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Sufficiency, Efficiency, Substitutions: Relative effectiveness to reduce the carbon footprint of France by 2050

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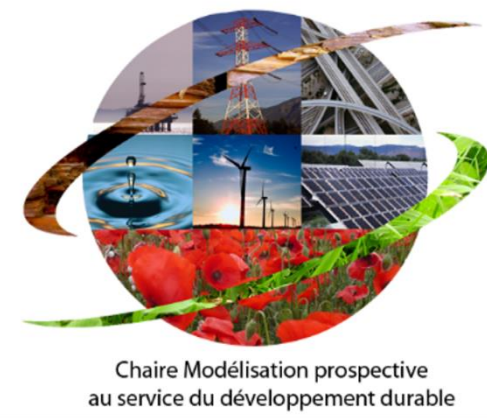
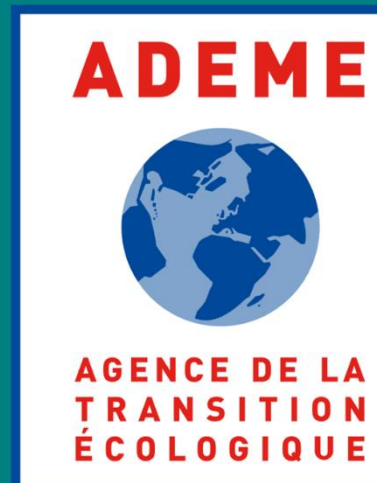


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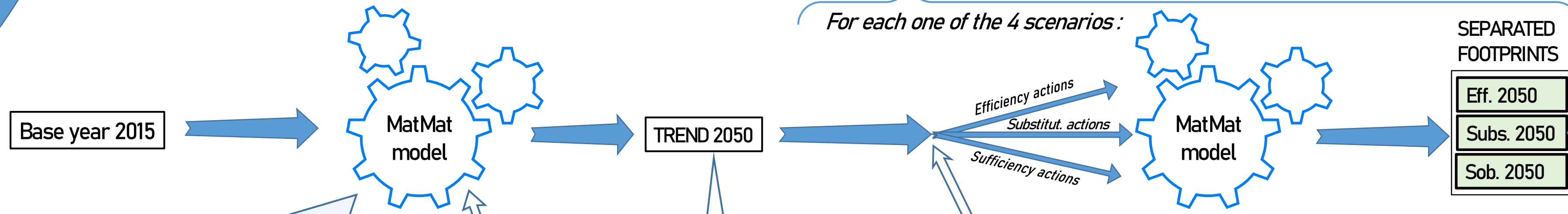
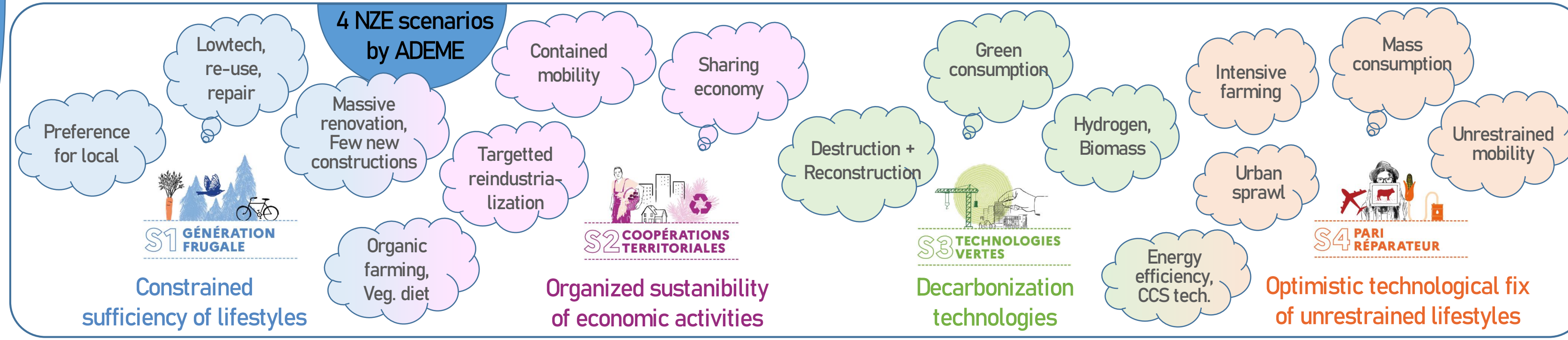
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Motivations

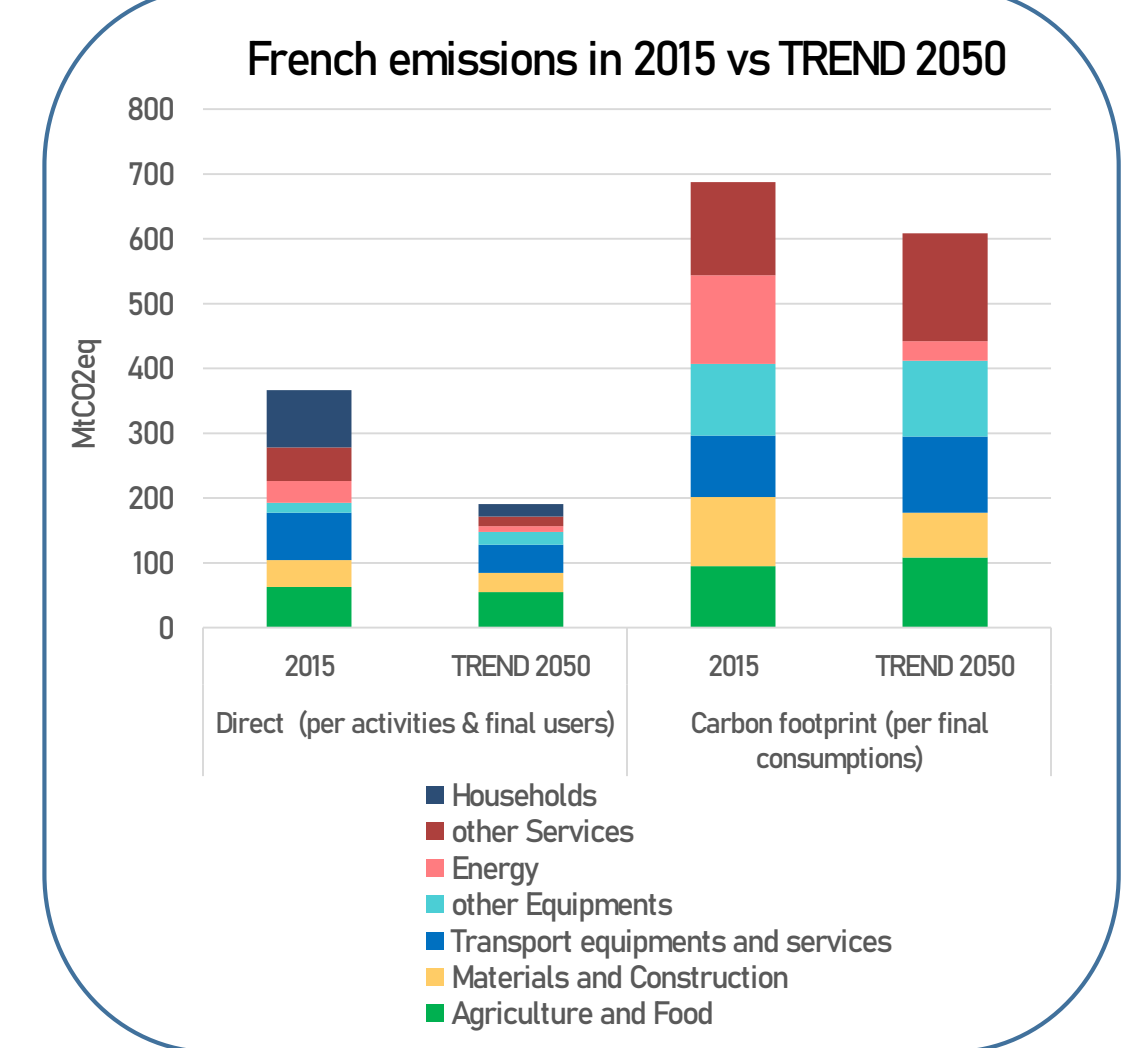
- NZE target = canceling domestic (direct) emissions. But western countries' footprints are largely imported, and generally no concerns about footprints in transition scenarios.
- NZE scenarios =
 - Decarbonizing energy systems
 - Energy efficiency gains
 - Material efficiency & circular economy
 - Shifting imports origins
 - Consumptions habits, sufficiency on demand and supply sides
- Here we discuss the relative effectiveness of each mitigation option.



MatMat = Single Region input-output + hybrid fluxes (kt / ktOE / € / tCO2eq)

	Activities (Z)	Final Demand (FD)
Produced domestically	Raw materials (kt, ktOE)	H G
	Energy (ktOE)	O O
	Materials (kt)	U V
Consumptions imported		S E G
		E R F INVESTMENTS
		H N C MATRIX
		O M F
		L E
		D N
		S T
Emissions dom.	Direct emissions of production	Direct emissions of final users
Emissions imp.	GHG content of intermediary imports	GHG content of imports for final demand

- Calibration:**
- Exiobase + national statistics for France (2015, 2019)
 - Hybrid multi-layers description.
 - Recycled and primary materials.
 - Investments matrix
- Emissions:**
- GHG = CO₂, CH₄, N₂O (from combustion, industrial processes and agriculture)
- Projection:**
- Exogenous deformation with BU data
 - Soft coupling with macroeconomic model outputs



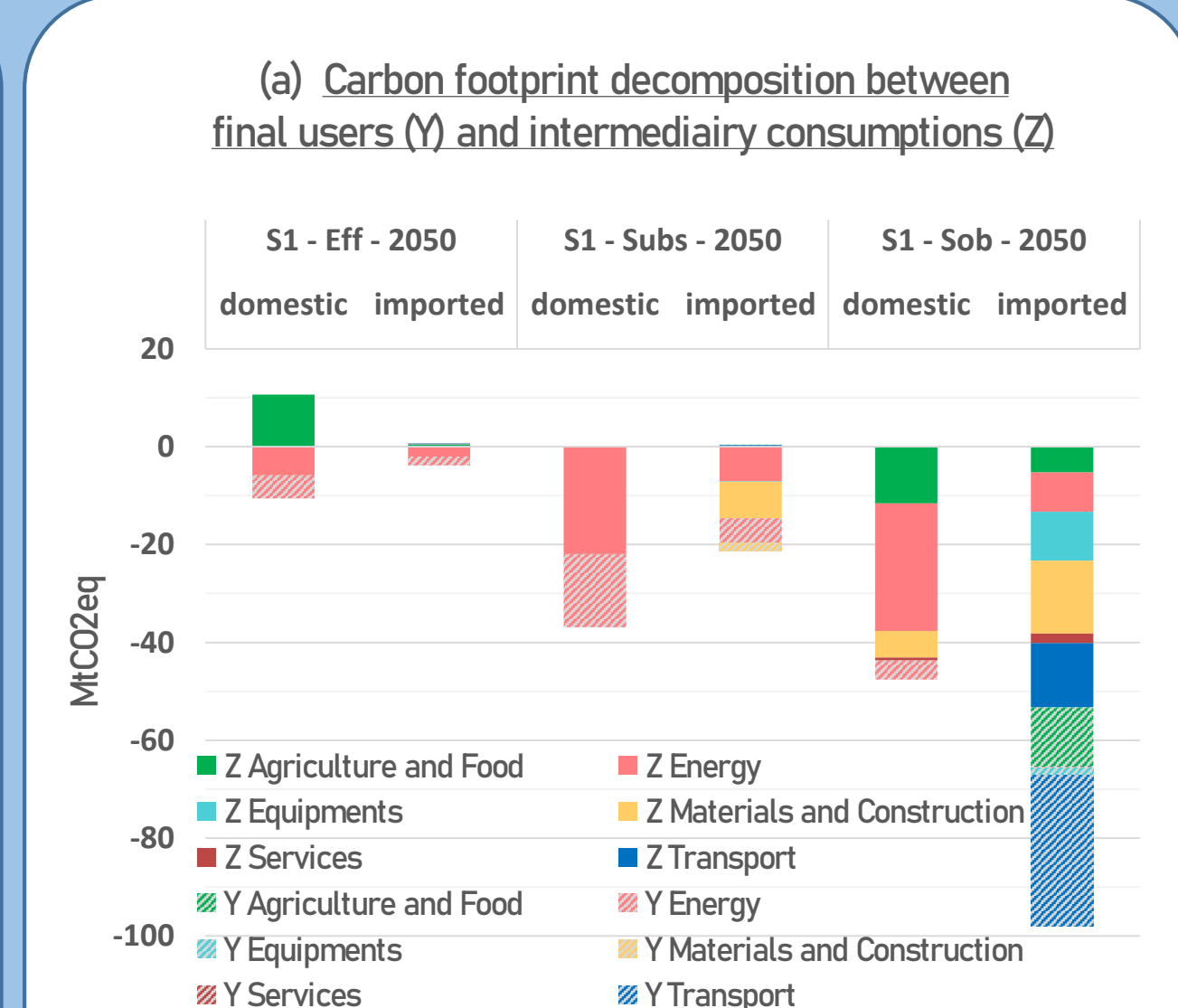
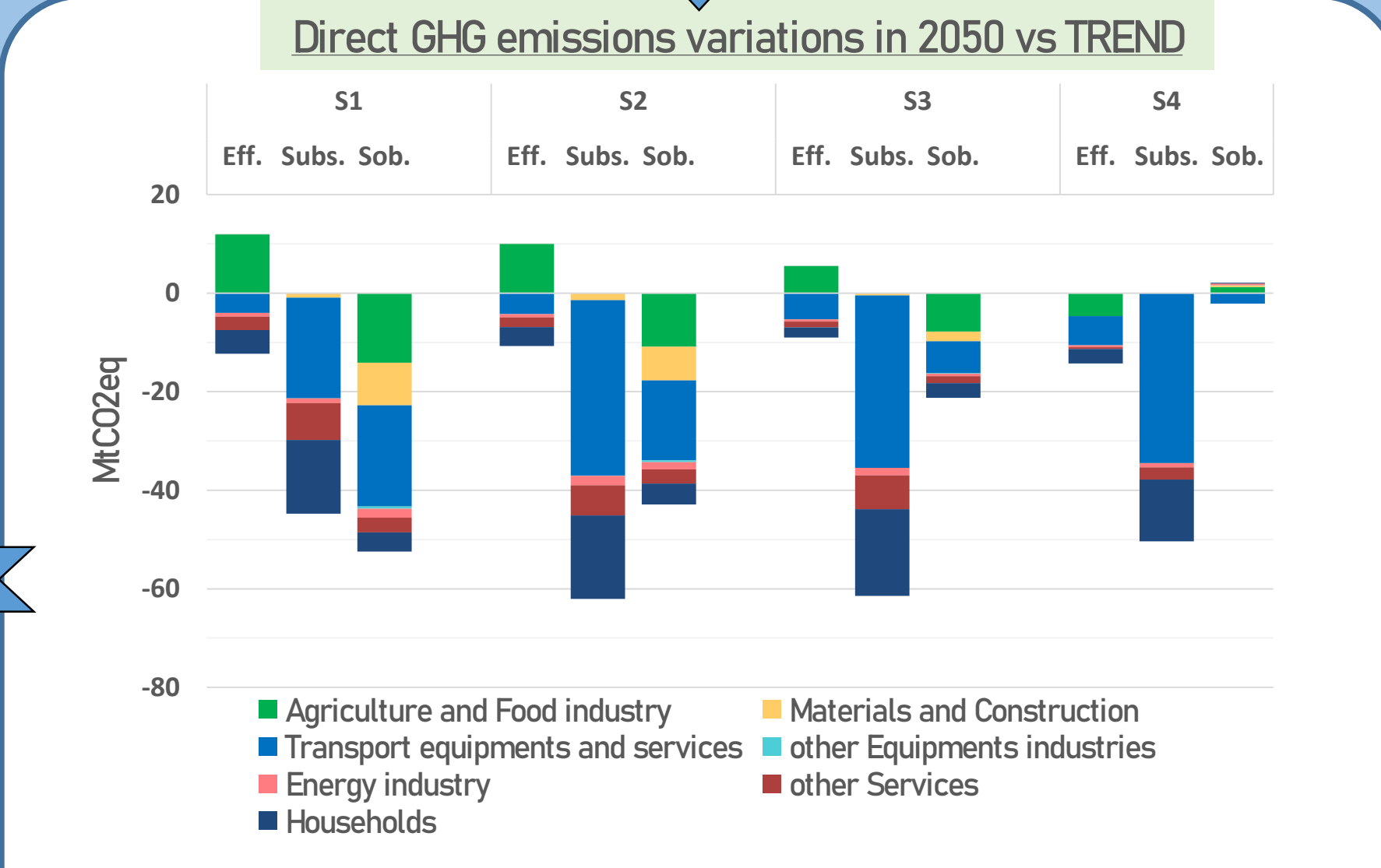
BU projections (vs TREND) after classification of actions:

	Food	Buildings	Housing	Energy	Transport	Materials
Efficiency	Yields of animal production.	Performance of heating systems (kWh/m2)	Performance of heating systems (kWh/m2). Consumption of home appliances (kWh/unit)	Fill rates of freight by road.	Energy efficiency gains by mode.	
Substitution	Changing energy sources (electrification of heating)	Changing energy sources (electrification of heating)	Share of biofuel, biogas, renewable elec.	Use of wood for energy.	Use of recycled materials.	Use of wood. Mass of batteries in EV.
Sufficiency	Reduction of chemicals inputs in agriculture. Veg. diet.	New constructions (m2). Surface of stock (heating) (m2)	New constructions (m2). Number of home appliances (cf. energy).	Total gas, oil and elec. consumption - tions of households	Passengers & freight fluxes per mode (modal shift and total). Fill rates of passengers transports.	Average mass of cars (kg). Material substitution to lighten cars.

Results

Compared to TREND 2050:

- Weak effect of efficiency. Most effective lever on direct emissions = Substitutions (changes to « green » technological alternatives). => in all scenarios in transport services and buildings/households.
- Sufficiency can have strong effects on footprint (S1 & S2) compared to direct emissions (up to x3) because of high imports rates of final and intermediary material consumptions (a), largely driven by FD levels decrease (b). => in S1-Sob, FD explains 80% of CF drop (55% via imports only).
- As the 3 levers can be cumulated without eviction and substitution effect being similar in all scenarios, the more sufficiency actions are implemented, the bigger the drop on footprint.
- Scenarios' philosophies are retrieved in results. In terms of « final services », ranking of CF reduction potentials through sufficiency is: transport > gov + services > food > housing > equipments.



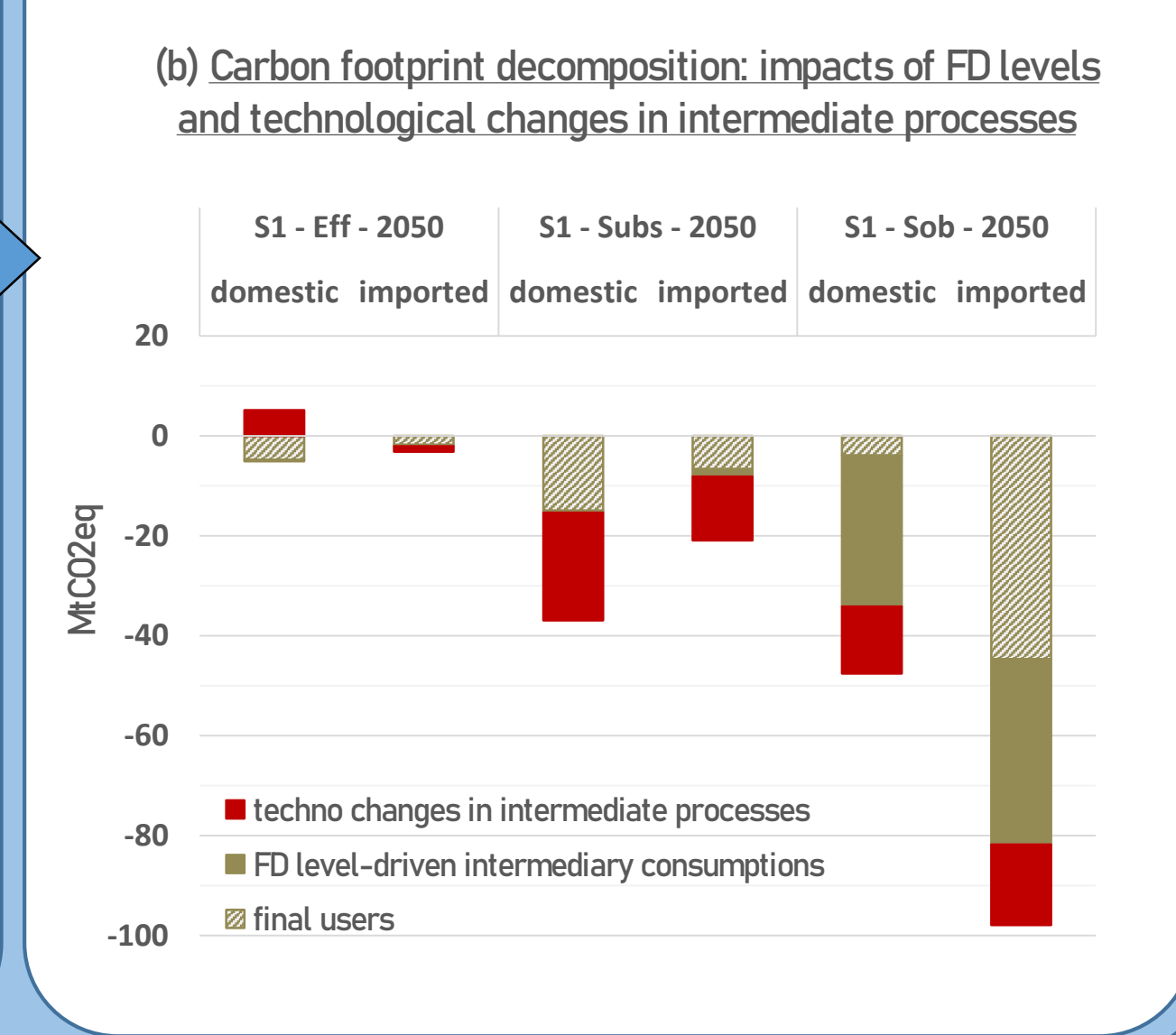
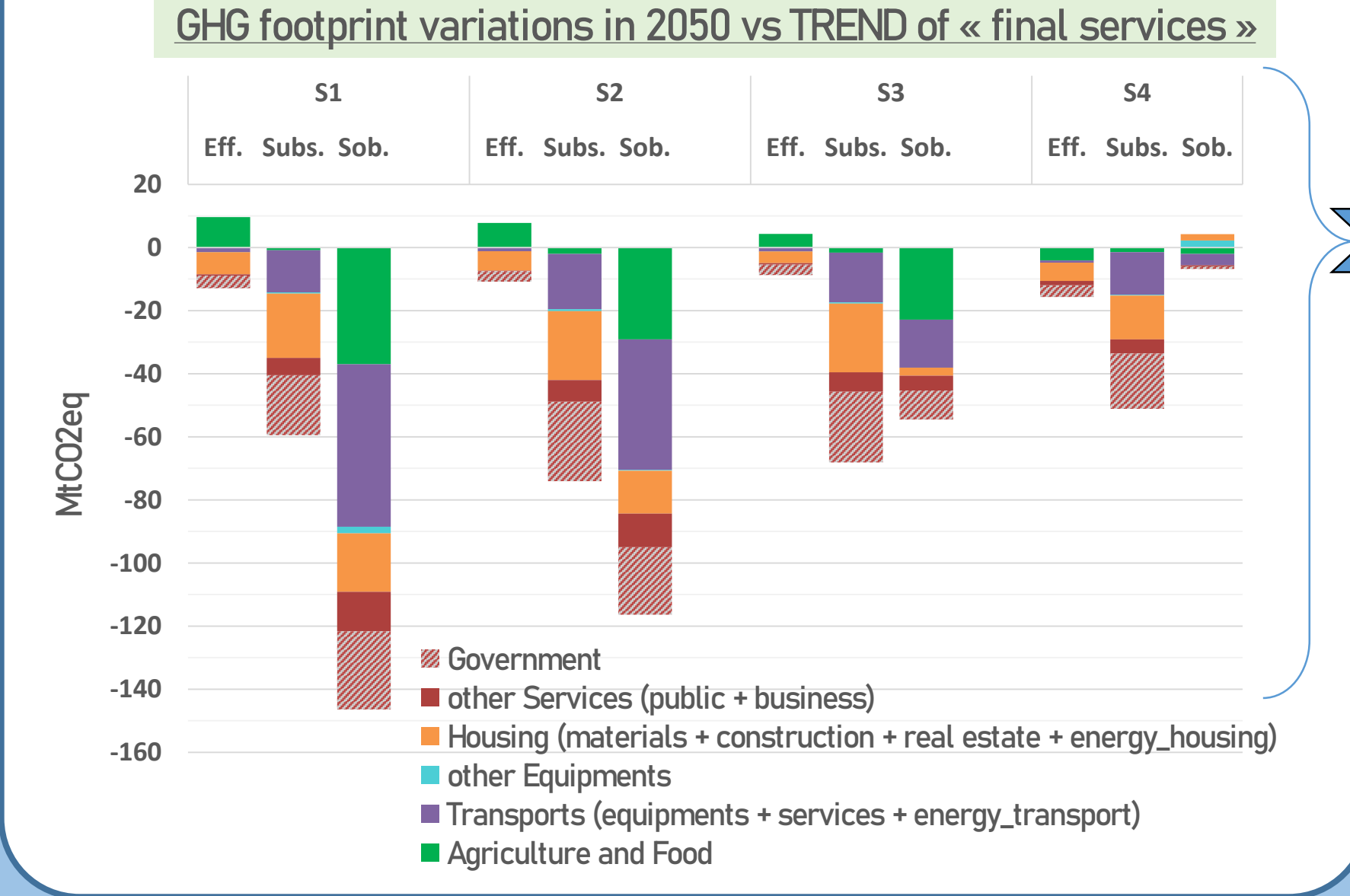
Future work

IDEAS IN THE SHORT TERM:

- Extend projections to more energy and non-energy consumptions.
- Analyse material footprints.

IDEAS IN THE LONG TERM:

- Disantangle macroeconomic consequences of sufficiency / efficiency / substitutions in TREND 2050 and define BU projections vs 2015.
- Study economic impacts of sufficiency BU actions.
- Post-growth scenarios, through demand and supply sides actions.



References

← ADEME scenarios

MatMat model technical reports →

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