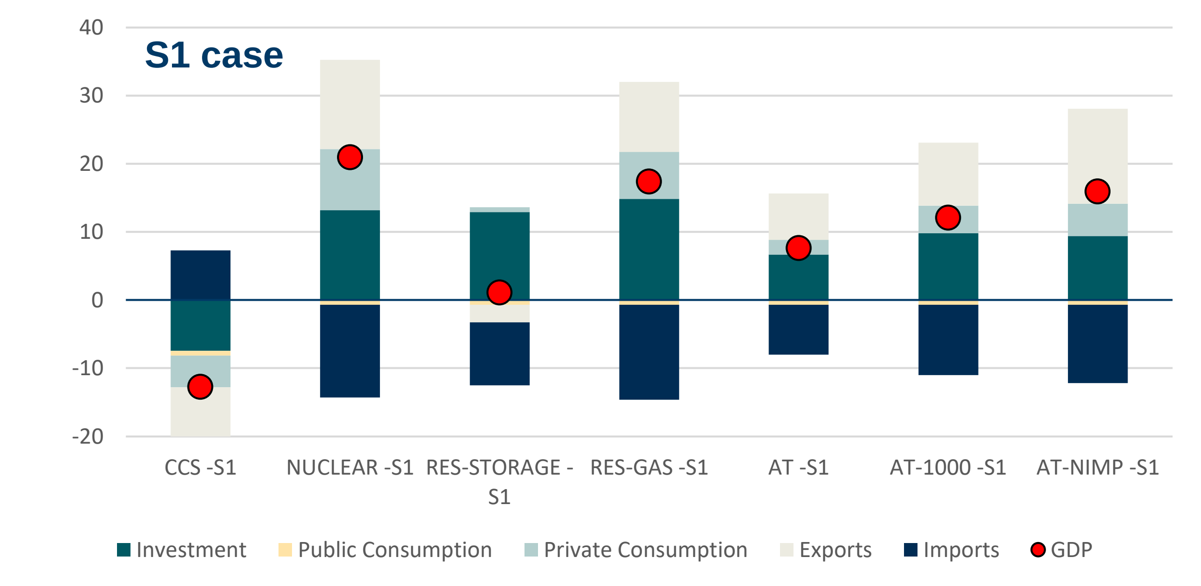
- S1 sees improved economic impacts in Nuclear, RES-Gas and all AT pathways
- S1 sees reduced economic impacts in RES-Storage and CCUS pathways
- Higher investment costs (0.1%-1% of GDP), higher economic output, higher employment and higher prices across all pathways

Conclusions

- Increased wind volatility especially impacts on RES-Storage pathway, with negative competitiveness impacts

Macroeconomic adjustment of the different scenarios (demand & price effects) – GDP – cumulative (2025-2050)



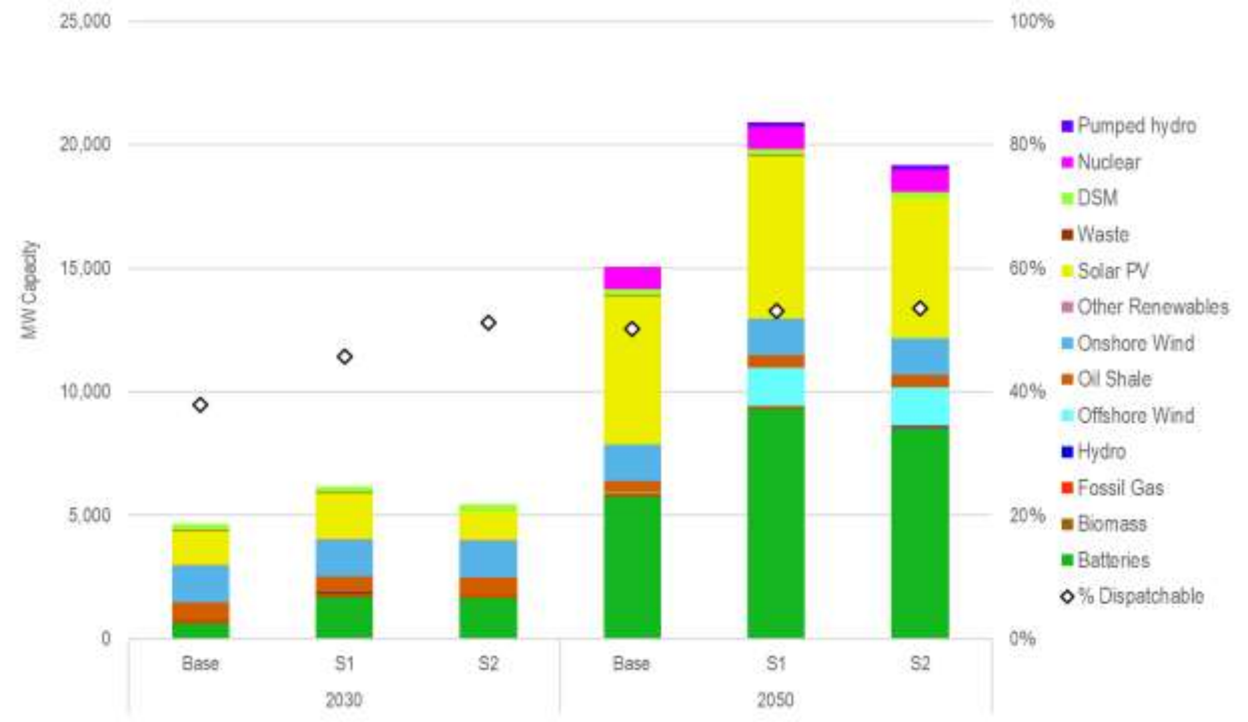


S2: Higher nuclear dispatch (90%) in the ‘*Nuclear*’ pathway

Main results:

- Higher generation from nuclear by 2050 but results in prices 40-50% higher than S1
- Reduces volume of solar and battery capacity compared to S1

Comparison of MW capacity in 2030 and 2050 for Base, S1 ‘*Nuclear*’ and S2 ‘*Nuclear*’ pathways



S2: Higher nuclear dispatch (90%) in the '*Nuclear*' pathway

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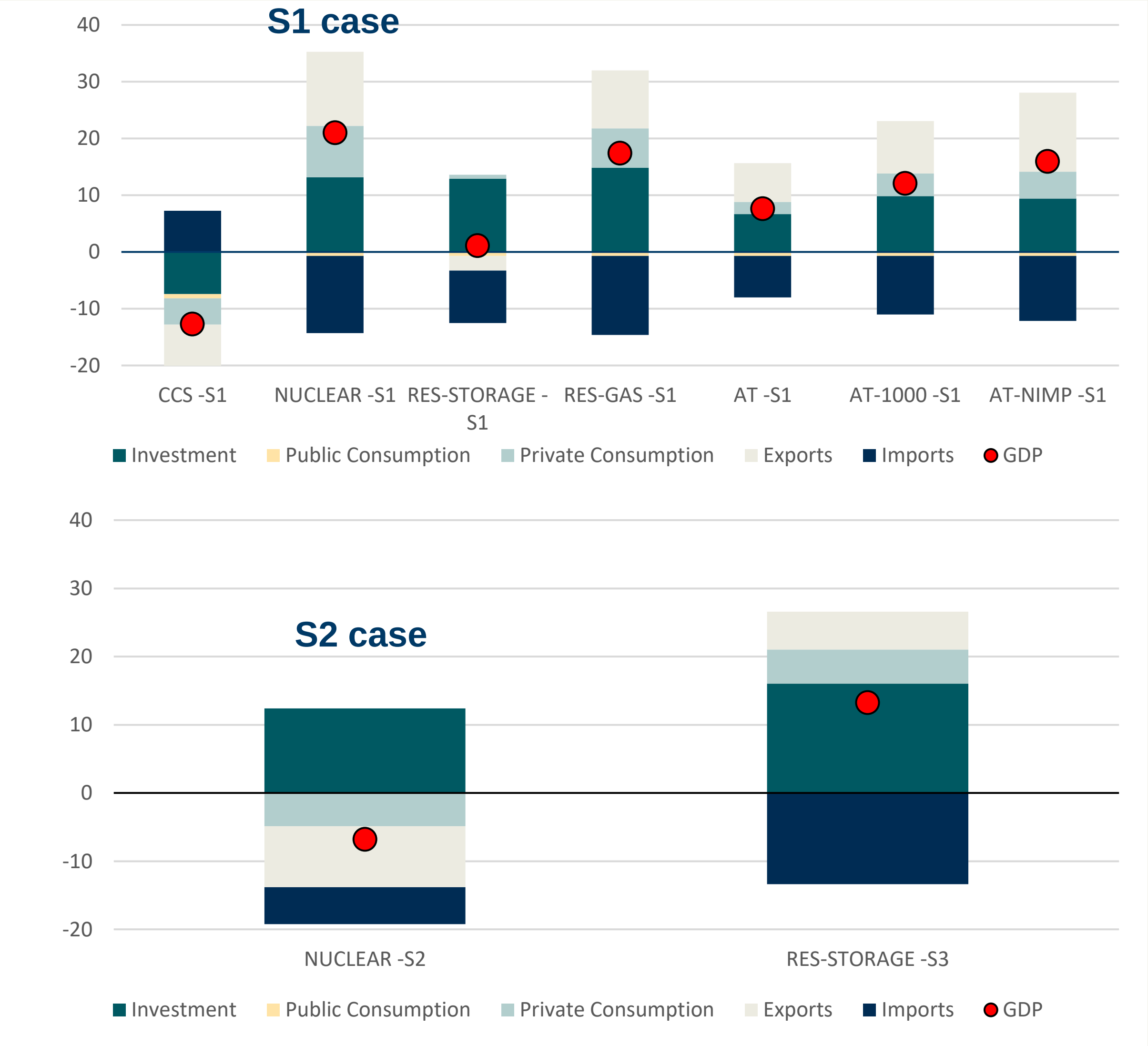
Main socio-economic impact results:

- S2 sees negative economic impact, reversing the previous positive outcome, as dispatchability requirement significantly increases prices compared to S1

Conclusions

- Do not recommend 90% dispatchability requirement for nuclear energy, as it would reverse the socio-economic benefits of the '*Nuclear*' pathway

Macroeconomic adjustment of the different scenarios (demand & price effects) – GDP – cumulative (2025-2050)

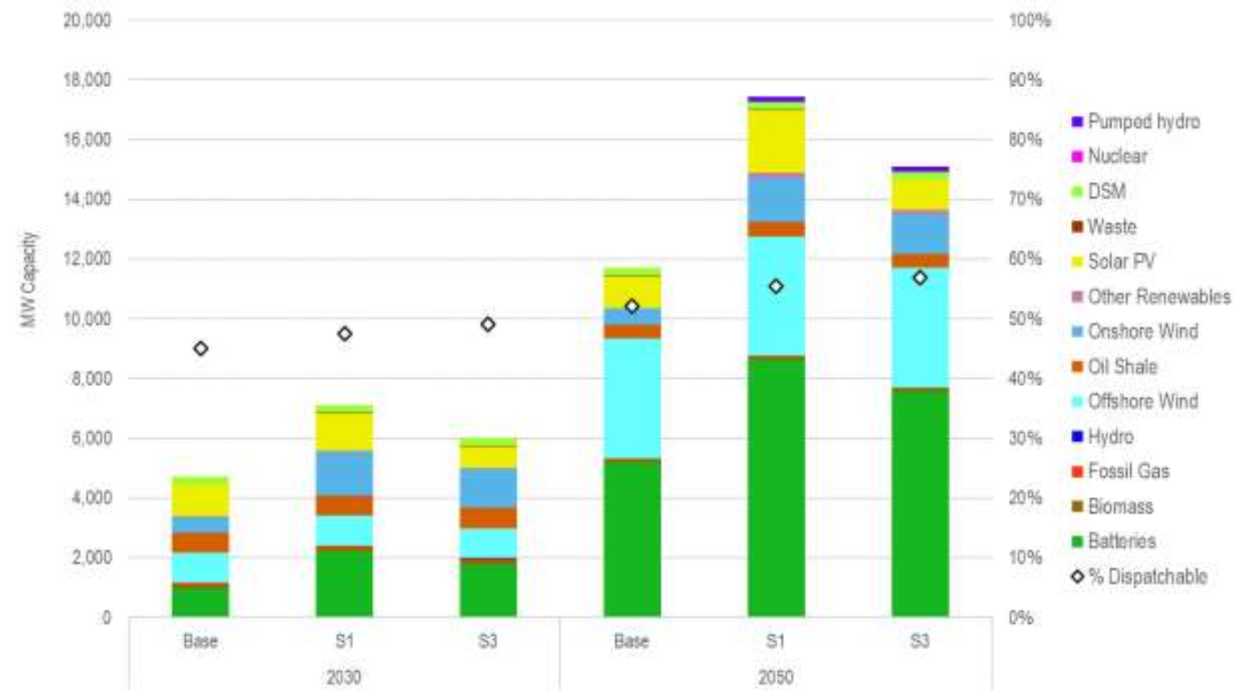


S3: Higher biomass prices in the '*Renewables + Storage*' pathway

Main results:

- Reduction in battery capacity additions, total generation and prices, compared to S1
- Response to prices leads to a small decline in (biomass-fueled) oil shale generation

<u>Comparison of MW capacity in 2030 and 2050 for Base and S1 & S3 '*RES +Storage*' pathways</u>



S3: Higher biomass prices in the '*Renewables + Storage*' pathway

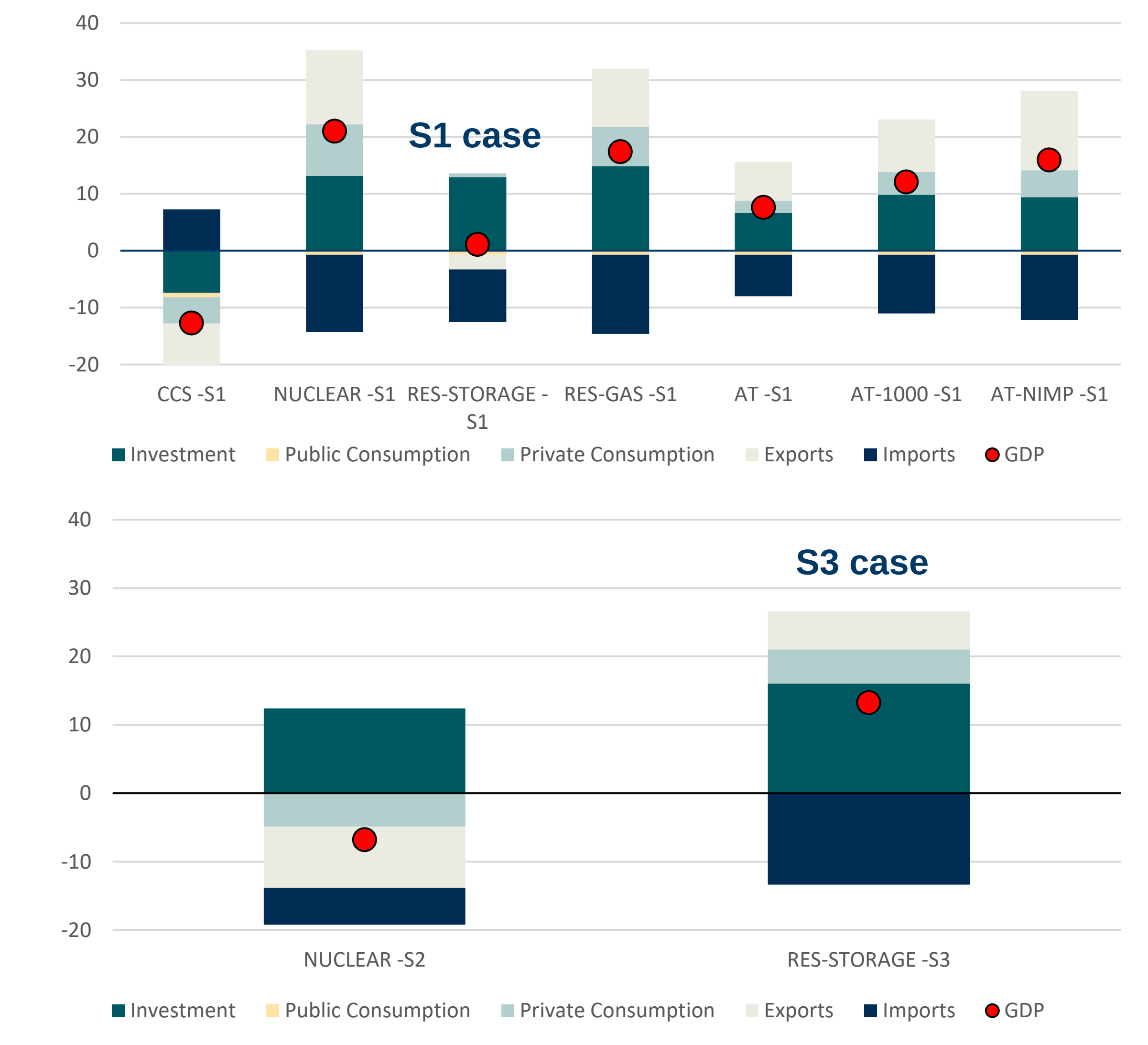
Main socio-economic impact results:

- RES-Storage see significant boost in positive economic impact due to changes

Conclusions

- '*RES + Storage*' pathway is robust to high biomass prices

Macroeconomic adjustment of the different scenarios (demand & price effects) – GDP – cumulative (2025-2050)



S4: Higher battery costs and pumped hydro in the '*Renewables + Storage*' pathway

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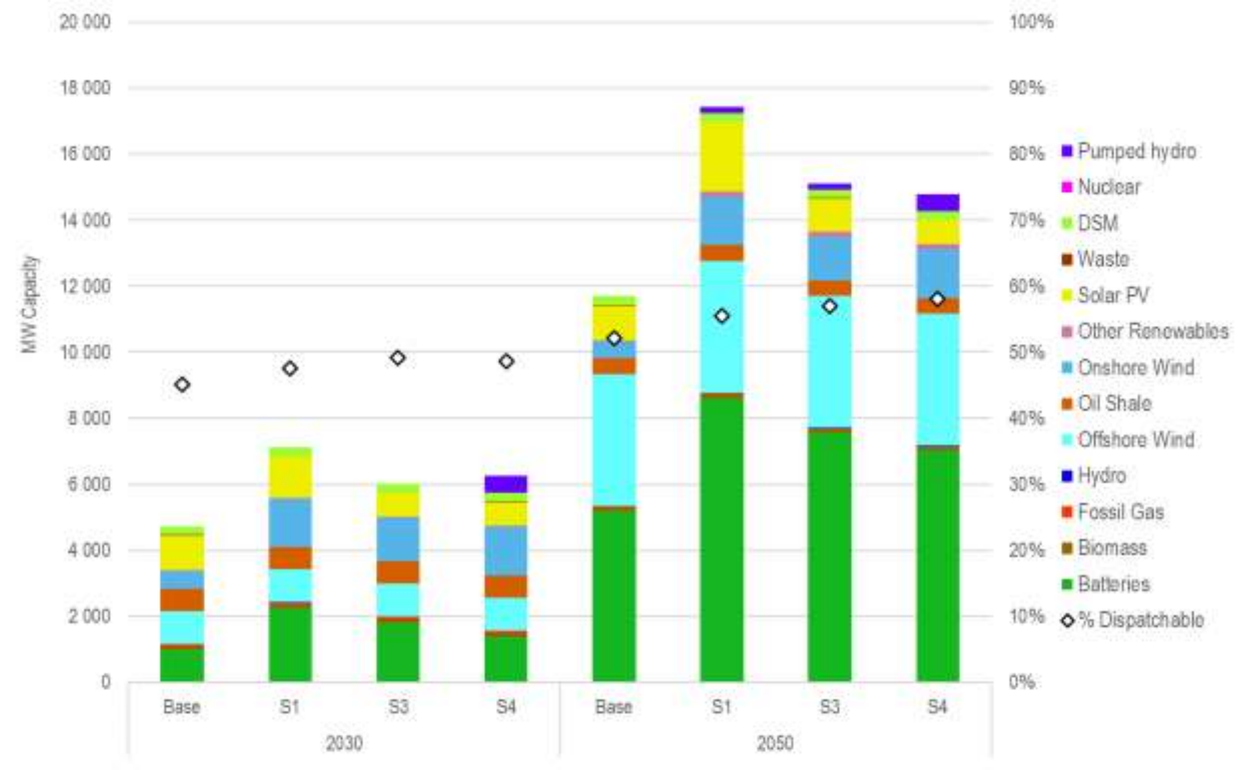
Main results:

- Reduction in battery and solar PV capacity additions, total generation and prices compared to S1
- Pumped hydro naturally displaces some battery storage, but higher battery costs also reduce business case for battery + solar PV combination
- Response to prices leads to a small decline in (biomass-fueled) oil shale generation

Comparison of MW capacity in 2030 and 2050 for Base, S1, S3 & S4 '*RES +Storage*' pathways



S4: Higher battery costs and pumped hydro in the '*Renewables + Storage*' pathway

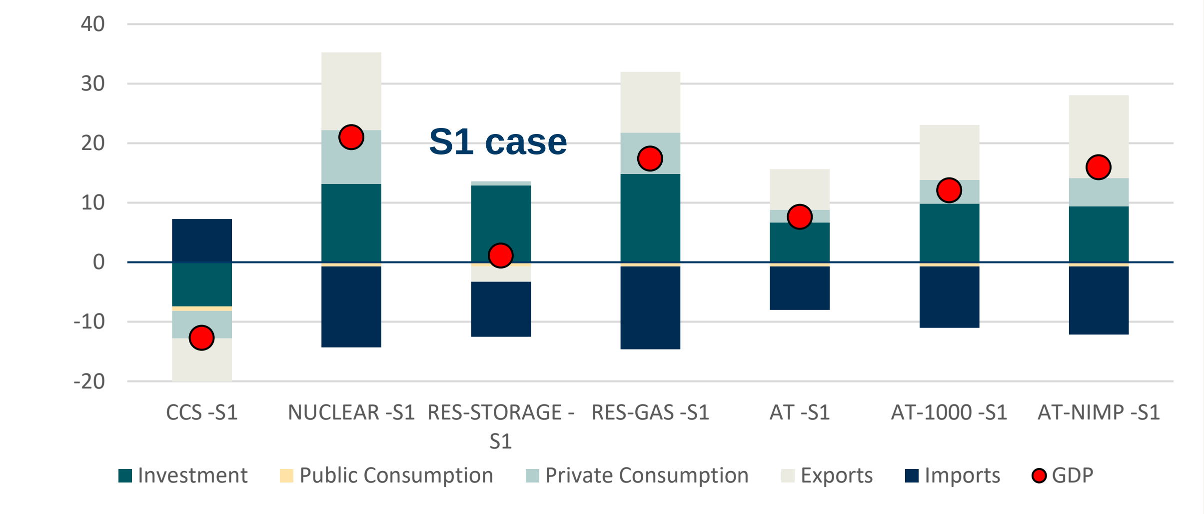
Main socio-economic impact results:

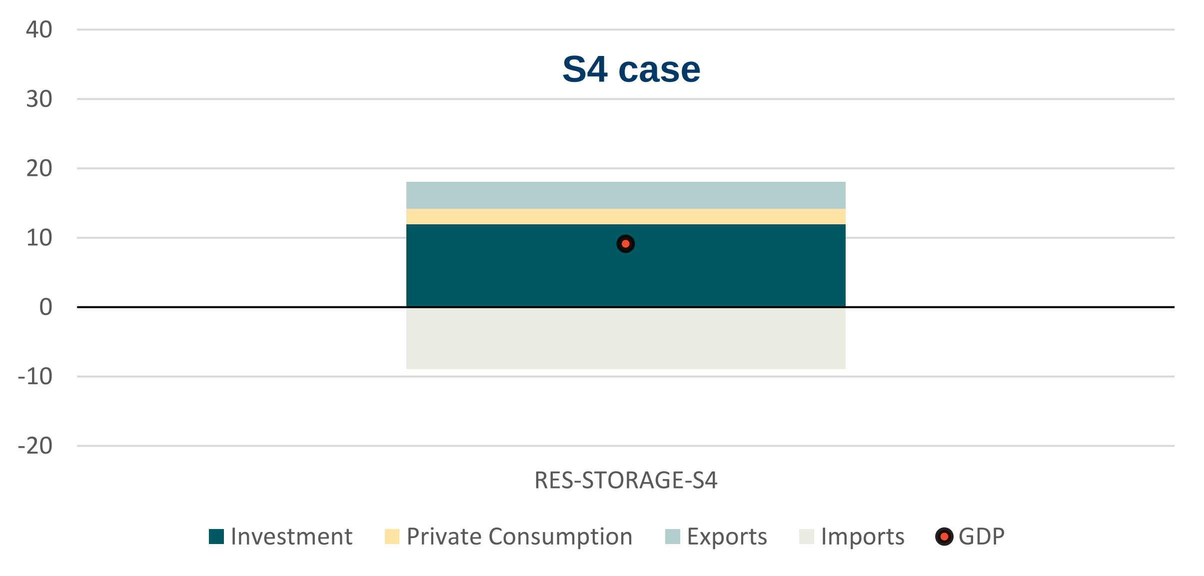
- RES-Storage see significant boost in positive economic impact due to changes

Conclusions

- '*RES + Storage*' pathway is robust to higher battery costs and full installation of the Paldiski pumped hydro plant;

Macroeconomic adjustment of the different scenarios (demand & price effects) – GDP – cumulative (2025-2050)





Key conclusions on the sensitivity analysis

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- Increased wind volatility requires more system flexibility and increases investments and costs
  - This is especially important for pathways with high renewable energy shares
- Some pathways are not recommended
  - CCUS is not recommended, performs poorly by almost every metric
  - Nuclear with an enforced 90% dispatchability is not recommended
  - Renewable gas is not recommended with 1000MW capacity additions, as these are not used. Lower capacities e.g. 200 MW may still be beneficial
- Paldiski pumped hydro facility offers mitigation against battery cost and volume related uncertainty
  - System uncertainties and higher costs in for e.g. batteries and biomass prices may reduce battery and solar PV capacity
- Most advantageous pathways based on socio-economic outputs from sensitivity analysis would be:
  - *‘Renewables + Storage’*
  - *‘Nuclear’* – without a dispatchability requirement
  - *‘All Technologies - No net electricity imports’*

Final action plans

Introduction

- The D7 Action plan report identifies a series of actions that would allow Estonia to potentially follow the modelled pathways, considering results from previous deliverables. It provides further pathway-specific considerations about the proposed actions, such as their costs, environmental impacts and legal aspects.
- The actions recommended have been identified by:
  - ✓ Reviewing current strategies and government initiatives that already align with the deployment objectives of the different pathways
  - ✓ Understanding main barriers stakeholders face in deploying decarbonisation technologies according to the trajectories set in the pathways;
  - ✓ Gathering opinions from stakeholders on actions they would like to see implemented to ensure they can do their part in the implementation of the decarbonisation pathways. Stakeholders were involved via interviews and a workshop held in February 2022;
  - ✓ Understanding from other countries how they are pursuing the same objectives and taking inspiration from those practices.

Limitations

- Suggested actions are focused on electricity sector. Interactions with other sectors (H&C, buildings, transport) are assumed in the baseline, but not fully explored → impacts on electricity demand, flexibility and network reinforcement
- Model also does not represent electricity distribution system, i.e. no reinforcement / extension needs or related costs are considered
- Actions

Barriers (as identified by stakeholders)

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- Lack of focus and clarity on government strategy
  - Government is not yet committed to its main strategy, which remains unclear (e.g. whether CCUS or nuclear will be part of it)
  - Lack of commitment increased perceived political risks for RE investments, as ambitious RE policies will negatively affect electricity market prices
  - Undefined optimal share of RE to be integrated in energy system. The current strategy of using fossil fuel plants controlled by SO as reserve capacity is discouraging private investments in storage and flexibility)
  - Mixed messages on trade-offs between nature conservation and renewable generation
- The planning process in electricity infrastructure suffers from bottlenecks and inefficiencies
  - Lack of incentives for local administrations and communities to approve the installation of renewable energy infrastructure (suffer a loss of amenities but receive no benefits in return)
  - Limited capacity and skills of local administrators involved in the planning process
  - Limited capacity and skills in the supply chain leading to long wait and high costs. Presumably due to time/cost constraints, insufficient robust work is being carried out which provides an opportunity for opponents of the project to exploit weakness in the application and delay / block the approval process.

Barriers (as identified by stakeholders)

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- Negative public opinion of renewable generation (in particular, local opposition to onshore wind farms)
  - Not-In-My-Backyard attitude is one of the main barriers
  - Perceived negative impact on the quality of neighbourhood, where people tend to have a biased view without properly / fully considering the positive impacts → Lack of proper communication and availability of correct information to the public
  - Vocal opponents of nuclear energy, despite evidence that population majority may be in favour
  - Awareness of cost implications of pursuing some pathways may reduce public support for government strategy by consumers / taxpayers
- Developers and investors require support to manage some risks beyond their control and reduce the premium they require on their investment
  - Guarantees of sufficient income during contract period are often required by lenders, i.e. unwilling to fund projects fully exposed to market risks
  - Future development of electricity prices is highly uncertain, which may be too low to ensure capital repayment to cover CAPEX / OPEX for RES investments
  - Financing less established technologies (nuclear, CCUS) faces different challenges, e.g. subsidies would not be needed for nuclear, but risk reduction is essential given the long payback period
  - The key barrier to investments in nuclear is more political than financial. Investors worry that government may:
    - Change strategy and abandon nuclear energy
    - Clamp down on profits
    - Subsidise deployment of a too high share of RE sources with low variable cost (wind/solar)
  - Substantial investments required in pre-construction phase is a key barrier to RE investment

Action sets

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	Objective	Actions
Infrastructure planning process reform	To remove main barriers and bottlenecks of the different elements of the planning process – slowness and unpredictability have been identified as key barriers to developing RES, especially for solar parks and onshore/offshore wind	• Streamline infrastructure planning approval process • Increase administrative resources dedicated to planning and permissions • Supporting actions to speed-up the approval process
Institutional reform	To establish an effective and efficient way to steer and monitor the deployment of decarbonization strategy (similar to several other MSs).	• Set up a nuclear regulator • Review the mandate of the Estonian National Regulatory Agency • Set up an Energy and Climate Agency • Increase cross border cooperation
New framework for investment risk reduction instruments	To reduce market risks for developers and protect investments against political risks	• Actions to stimulate the uptake of Power Purchase Agreements (PPAs) • Amendment and extension of the current renewable electricity auction scheme • Move all or part of the funding for renewable electricity to the fossil gas bill or to other funds • Extend the current size of state guarantees provided by Kredex and develop a broader framework for government guarantees • Public co-investing and sharing risks

Action sets

	Objective	Actions
Support for RES for households and SMEs	To increase private investments in renewable energy, alongside actions to refurbish the building stock to increase cost-effectiveness	• on-site small scale renewable generation support scheme, in combination with other actions to incentivise building renovation • Allow Households and SMEs to invest in remote renewable electricity generation (virtual metering)
Power networks and infrastructure	To ensure network capacity, increase uptake of battery storage and incentivise Demand Side Response	• Develop a national flexibility strategy • Review the approach for balancing the electricity system • Improve batteries' economic viability and access to finance • Remove the double network charges for network-connected storage • Create a demand side management framework • Other actions to support storage know-how and reduce barriers • Consider alternative design models and funding mechanisms for key offshore infrastructure • Reinforcement to transmission and interconnection infrastructure
Involvement of civil society	To enhance public acceptance of energy infrastructure projects	• Information campaign to be launched together with a new renewable energy strategy • Setup One-stop shops • Local action groups • Facilitate the uptake of Citizens and Renewable Energy communities

Pathway-specific actions

RES + Storage pathway

This pathway 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)

	Priority actions
Offshore wind	• Streamline planning approval process via simplified procedure and a dedicated task force at government level; ensure timely availability of appropriate transmission capacities and connections • Facilitate participation of international actors in tenders to maximise competition, as far as possible • Set up technology-specific reverse auctions to be held in 2024, 2026, and 2028 to procure 3.6 TWh/year to reach 1 GW target by early 2030s (additional auctions may have to be set up, depending on market developments) • TSO should pursue plans for hybrid offshore grid in the Baltic sea
Onshore wind + solar PV	• Streamline planning approval process via simplified procedure and provide additional resources and incentives for local administrations and local communities • Extend current technology-neutral auction scheme to stimulate additional 3.1 TWh of onshore wind and 1.3 TWh of solar PV by 2030; Auctions to be held in 2025, 2027 and 2029
Security of energy supply and flexibility	• Elaborate and publish a strategy on security of supply and flexibility that is tailored to the expected deployment trajectory of wind and other renewable energy sources
Consumer support	• Provision of support for vulnerable households as this is a relatively expensive technology mix which can result in higher electricity prices than in other pathways

Nuclear and *RES* + *Storage* pathway

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- This pathway considers **deployment of 900 MW of Generation III+ small modular nuclear capacity** by 2040 + 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)
- Additional considerations:
  - Technology that may be **commercially unavailable for several years:** a nuclear strategy with clear milestones, and clear assignment of responsibilities and liabilities to the stakeholders involved is necessary. In case remedial actions are triggered, the short-term remedial actions likely to be more expensive for consumers.
  - Reliance on vast battery capacity in 2050 exposes this pathway to the risk that **battery prices remain high and not decline to expectations**

	Priority actions
Continue development of nuclear energy deployment	• Develop an Estonian Nuclear Energy Strategy • Set up a Nuclear Authority with clear mandate and adequate power and resources • Develop framework for risk assessment and transfer where appropriate, state support and state guarantees • Establish further cooperation channels with potential commercial and technical partners across the EU • Build necessary skills in the public and private sectors • Prepare early involvement of stakeholders and citizens
Renewable electricity generation	• Streamline and speed up the planning process, focussing on onshore wind energy and solar PV (rooftop and ground-based) • Set up technology-specific reverse auctions so that support contracts would expire by late 2030s • Set up auction scheme to stimulate a further 3.8 TWh of renewable electricity generation by 2030 • Identify additional rooftop / ground sites for solar PV installation; Mandatory solar PV in all buildings
Security of energy supply and flexibility	• Elaborate and publish a strategy on security of supply and flexibility that is tailored to the expected deployment trajectory of wind and other renewable energy sources

CCUS and *RES* + *Storage* pathway

Trinomics

- This pathway explores the **addition of carbon capture to two large oil shale generators** in Estonia

	Priority actions
Support deployment of CCU	• Pass a supporting legislative package, including the review of mandate of the Competition Authority to be responsible for CO_2 • Develop a national strategy for CCUS • Develop a strong business case to complete against similar proposals to obtain support from EU funds • Ensure that any support to developers and investors should only be granted when market conditions are unfavourable; possibility to run a competitive process for the award of support to be considered
Deploy technology in the short term while opening opportunities in the long term	• Identify right development grant from EU to address the high capital investment required • Provide operational support via subsidy to address revenue uncertainty • Tailored risk management framework with some risks to be absorbed by the government
Onshore wind + solar PV	• Streamline planning approval process via simplified procedure and provide additional resources • Launch further reverse auctions
Security of energy supply and flexibility	• Elaborate and publish a strategy on security of supply and flexibility that is tailored to the expected deployment trajectory of wind and other renewable energy sources

RES GAS pathway

- This pathway assumes the implementation of **1 GW of new biogas generation** by 2030

	Priority actions
Onshore wind + solar PV	• Streamline planning approval process via simplified procedure and provide additional resources • Award substantial incentives / support to new solar PV and onshore wind installations by launching technology neutral auctions
Support deployment of biogas	• Stimulate 1.9 GW of capacity and 85 GWh of electricity by 2030 both via biogas peaking plants and batteries through dedicated risk reduction mechanism to support new biogas plants, e.g. dedicated support instrument / capacity-remuneration instrument or (preferably) be included into a market instrument to support flexibility and reserve capacity providers in general
Security of energy supply and flexibility	• Elaborate and publish a strategy on security of supply and flexibility that is tailored to the expected deployment trajectory of wind and other renewable energy sources

All Technologies pathway

- *‘All technologies’* pathway allows the model to invest in any electricity generation technology based on least-cost optimization
- ‘*All technologies – no net electricity imports*’ pathway requires that electricity imports and exports should offset each other
- *‘All technologies + 1000 MW’* pathway applies the constraint that Estonia must have at least 1000 MW of readily dispatchable electricity production capacity at all times
- Actions aim at
  - ✓ Setting up appropriate technology-neutral market instruments
  - ✓ Ensure a level playing-field across technologies to foster competition (may require more support to help some technologies reach maturity)
  - ✓ For AT – NIMP & AT + 1000 pathways, provisions should be made to reward capacity rather than generation

	Priority actions
Support to renewables	• Continue launching technology neutral auctions, with target of achieving 3 GWh of onshore wind and 1.6-2.6 GWh of solar PV by 2030 • (AT – NIMP) Technology specific auction for offshore wind to procure 2,500 TWh should be implemented by 2025 • Substantial new fossil gas capacity is required, although utilization is low; capacity-based support mechanism may be required for AT + 1000 • Identify additional rooftop / ground sites for solar PV installation; Mandatory solar PV in all buildings
Support to other new emerging technologies (e.g pumped hydro or nuclear)	• Support R&DI for both generation and flexibility technologies • Support for a “slow burning” nuclear programme • Set up programme for enhancing case for CCUS
Security of energy supply and flexibility	• Elaborate and publish a strategy on security of supply and flexibility that is tailored to the expected deployment trajectory of wind and other renewable energy sources

Conclusions