



Nuclear prolongation scenarios in a transition to Belgian net zero carbon energy system emissions

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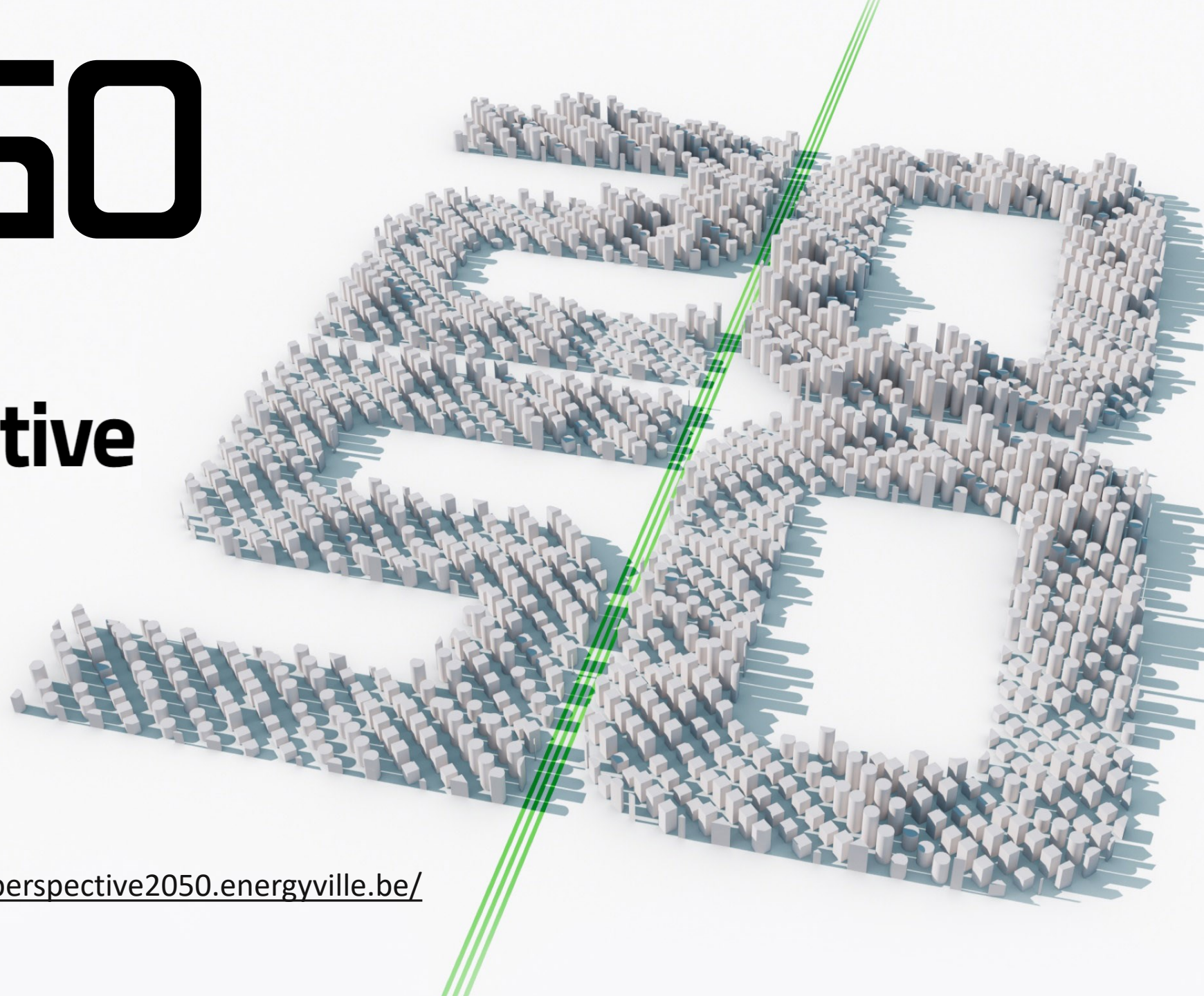
Motivation and objectives (research questions)

Central questions

- Could 20 years of lifetime extension D4/T3 be cost effective?
- Under what total levelized costs would an additional 2GW, 20y lifetime extension (D3/T2) make sense?
- What's the impact on other generation capacity, import, CO₂ emissions?

PATHS 2050

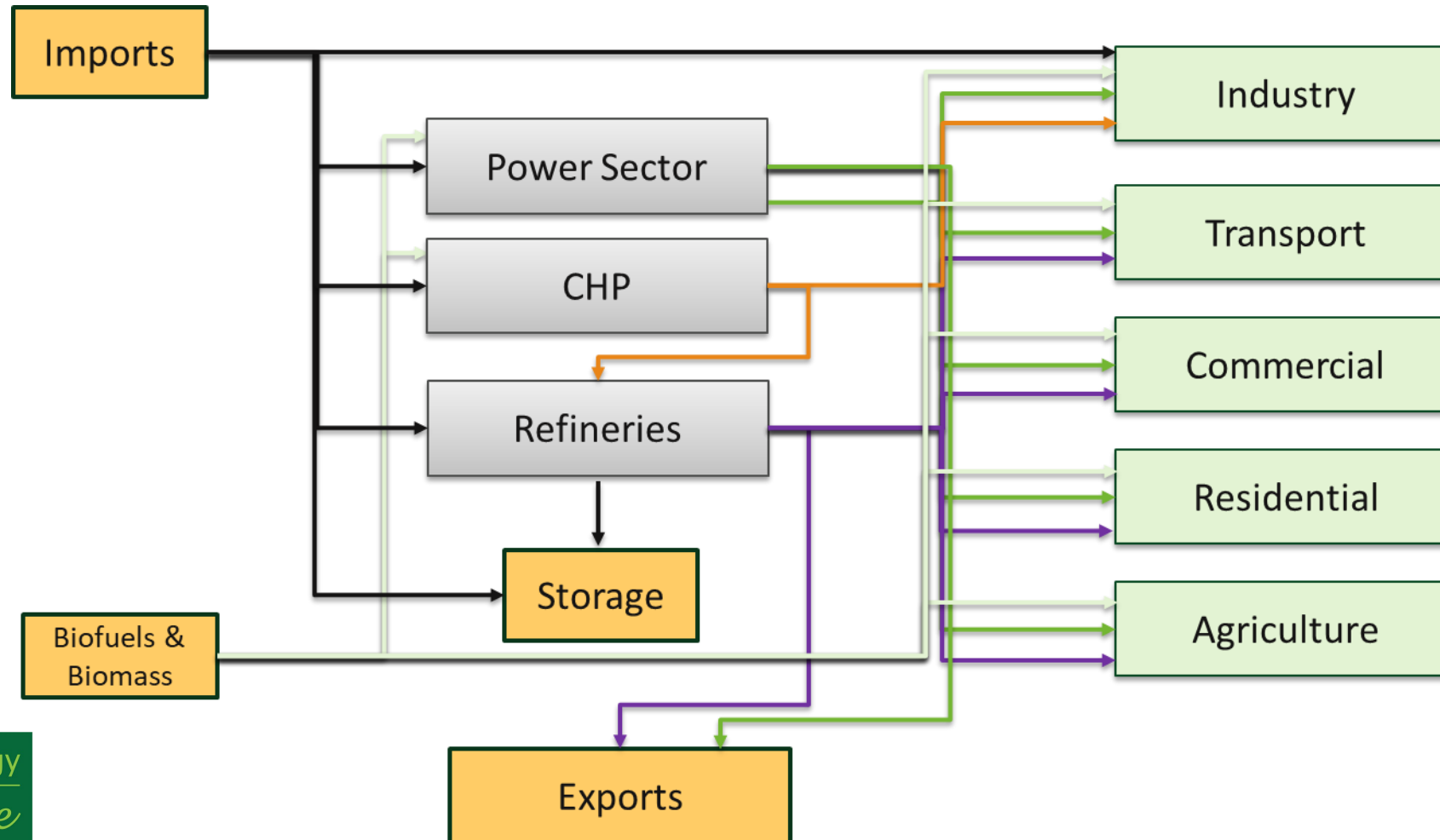
The Power of Perspective



<https://perspective2050.energyville.be/>

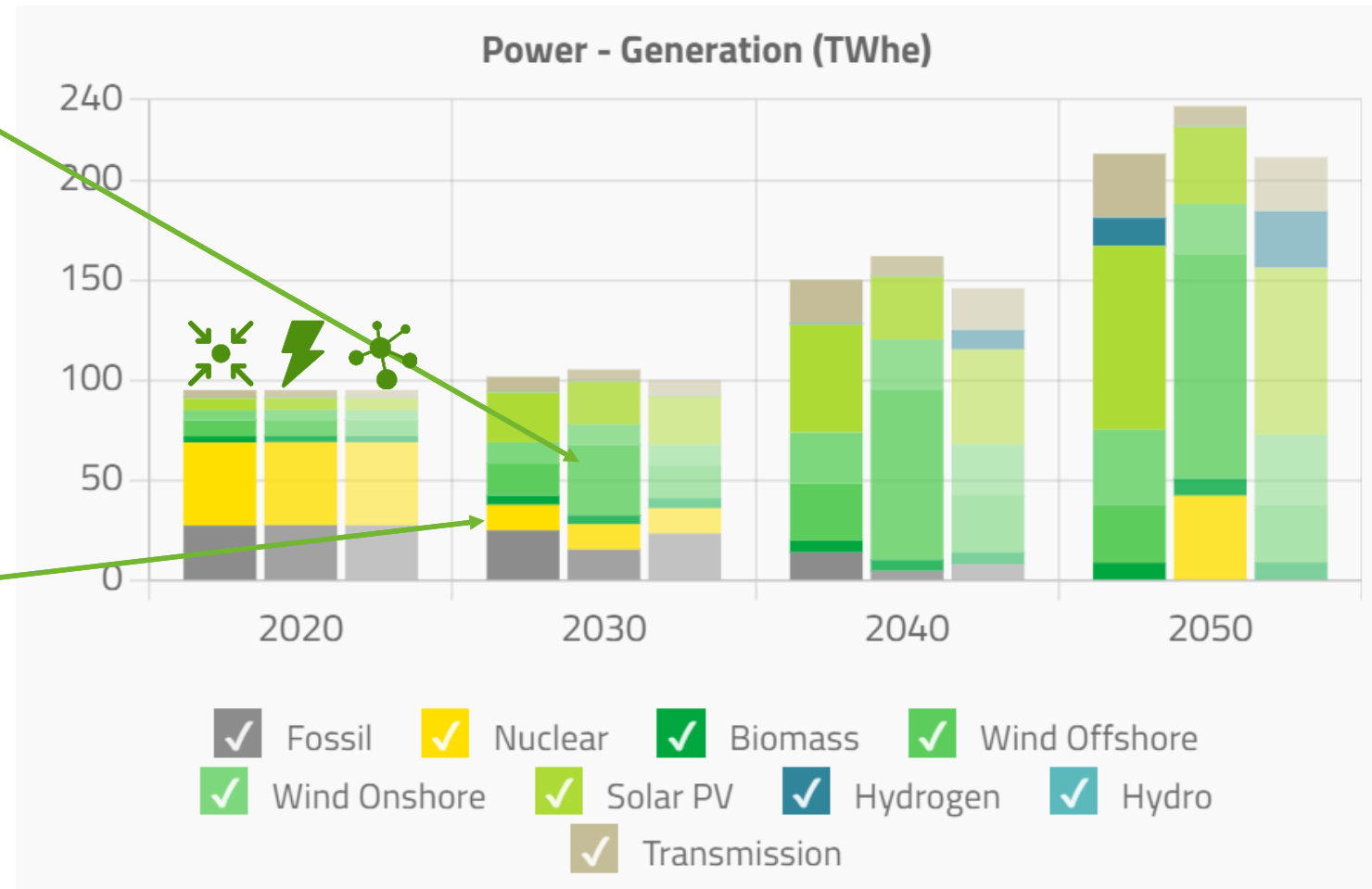
TIMES-BE model - simplistic

One large techno-economic **optimization over the full time horizon** including all technologies, energy carriers and processes



PATHS 2050 results

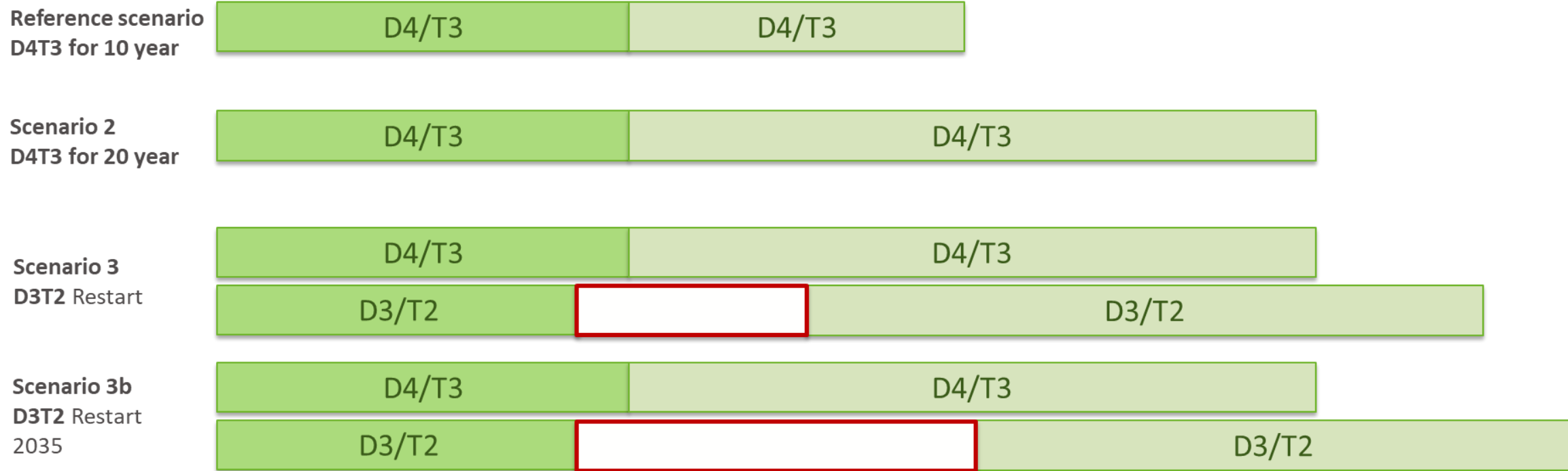
- Electrification scenario:
 - More access to offshore wind will lower electricity production cost and system costs from 2030 onwards
 - Up to 6 GW of new nuclear (SMR) is selected >2045
 - 10y Lifetime extension of D4/T3 selected in all scenarios



The nuclear power plants today

Power plant	Capacity (MW)	Commercial operation start	Status
Doel 1 & Doel 2	890	1975	In operation until 2025
Doel 3	1006	1982	Closed Sept 2022
Doel 4	1039	1985	Extended 2025 – 2035
Tihange 1	962	1975	In operation until 2025
Tihange 2	1008	1983	Closed Jan 2023
Tihange 3	1046	1985	Extended 2025 – 2035

Scenario overview



Approach -disclaimer

- Nuclear power plant extension costs are critically dependent on design, location, components, construction time...
 - **Cost of nuclear lifetime extensions are not public information, and require a dedicated detailed assessment, which is beyond the scope of this study.**
 - In TIMES BE, we use the strike price of 65 – 75 €/MWh for D4/T3 extension as communicated in a parliamentary debate* to approximate the levelized cost of electricity generation, considering all costs.
- ⇒ Question is reversed for D3/T2 restart: which total cost of operation (€/MWh) is needed for extended nuclear power plants to be cost effective in the energy transition?
- ⇒ Study is a ‘what if’ analysis, not a prediction of costs.



*<https://www.dekamer.be/doc/CCRI/pdf/55/ic1143.pdf>

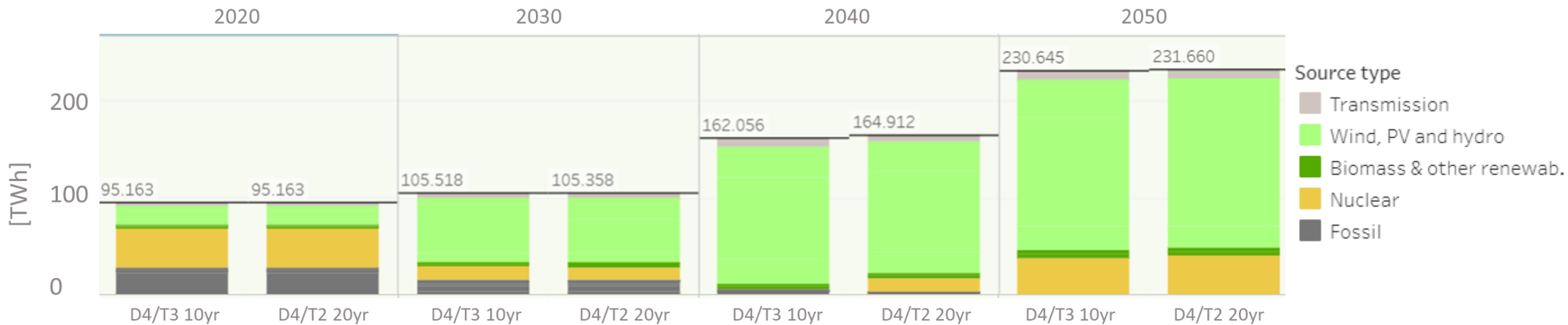
Main scenarios tested

Scenario	Assumption D4/T3	Assumption D3/T2
D4/T3 10	Extension D4/T3 2025 - 2035 Total LCOE: 75€/MWh	No extension
D4/T3 20	Extension D4/T3 2025 - 2045 Total LCOE: 65€/MWh	No extension
D4/T3 + D3/T2 2030	Extension D4/T3 2025 - 2045 Total LCOE: 65€/MWh	Extension D3/T2 2030 - 2050 Total LCOE: Sensitivity analysis
D4/T3 + D3/T2 2035	Extension D4/T3 2025 - 2045 Total LCOE: 65€/MWh	Extension D3/T2 2035 - 2055 Total LCOE: Sensitivity analysis

[1] This number was mentioned in a parliamentary session by minister Tinne Van der Straeten*. In this study, we use this strike price to approximate the levelized cost of electricity production. Costs related to nuclear waste processing and storage, financing costs, security etc. are assumed to be included in this number. This number is an external model assumption, this study does not have information on how the different cost components add up to this number. All nuclear power plants are modelled with an annual availability of 80%. All results expressed in €2019. [2] The extension of D3/T2 is only assumed to start in 2030, due to the preparatory works that need to be done. LCOE = Levelized Cost of Electricity.

*<https://www.dekamer.be/doc/CCRI/pdf/55/ic1143.pdf>

Impact on energy system – 20yr extension D4/T3

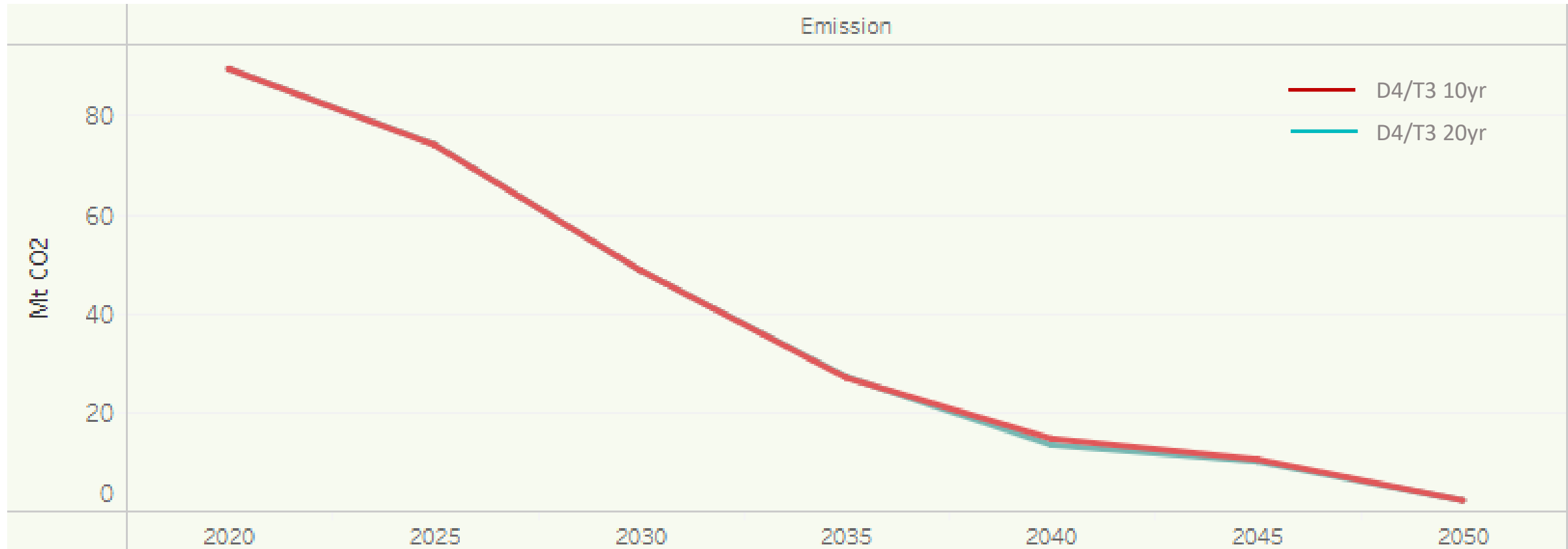


- Extension commercially viable with the assumed levelized cost of electricity of 65€/MWh *
- Nuclear extension of 20 year instead of 10 year replaces renewable investments:
 - In 2040, every produced TWh of nuclear due to D4/T3 extension, replaces 0.6TWh renewables

*model runs with 3% discount rate, start year 2030, 80% availability, value is assumed to include all relevant costs, expressed in €2019.

Emissions extension D4/T3

Total Emission(Mt CO2) per Scenario

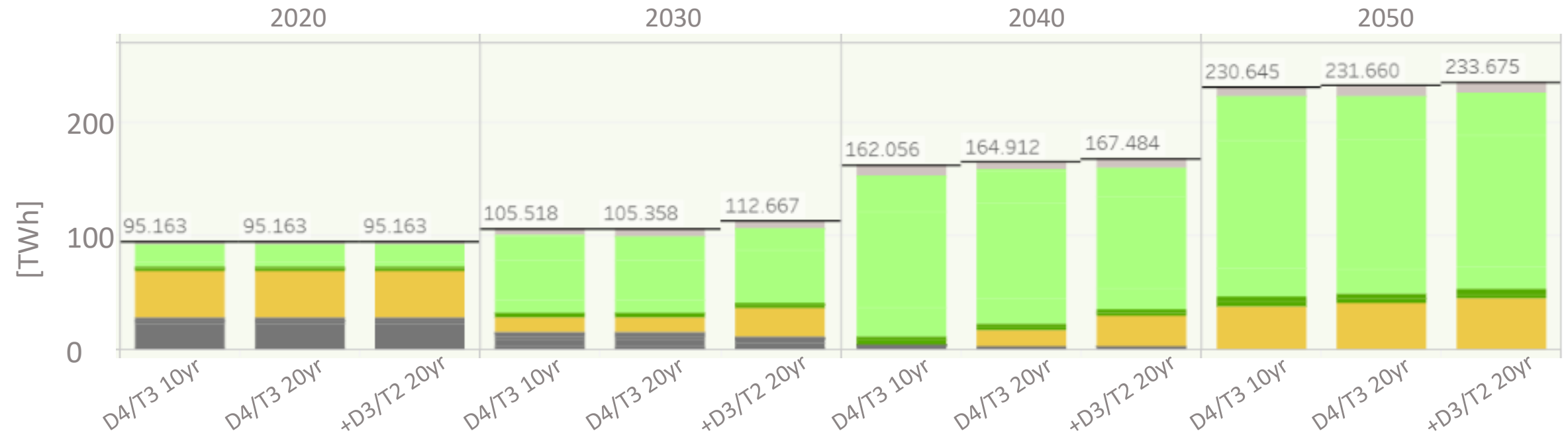


- CO₂ emission savings of max 1.3Mton/year in 2040 due to 20 years extension in comparison to a 10 years extension.

Conclusions – D4/T3 extension to 20 years

- Nuclear lifetime extension of D4/T3 was assumed to have an LCOE of 65€/MWh for 20 years of extension, which is economically viable in the energy system.
- Emission savings of 2GW nuclear lifetime extension are larger in the coming 10 years than between 10 and 20 years from now. CO₂ emission savings of max 1.3Mton/year in 2040 due to 20 years extension in comparison to a 10 years extension.
- Mainly in the second decade, renewable investments are impacted by nuclear lifetime extension:
 - In 2040, every TWh of nuclear electricity production replaces 0.6TWh of renewables, when comparing scenarios with 10year and 20 year extension

Results: + D3/T2 20yr extension

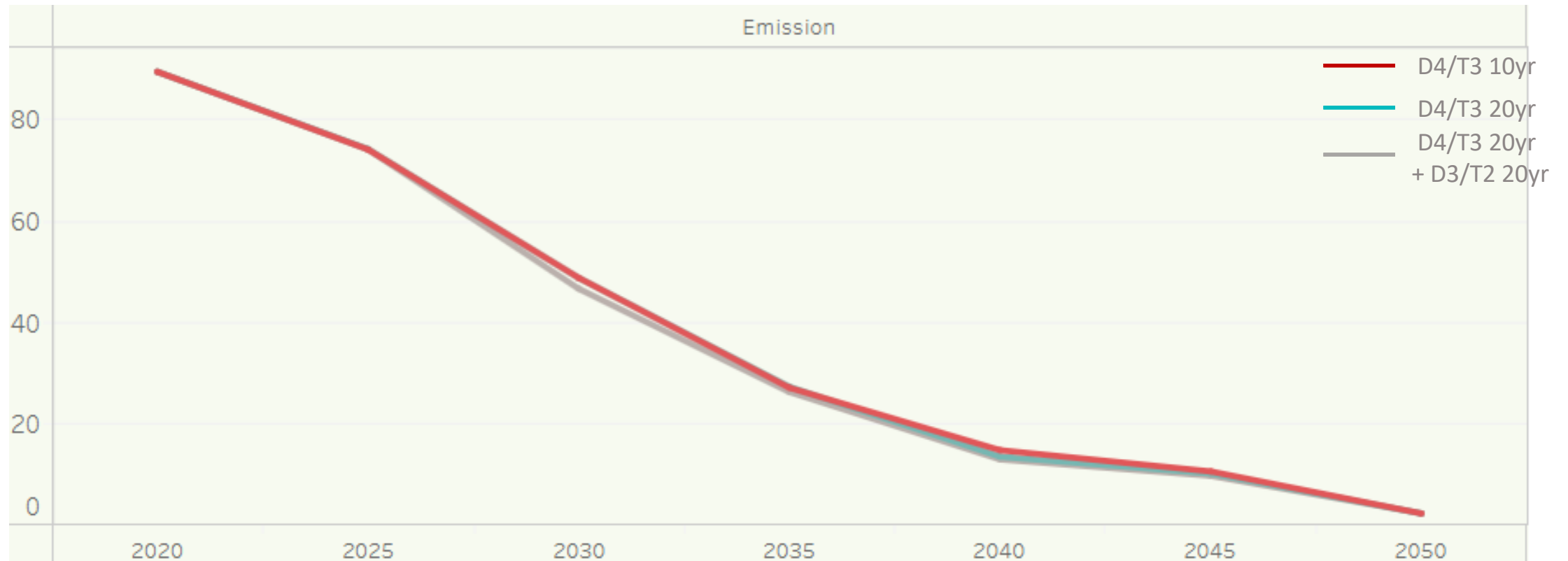


- Extension D3/T2 on top of D4/D3 commercially viable **only below 75€/MWh**, if ready in 2030*
- Extension D3/T2 on top of D4/D3 commercially viable **only below 70€/MWh***, if ready in 2035,
- By 2040, the extension of D3/T2 on top of D4/D3 mainly replaces renewables and new nuclear:
 - In 2040, the restart of D3/T2 **replaces 0.8TWh of renewables for every TWh of nuclear**, in comparison with only D4/T3 extension
 - In 2050, mainly investments in new nuclear are replaced by restart of D3/T2.

*model runs with 3% discount rate, start year 2030, 80% availability, value is assumed to include all relevant costs, results are expressed in €2019.

Emissions extension D4/T3

Total Emission (Mt CO₂) per Scenario



- CO₂ emission savings of 1.8Mton/year in 2040 due to 4 GW nuclear with 20 years extension, compared to no available nuclear in 2040.

Conclusions on D3/T2 restart on top of D4/T3 extension

- Data on the restart cost and time at which D3/T2 can be restarted are not available.
- Nuclear extension of D3/T2 between 2030 – 2050 is only part of a cost optimal energy mix with a levelized cost of electricity below 75 €/MWh*.
- Nuclear extension of D3/T2 between 2035 – 2050 is only part of a cost optimal energy mix with a levelized cost of electricity below 70 €/MWh.
- Investment in renewables and nuclear are impacted by D3/T2 restart,
 - In 2040, every TWh of nuclear electricity production replaces 0.8TWh of renewables, when comparing with a scenario where only D4/T3 is extended for 20 year
 - In 2050, mainly investments in new nuclear are replaced by restart of D3/T2.
- Emission savings are higher for first 2GW of extended nuclear power plants. CO₂ emission savings of 1.8Mton/year in 2040 due to 4 GW nuclear with 20 years extension, compared to no available nuclear in 2040.





Thanks!

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Impact on renewables: tables

Technology – D4/T3 20 years extension instead of 10 years extension	Impact in 2040 on capacity (GW)	Impact in 2040 on generation (TWh)
PV	- 2.6 (-8%)	- 2.6 (-8%)
Wind onshore	- 1.8 (-15%)	-3.5 (-15%)
Wind offshore	- 0.4 (-2%)	-1.3 (-2%)
Fossil based electricity	- 1.6 (-32%)	-1.2 (-22%)

D3/T2 Restart + D4/T3 extension, vs only D4/T3 extension	Impact in 2030 on capacity (GW)	Impact in 2030 on generation (TWh)	Impact in 2040 on capacity (GW)	Impact in 2040 on generation (TWh)	Impact in 2050 on capacity (GW)	Impact in 2050 on generation (TWh)
PV	-1.3 (-6%)	- 1.2 (-6%)	-5.1 (-17%)	-4.8 (-17%)	0	0
Wind onshore	0.0 (0%)	0.0 (0%)	-1.4 (-14%)	-2.9 (-14%)	-0.7 (6%)	-1.3 (6%)
Wind offshore	0.0 (0%)	0.0 (0%)	-0.8 (-3%)	-2.8 (-3%)	0	0
Fossil based electricity	-0.5 (-8%)	-3.9 (-25%)	-0.6 (-26%)	-0.8 (-24%)	0	0
New nuclear	N/A	N/A	N/A	N/A	- 1.2 (30%)	-9.7 (-37%)

Table conversion €2019 to €2023

€2019	€2022	€2023
65	74	77
75	85	89