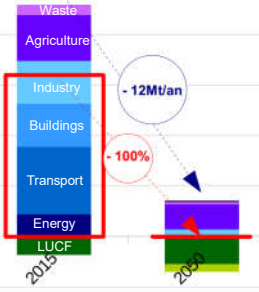


## 1 Introduction



Net-zero GHG emissions in France in 2050:

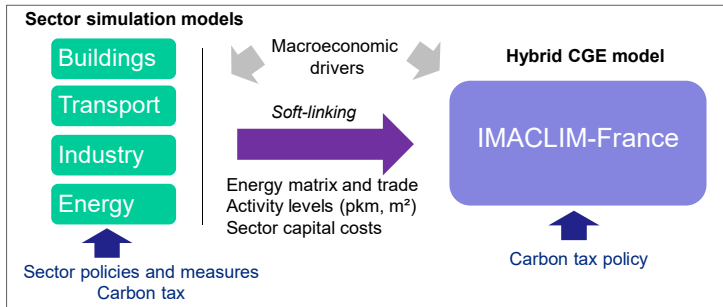
- Residual emissions in Agriculture, Industry and Waste sectors
- Carbon sinks in LUCF sector and via CCS technologies offset residual emissions
- Zero energy-related CO2 emissions required**

### Research questions:

- What techno-economic pathway to reach zero energy-related emissions?
- What macroeconomic and social implications of the transition in the medium and long run?

## 2 Methods

### Linked energy-economic modelling



## Scenarios

	Current Policies (CP) scenario	Net-zero Emissions (NZE) scenario
<b>Macroeconomic drivers</b>		
Trend GDP growth	1.4%/yr (2010-2030) – 1.8%/yr (2030-2050)	Id
World energy prices	IEA RTS 2030-2050: Oil (USD/bbl): 111 - 137 Gas (USD/MBtu): 10.3 – 12.6	IEA 2DS 2030-2050: Oil (USD/bbl): 85 - 72 Gas (USD/MBtu): 9.4 – 10.5
<b>Buildings</b>		
<i>New buildings</i>	Thermal regulations and energy standards (< 50kWhPE/m <sup>2</sup> /yr)	<i>New buildings</i> More stringent thermal regulations and energy standards: energy consumption ceiling (+ GHG criteria) per use to reach 20 kWhFE/m <sup>2</sup> /yr in 2050
<i>Retrofitting of existing buildings</i>	Tax credit (30% of investment) and zero-interest loan	<i>Retrofitting of existing buildings</i> Stronger incentives 700,000 retrofitted dwellings/yr and full low-energy buildings by 2050 GES criteria included
<b>Transport</b>	+35% p.km/t.km in 2050 No significant modal shift New vehicle standards (LDV and trucks) - Ex: ICE cars: 4.7l/100km beyond 2030 Slow electrification of LDV fleet, little incorporation of low-carbon fuels (biogas, biofuels) Fiscal incentives (bonus-malus, premiums, etc.)	+30% p.km/t.km in 2050 Modal shift: 4% from cars to collective transport and bike New vehicle standards (LDV and trucks) - Ex: ICE cars: 2l/100 km in 2050 Massive electrification of LDV fleet, mixed electric/biogas/biofuel fleet for trucks and buses; penetration of low jet-fuel Increased occupation rate (+15% in 2050) of cars Stronger fiscal incentive
<b>Industry</b>	Incentives for electrification of processes EU-ETS	Maximum energy efficiency 80% electrification target, rest bioenergy Circular economy, bio-sourced materials EU-ETS
<b>Energy</b>	Current support to REN extended	Zero carbon energy system in 2050: zero carbon electricity and heat + bioenergy Strong support to REN
<b>Carbon tax policy</b>		
Carbon price	100€/tCO <sub>2</sub> from 2030 to 2050	225€/tCO <sub>2</sub> (2030), 400€/tCO <sub>2</sub> (2040), 600€/tCO <sub>2</sub> (2050)
Recycling	Decrease of payroll taxes (PT)	Hybrid recycling (HB): Lump sum to households + energy cost offset of productive sectors

## 4 Discussion

- Possible macroeconomic and social dividend with the net-zero emissions scenario
- Need to manage the transition through appropriate recycling of carbon revenues and to deal with the uncertainty linked to the international context (global climate action and fossil fuel prices especially)
- Beyond, need to:
  - Deal with short-term issues: carbon tax impacts, de-risking of low carbon investments
  - Close the "financing gap" for the required investments

## 3 Results

### CO2 emissions pathways

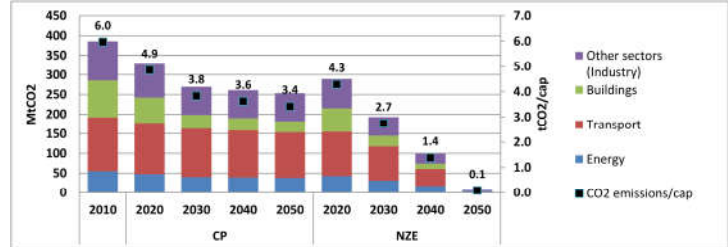


Figure 1. CO2 emissions and CO2 emissions/cap in CP and NZE scenarios

### Macroeconomic and social implications

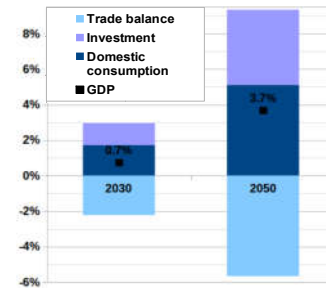


Figure 2. Decomposition of relative GDP variation in NZE compared to CP in 2030 and 2050

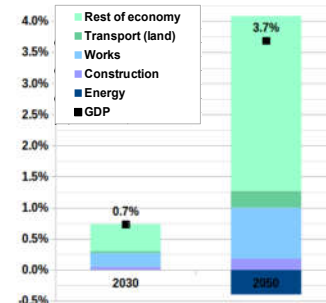


Figure 3. Sector contributions to relative GDP variation in NZE compared to CP in 2030 and 2050

- Macroeconomic dividend in NZE scenario, enhanced in the long run
- Virtuous cycle through investment stimulus, energy efficiency gains and cancellation of fossil fuel imports / more than offset mitigation costs in the long run
- Ripple effect of key sectors (construction, works and transport) on the rest of the economy
- 700 000 additional jobs in 2050 (70% in the construction sector)

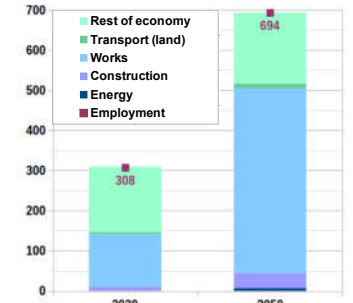


Figure 4. Variation of employment in NZE compared to CP in 2030 and 2050. (full time equivalent jobs)

### Management of the transition

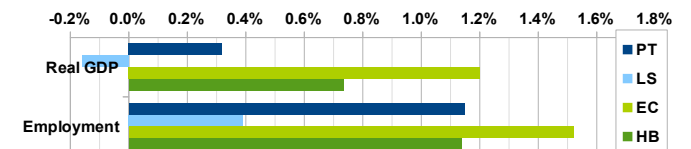


Figure 5. Relative variations of GDP and employment in 2030 in NZE compared to CP according to the recycling scheme of carbon tax revenues in NZE. PT: reduction of payroll taxes; LS: lump sum transfer to households; EC: redistribution of revenues to productive sectors according to their energy costs; HB: reference hybrid recycling scheme

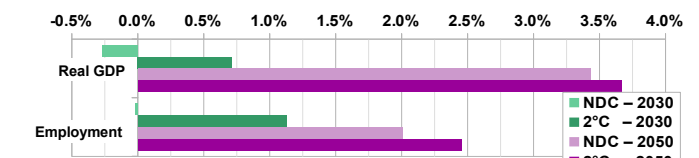


Figure 6. Relative variations of GDP and employment in NZE compared to CP in 2030 and 2050 according to the international context in NZE. NDC: AIE RTS fossil fuel prices; 2°C: AIE 2DS fossil fuel prices