Orienter la future transition énergétique vers le zéro émission nette de CO_2 : le cas de la France et de la Suède

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Introduction

Energy transition to low-carbon future will not occur spontaneously

France and Sweden: 2 similar countries

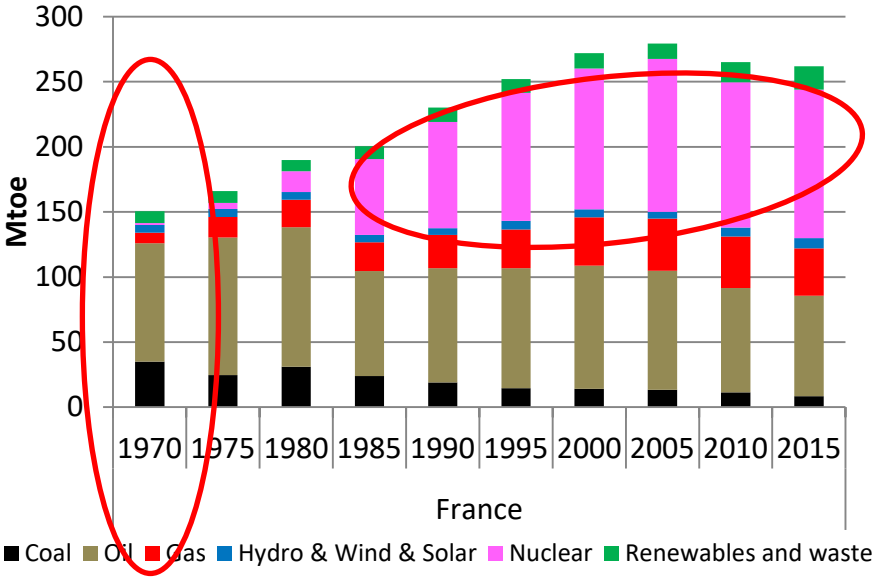
- High share of **nuclear** and **hydro** in electricity mix
- High potential of **biomass**
- **Ambitious** climate goals

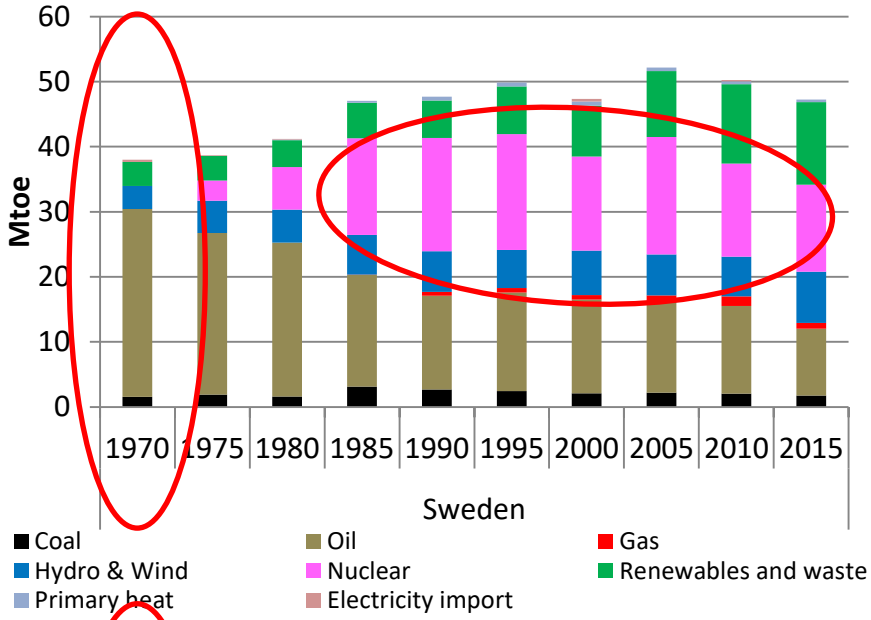
BUT also have differences

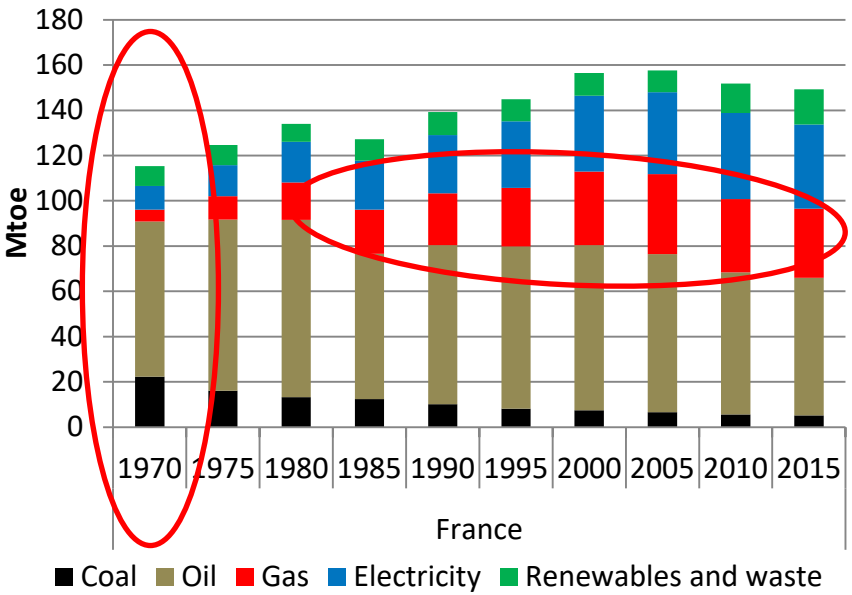
Can we get insights from how to achieve the energy transition to net-zero emission by comparing those two countries, which share similarities, but still partly have chosen different pathways? And if yes, which are those insights?

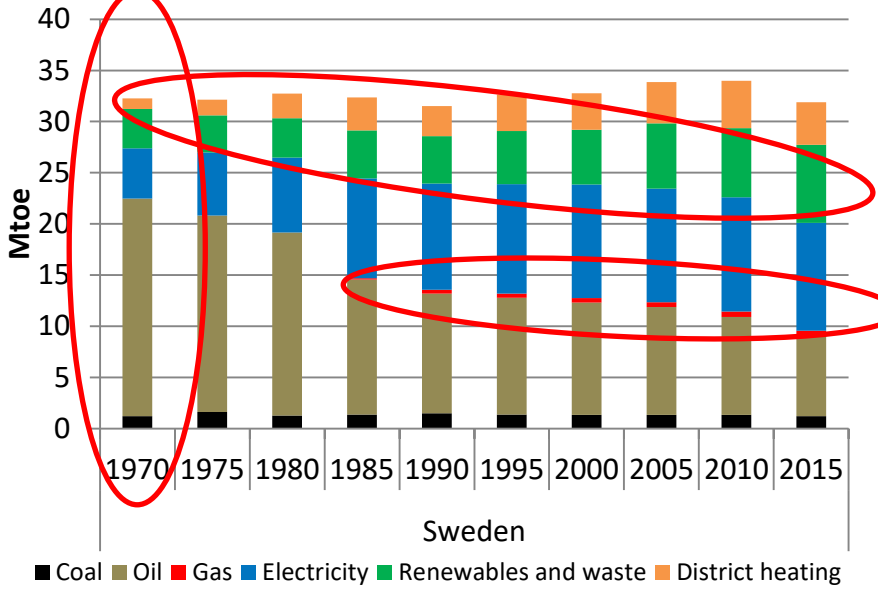
PAST EVOLUTION OF THE ENERGY SYSTEMS IN FRANCE AND SWEDEN

Primary and final energy consumption









Main drivers in both countries

Area	France	Sweden
Nuclear program	Launched after WWII **Massive deployment** enabled by: - Strong support of the technocratic elite - Economies of scale **Since 2010**: debate on the nuclear place	Launched after WWII **Significant deployment** enabled by: - Support from the state and energy-intensive industries **Since 1979**: regular announcement of nuclear phase-out
Biomass	Until the mid-2000s: **few measures** to support Currently: development of biofuel and biogas	**Numerous measures** to support its development : - Research program - Link with the forest industry - Continued and consistent political support
District heating	No specific support due to low electricity price (overcapacity) and warmer climate	- Housing programs - Support from municipalities, cooperation with energy industries
Carbon tax	**Recent implementation** but subject to strong protests → evolution currently stopped	Tradition of energy tax **Fiscal reform in 1991** → introduction of a carbon tax, continuous and progressive increase since

Two different approaches to energy policy 1/2

- France: **A technocratic vision focusing on nuclear power**
  - Significance of nuclear power in the French energy system
  - Other measures:
    - Implementation after the oil crisis but quickly abandoned (nuclear overcapacity)
    - Recently reinforced
  - Many challenges:
    - Reach law targets (French energy transition law for Green Growth)
    - Nuclear future: opening of Flamanville, decrease in the power mix, new construction, etc.
    - Evolution of the carbon tax

→ **one energy transition** (electricity sector)

Two different approaches to energy policy 2/2

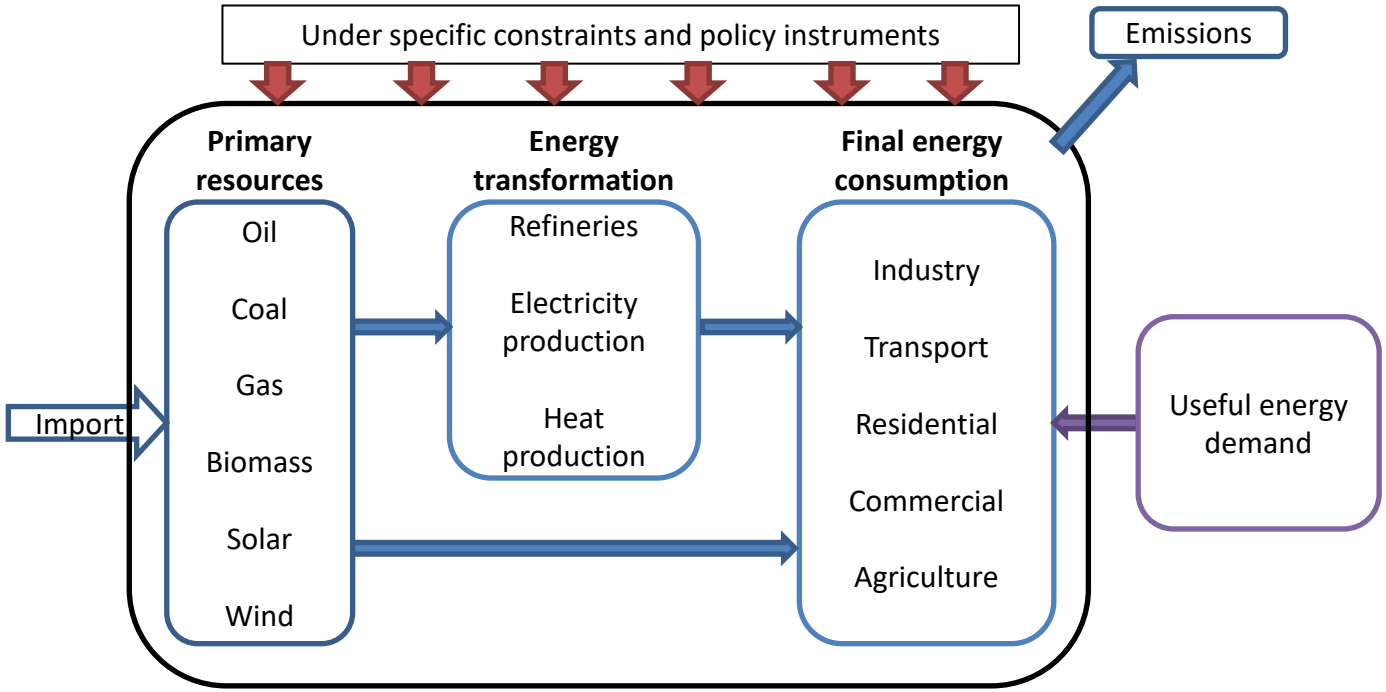
- Sweden: **A will to be a frontrunner that translates into multiple tools**
  - Nuclear, biomass, district heating, taxes
  - Shift in the driver of energy policy: energy independence → nuclear reduction
  - Measures proved to be well suited for the introduction of the carbon tax → CO_2 emissions reduction
  - Many successful evolutions:
    - High electrification of its energy system
    - High use of biomass (in particular in its industrial and residential sectors)

→ **two energy transitions** (electricity sector and heating sector)

WHAT TRANSITION FOR THE FUTURE? COMPARISON OF PATHWAYS TO CARBON NEUTRALITY

The TIMES modelling framework

- Use of TIMES model : TIMES-France and TIMES-Sweden
  - A bottom-up optimization model driven by services demand
  - Reference energy system:



- Optimal choice of technologies by minimizing the overall discounted cost of the energy system over a specified horizon:

$$\sum_{y \in Years} (1 + d_y)^{REFYEAR - y} * ANNCOST(y)$$

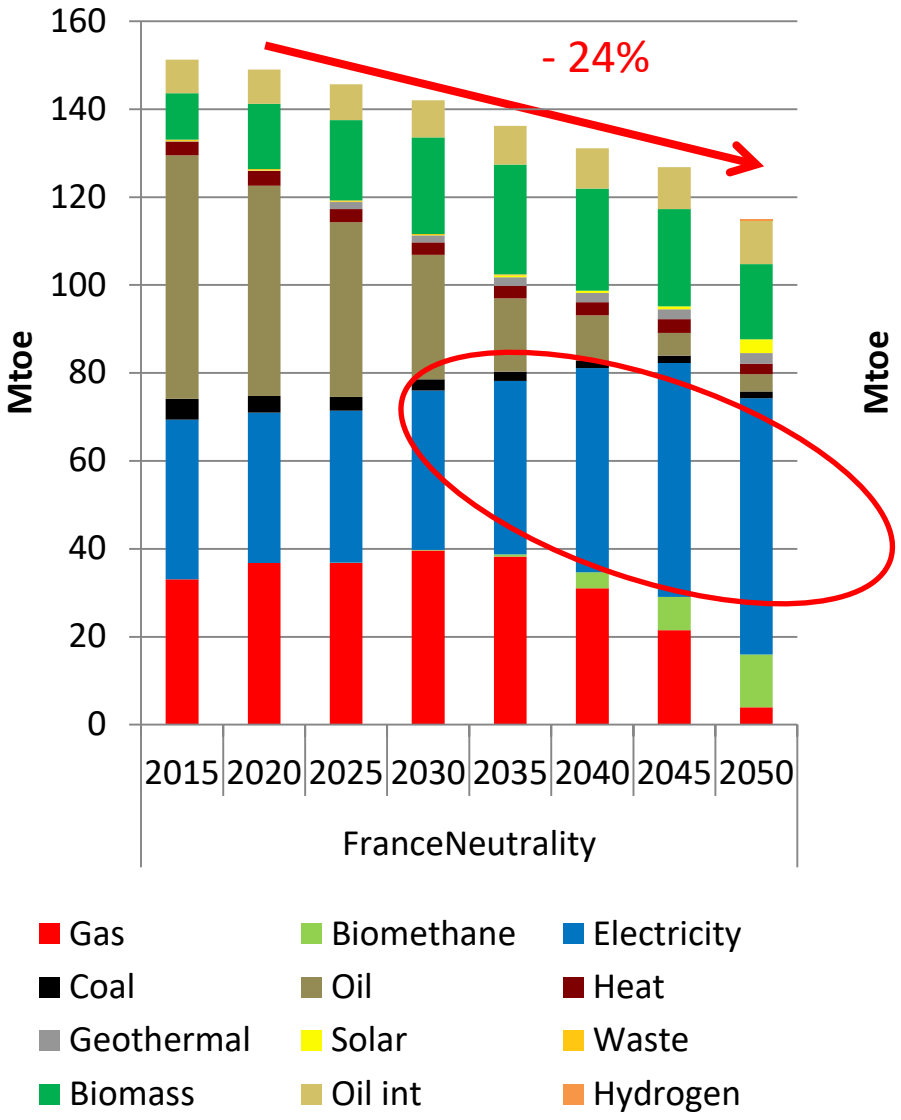
Two scenarios for carbon neutrality

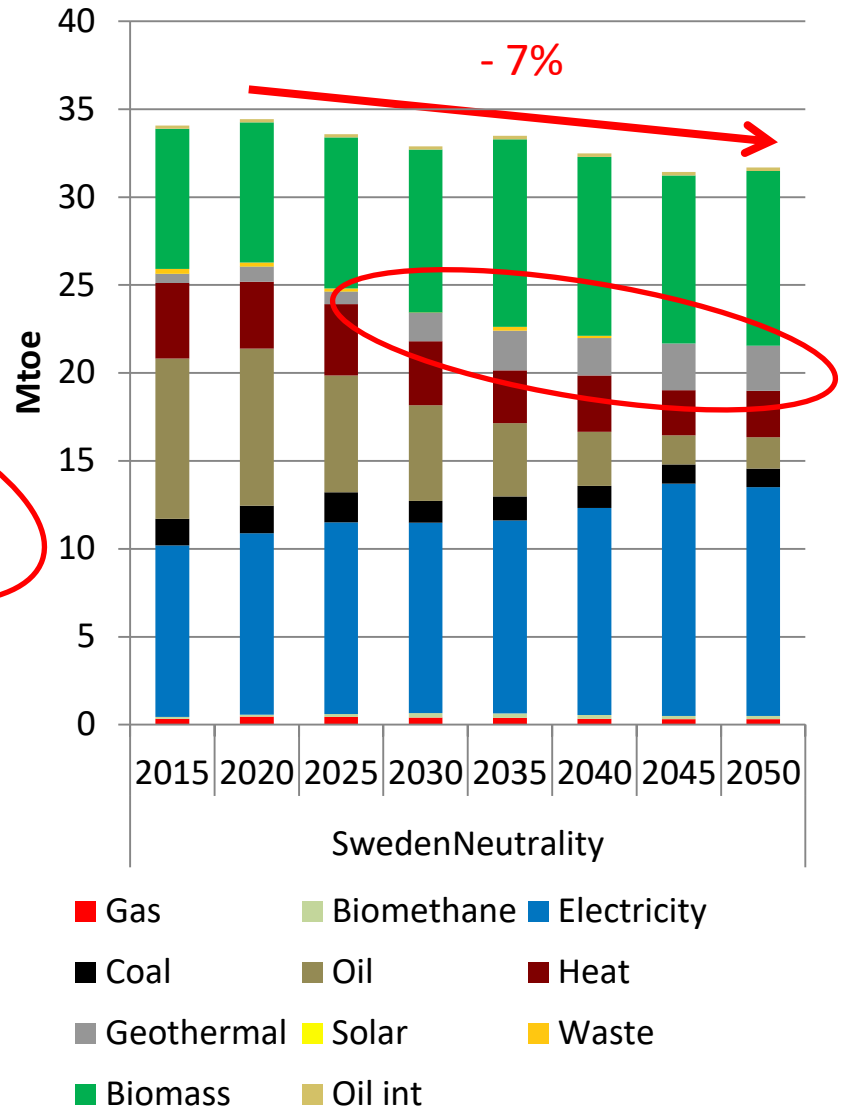
- The models share the same:
  - Reference Energy System, with some national adjustments
  - Techno-economic database but with adaptation to national context
  - EU-ETS: EU Commission projection
  - Energy prices: WEO 2018

- Differences:
  - Discount rate: France 4.5% / Sweden 3.5% (official recommendations)
  - Demand: France official projections / Sweden official projections + link with a national CGE model
  - Carbon neutrality goals: France 2050 / Sweden 2045
  - Nuclear constraint in France: 50% by 2035

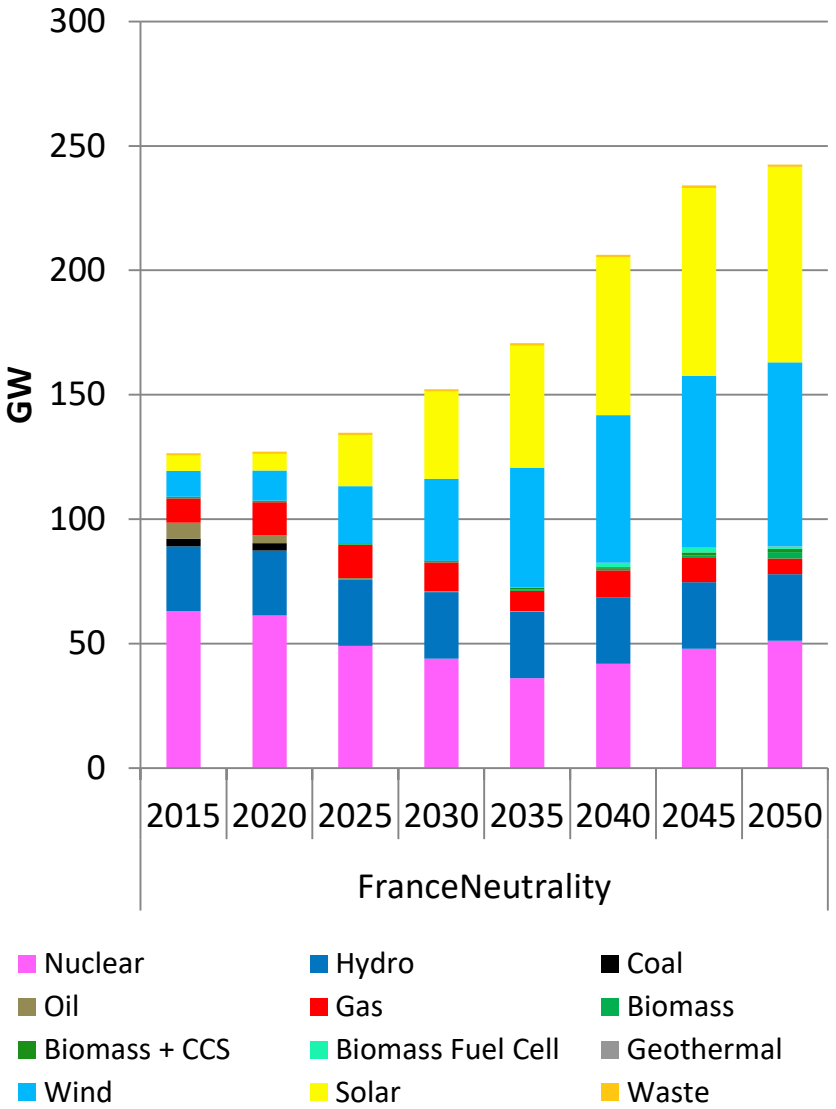
- Two scenarios:
  - FranceNeutrality
  - SwedenNeutrality

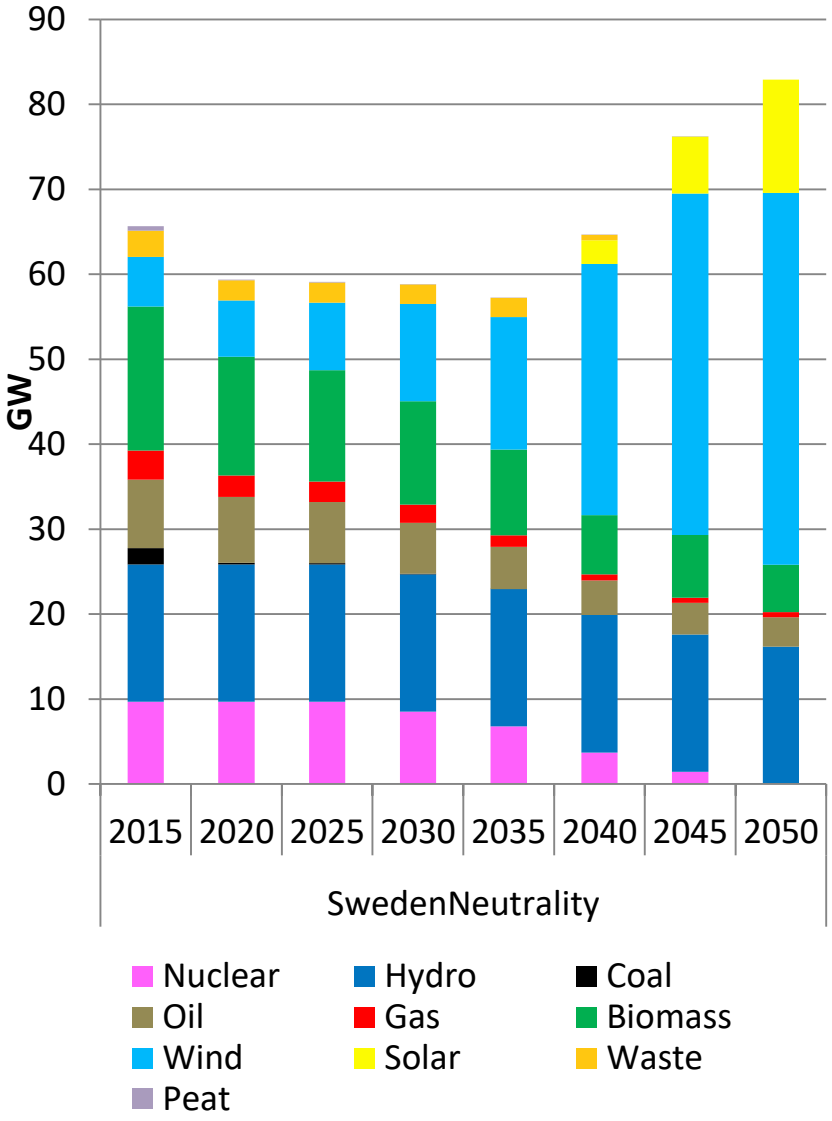
Final energy consumption



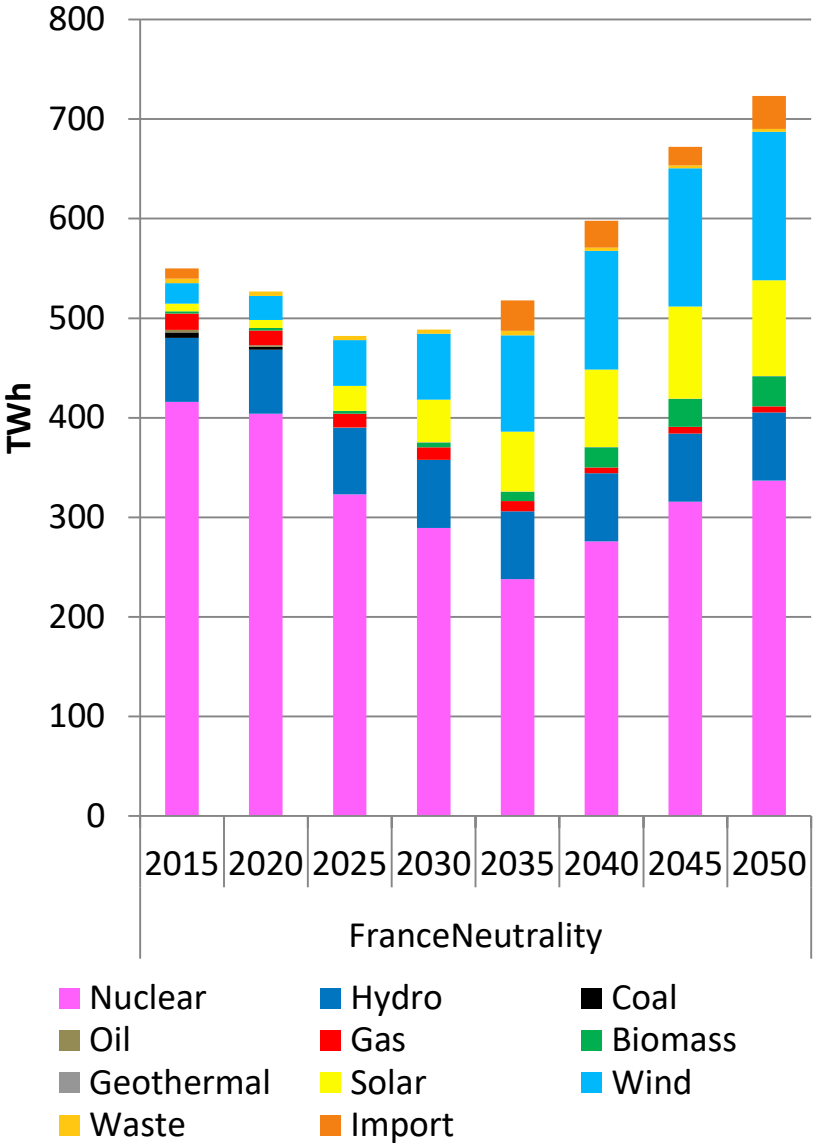


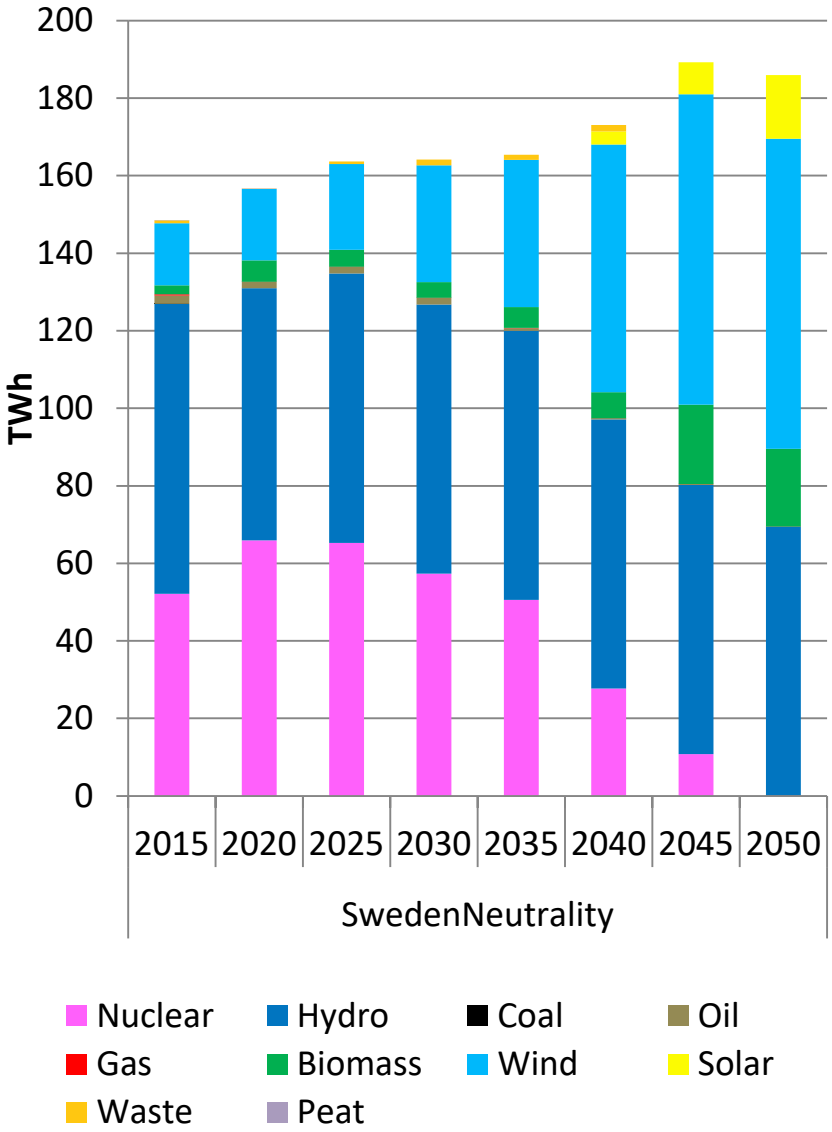
Power sector: capacities 1/2



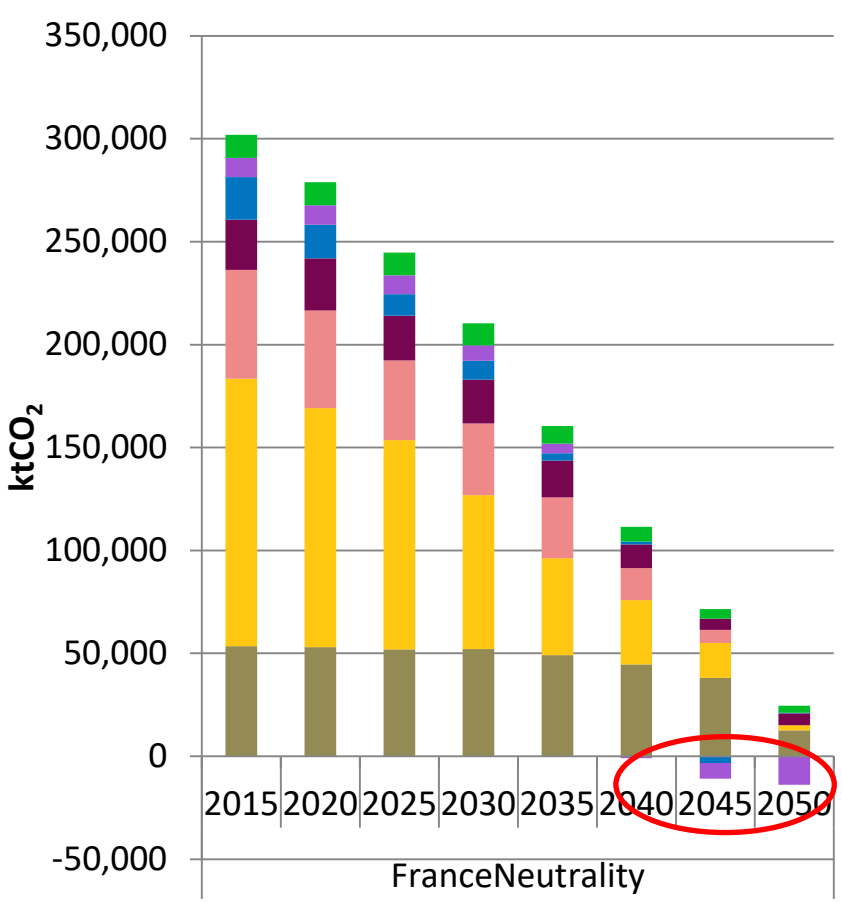


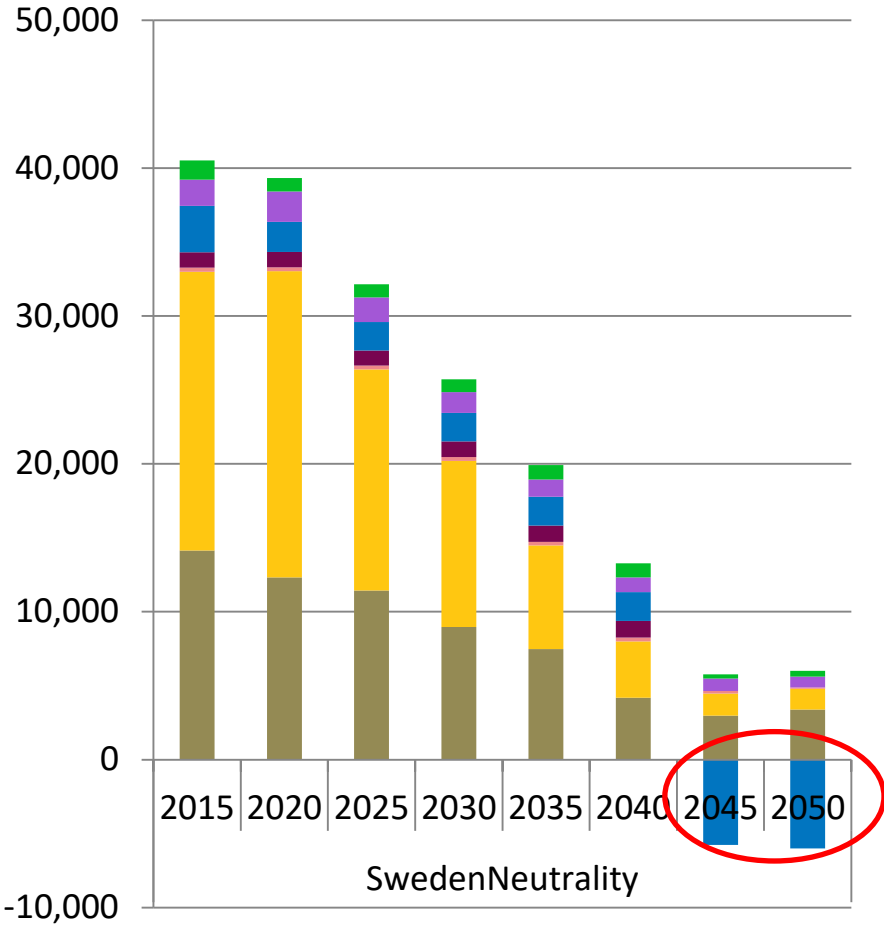
Power sector: production 2/2





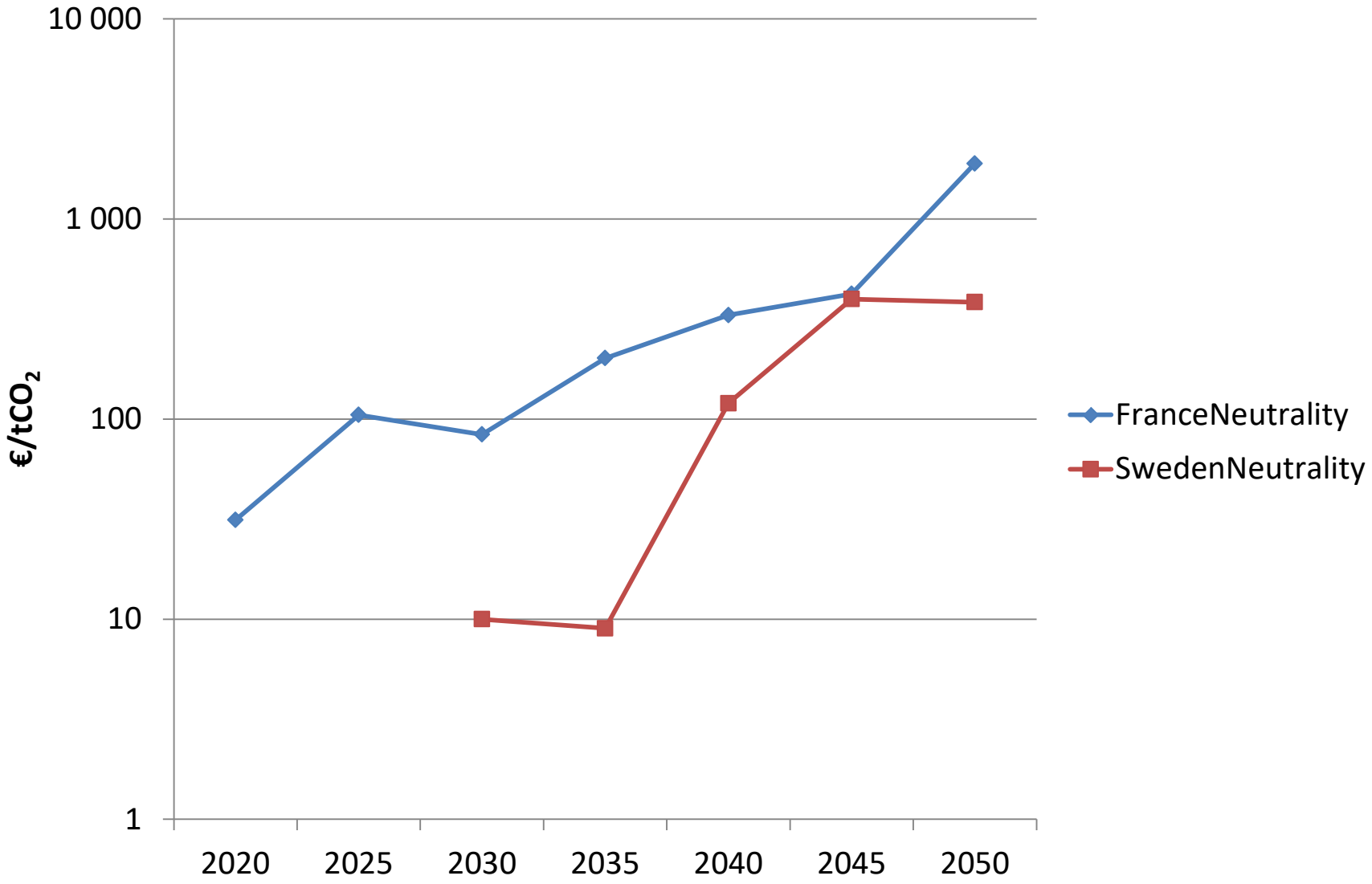
CO_2 emissions





Industry
Transport
Residential
Commercial
Electricity and Heat
Supply
Agriculture

Marginal cost of CO_2



Discussion and conclusion

- Importance of public policies to explain the past energy transitions in Sweden and in France:
  - Objectives were not environmental
  - Managed to decrease their oil dependence but through different measures
  - Sweden: developed measures that afterwards proved effective to reduce CO_2 emissions even if it was not their main goal
- Future energy transitions:
  - Different challenges in most sectors:
    - Sweden: Transport & Industry sectors
    - France: Electrification of its industry sector, transport sector, residential and commercial sector, decarbonization of gas consumption
  - Development of negative emissions
  - Resulting marginal cost indicates that Sweden goal is more realistic than the French one

THANK YOU FOR YOUR ATTENTION

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Policy implications

- Public policies should set realistic and achievable climate goals
- Targets should be supported by a long-term vision for the energy system → Investments in some technologies like nuclear or CCS must be anticipated.
- Consistent and long-term support for public energy policies
- Next question: governance issue

Energy system and economic indicators

Indicator	EU average		France		Sweden	
	1990	2016	1990	2016	1990	2016
Population [thousands poeple]	475,188	510,277	58,227	66,730	8,527	9,851
Population growth		7%		15%		16%
GDP [Mrd EUR at 2010 exchange rates]	8,988	13,825	1,440	2,122	243	423
GDP growth		*54%*		*47%*		*75%*
GDP [Mrd EUR] per capita	18.915	27.093	24.732	31.801	28.455	42.990
FEC per capita [Mtoe/cap]	2.3	2.2	2.3	2.2	3.7	3.3
Energy per Capita [Mtoe/cap]	3.5	3.2	**3.9**	**3.7**	**5.6**	**5.0**
CO2 Fuel combustion	4,126	3,234	363	315	52	37
growth		*-22%*		*-13%*		*-29%*
CO2 per Capita (energy system only) - kg CO2/cap	8.7	6.3	**6.2**	**4.7**	**6.1**	**3.7**
CO2 emissions - National total (incl. international aviation)	4,545	3,637	407	357	59	45
growth		*-20%*		*-12%*		*-23%*
CO2 per Capita - kg CO2/cap	9.6	7.1	**7.0**	**5.4**	**6.9**	**4.6**
GHG emissions - National total (incl. international aviation)	5,720	4,441	555	475	73	55
growth		*-22%*		*-14%*		*-24%*
GHG per Capita - kg CO2/cap	12.0	8.7	**9.5**	**7.1**	**8.5**	**5.6**