



Costs and risks of decarbonization and nuclear power: a TEMOA - Europe - scenario analysis

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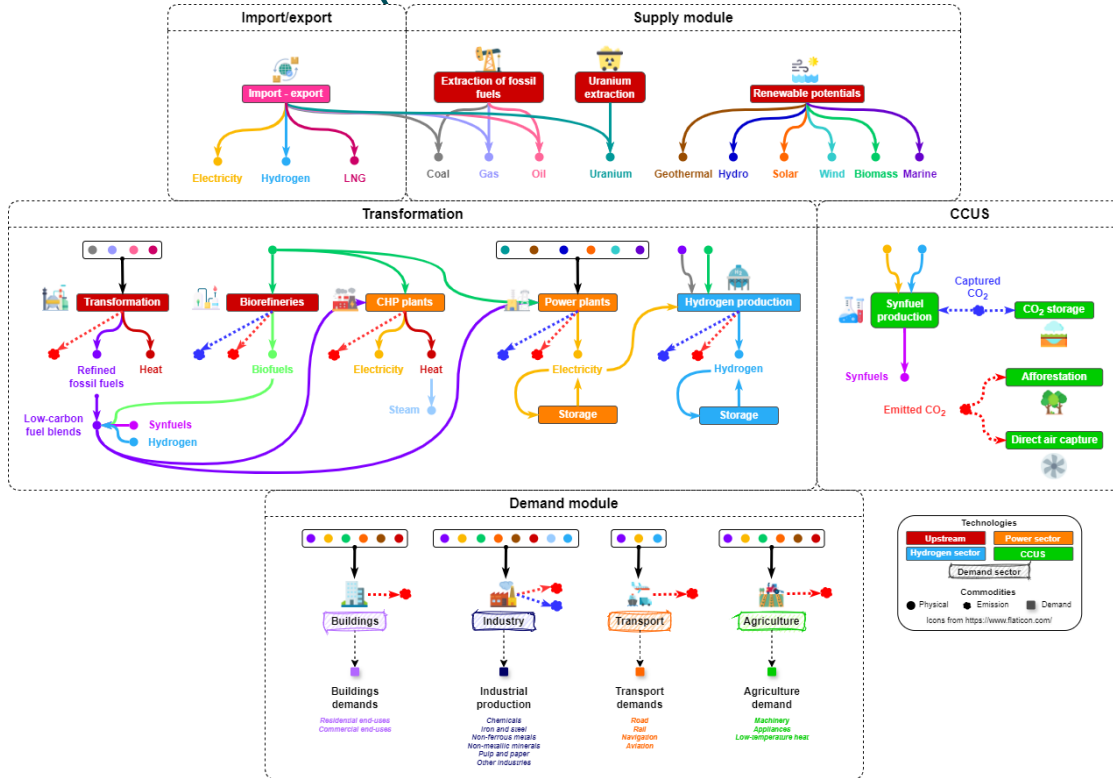
Aim of the work

1. Examine the role of nuclear power in the EU across different scenarios , including decarbonization efforts , the implementation of a carbon tax, and a business - as - usual (BaU) approach .
2. Explore how nuclear energy can support the EU's transition to a low - carbon economy when carbon taxes are applied .
3. Determine whether nuclear energy can help achieve a net - zero emissions target at a lower cost.
4. Conduct a sensitivity analysis to evaluate the impact of various factors on the results .

Existing literature

1. Nuclear as renewable energy in the EU Taxonomy from 2019
2. Chen et.al. (2022) on nuclear and land use. Nuclear mainly used when there are import constraints / transmission network constraints (Wetzel et.al., 2023)
3. Several authors linking nuclear with (green) hydrogen production (Sasanpour et.al. 2021)
4. Social acceptability + (perceived) risks (Cotterman et.al., 2021)

The model (Lerede et.a I. 2023)



TEMOA-Europe is an energy system optimization model for the European energy system, considered as a whole. It minimizes investment costs under a set of constraints .

- ❖ Modeling all the energy sectors .
- ❖ Oriented to capacity expansion .
- ❖ Single region .
- ❖ Time horizon

Hypothesis

Power plant	Investment cost (M€/GW)			
	2020	2030	2040	2050
LWR (light water reactor, gen III)	3200			
EPR (EU pressurized reactor)	6600	5100	4800	4500
FR (LMFBR) Liquid metal fast breeder reactor gen IV		9600	8700	7935
ABWR (advanced boiling water reactor gen III)			8700	7950

Hypothesis

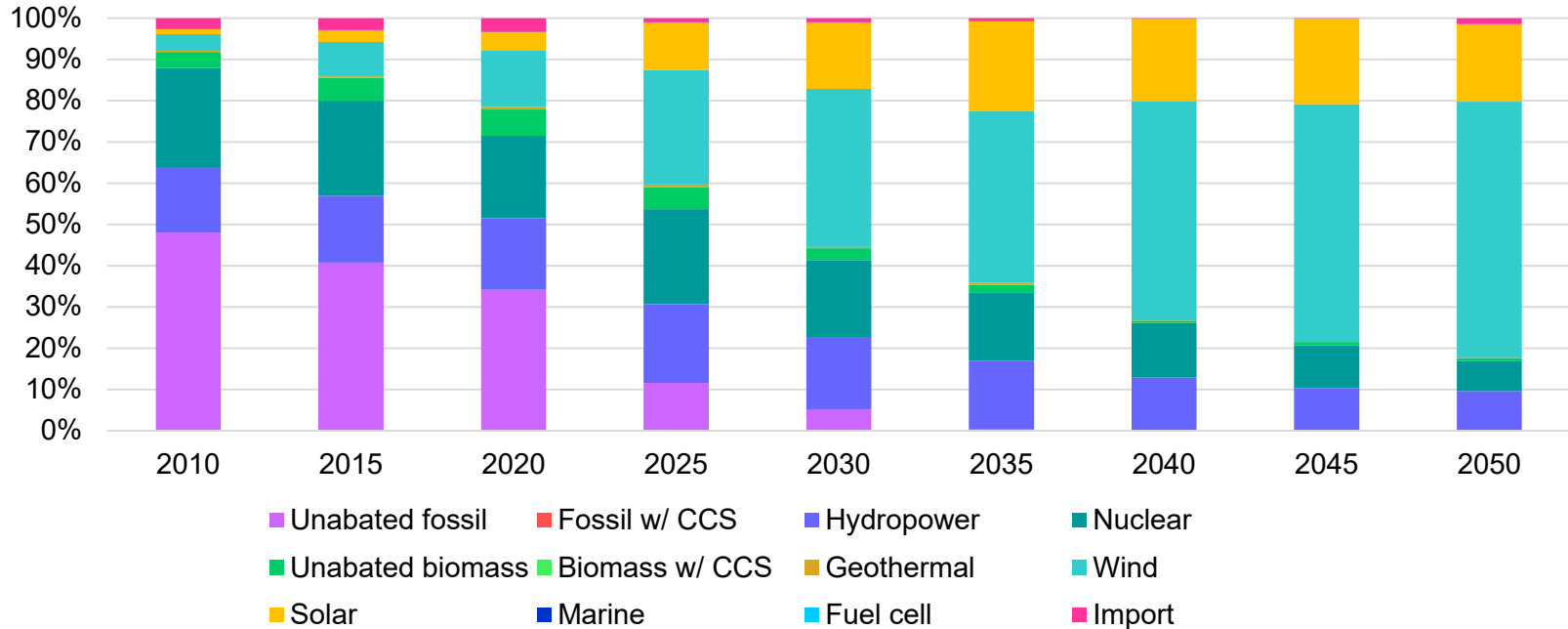
Commodity	Price
Coal	0.17 €/kg
Oil	0.48 €/l
Gas (pipeline)	0.66€/Smc (or 61.68 €/MWh)
LNG	0.7€/Kg
Uranium	0.40 M€/PJ or 0.00144 €/ Kwh
Electricity	0.10 €/ KWh

Scenarios

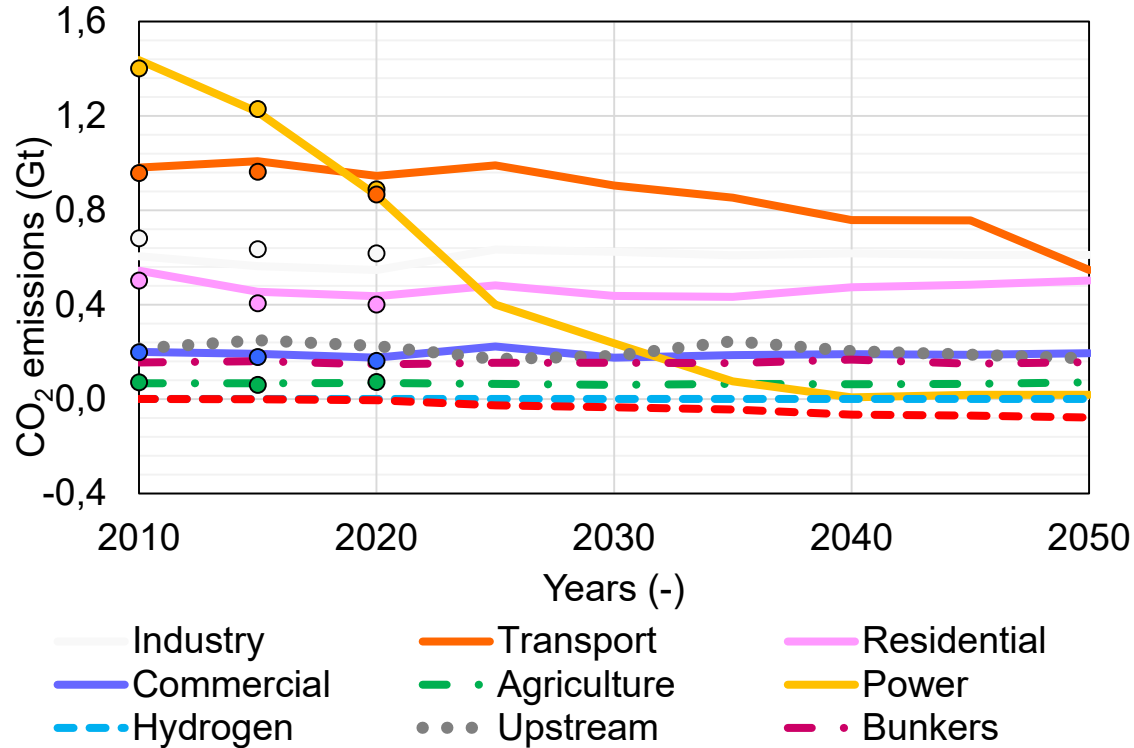
Scenario	Carbon Tax	Zero Emission Target
BaU	X	X
Carbon tax (all sectors)with/ without nuclear	YES	X
NZE with/ without nuclear	YES	YES

BaU

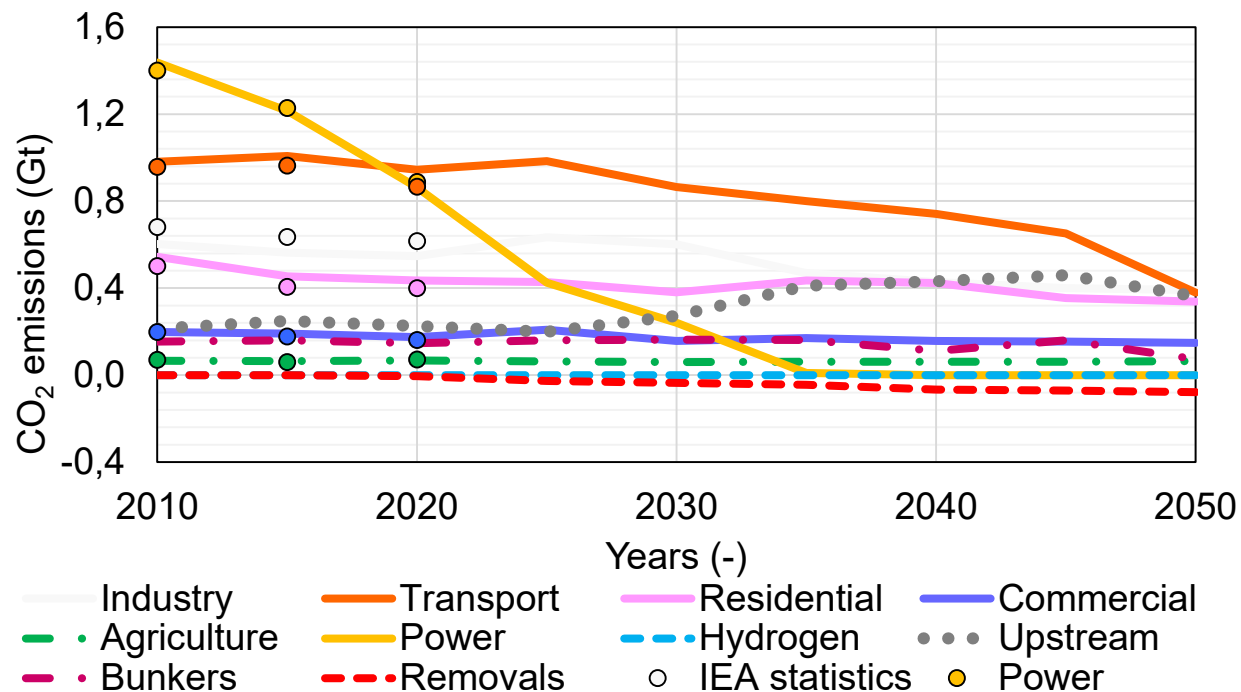
Electricity generation share



Bau and emissions

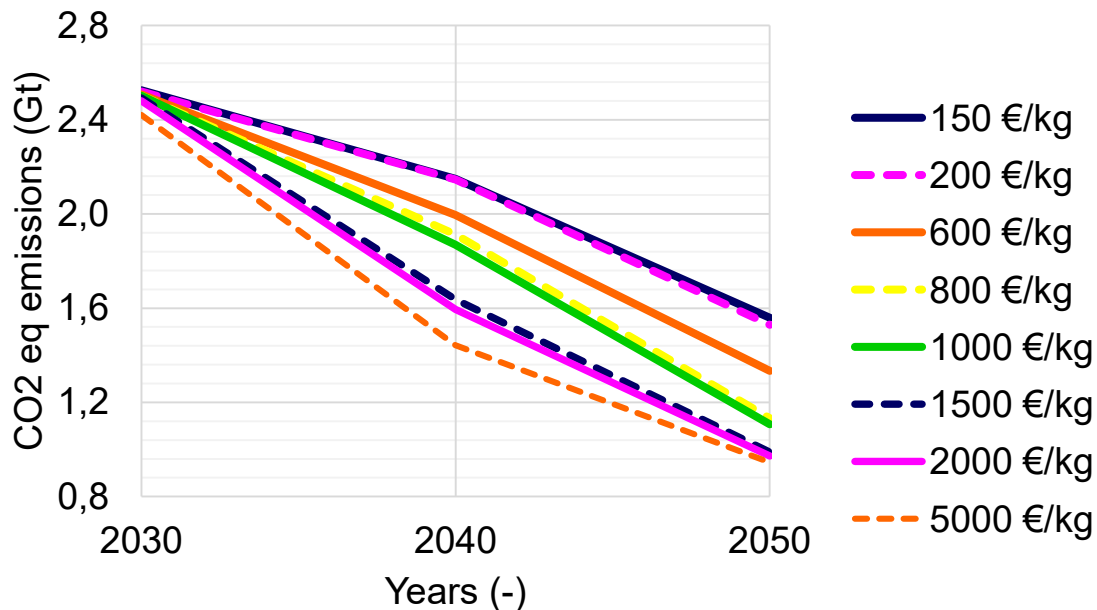


Carbon tax+nuclear and emissions

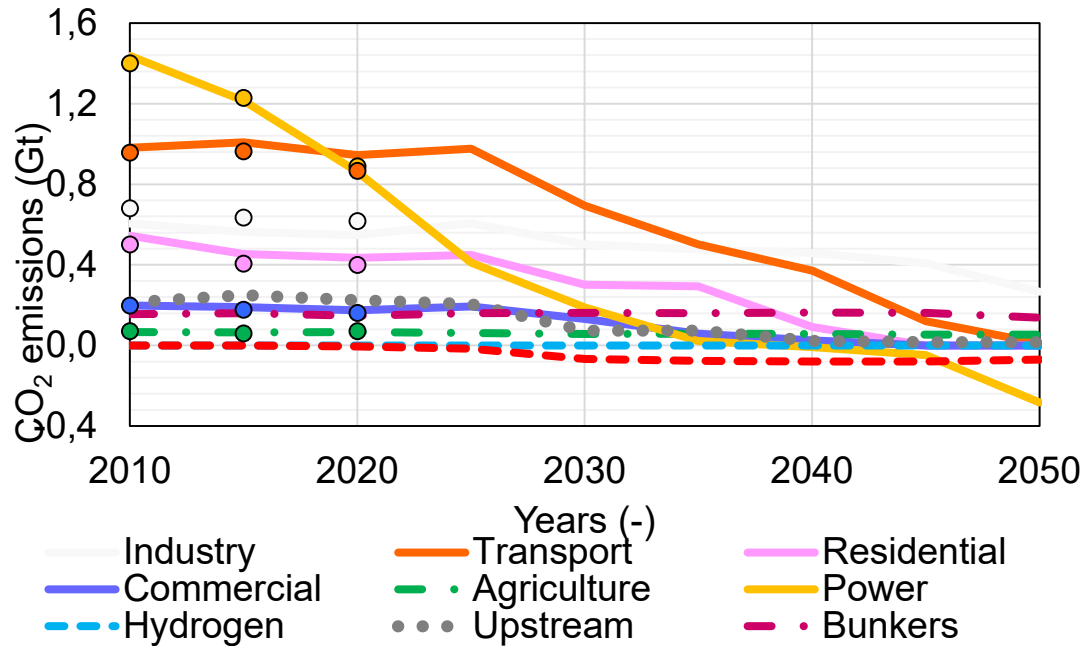


Carbon tax and emissions

The carbon tax is progressively increased in the absence of any constraint on CO₂ eq emissions and forcing the decrease of nuclear fission capacity. A carbon tax > 1500 €/kg is basically useless for further emissions reductions.

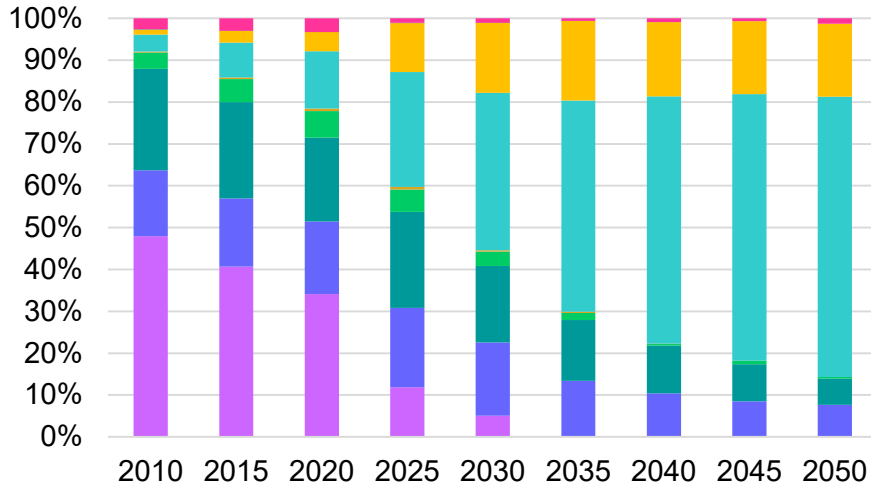


NZE and emissions

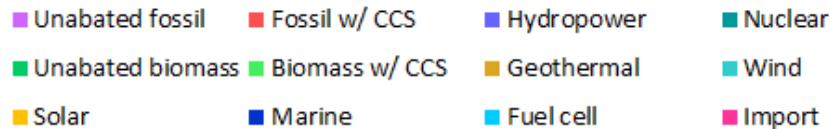
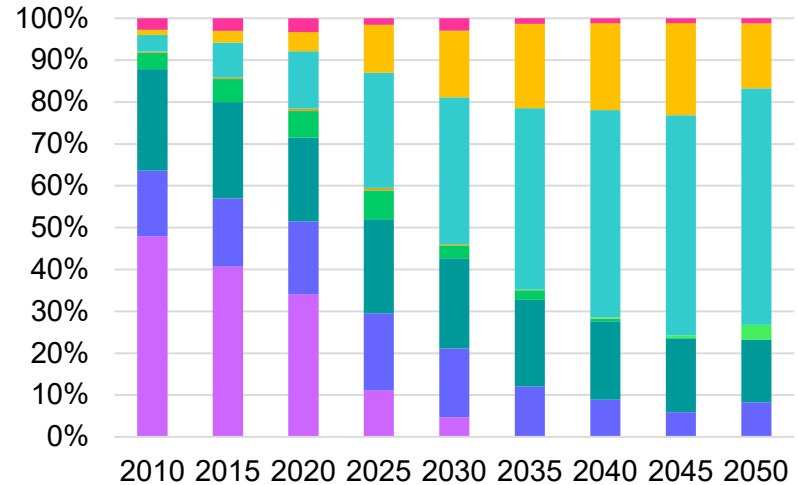


Electricity generation share

Carbon tax YES, NetZero : NO



NetZero : YES



Comparison between scenarios

- Nuclear helps reducing costs in the NZE
- This results increase if EUTaxonomy is simulated (HR reduction for nuclear plants)
- No significant role of nuclear when carbon tax is applied
- Scenario with carbon tax does not achieve zero emissions (even with very high CT)

Sensitivity analysis: NZE+Nuclear

Constraints	Share of nuclear on electricity mix	Savings (bn/euro)	Electrification
Base	41%	0.00	5846
Base*1.5	52%	46.42	6403
Base*2	63%	55.85	7318

Ratio behind nuclear constraints in the model:

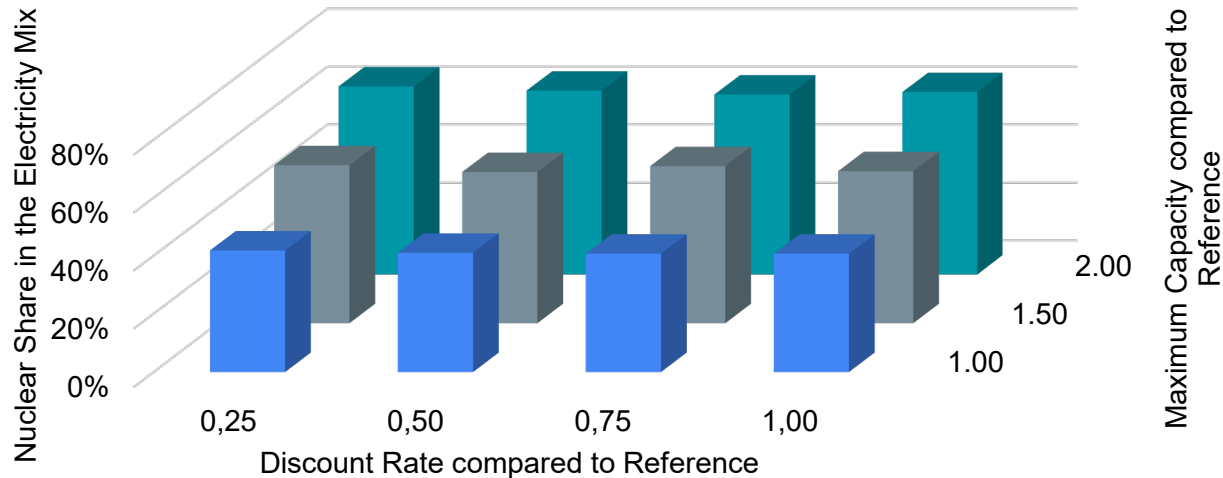
- Historical data
- Phase out planned
- Social acceptability

Sensitivity analysis: NZE+Nuclear

- NZE achieves zero emissions by definition, but nuclear can help reducing costs
- If not constrained, nuclear is chosen by the model and may increase its generation share up to 63%
- Nuclear helps achieving zero emission scenarios at lower costs (than reference scenario)

Sensitivity analysis: EU taxonomy and cost of capital

Nuclear share with NZE CO2 target, Carbon tax for all sectors



Thanks for your attention!

