ELECTRIC VEHICLES IN THE EUROPEAN UNION: CONDITIONS FOR SUCCESS, IMPACTS ON POWER SYSTEM AND ON CO$_2$ EMISSIONS

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OUTLINE

Context

Objectives

Methodology

Results

Major Findings

CONTEXT

- Passenger car journeys are about 72% of all passengers kilometers.

- Private cars are projected to double the passenger transport activity between 1990 figures and 2030.

- IN EU_{27}, the number of kilometers travelled by passenger grew by 1.2% in 2007 compared to 2006.
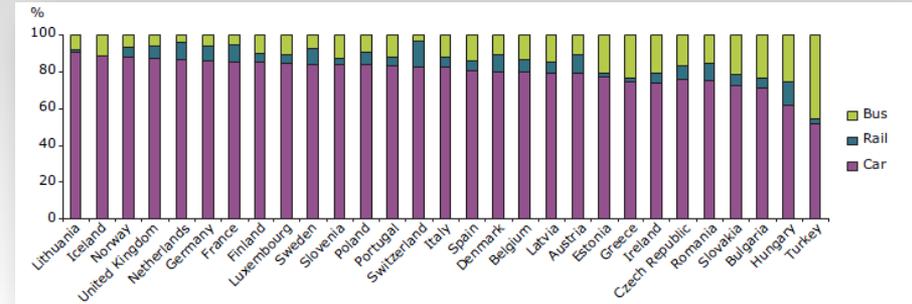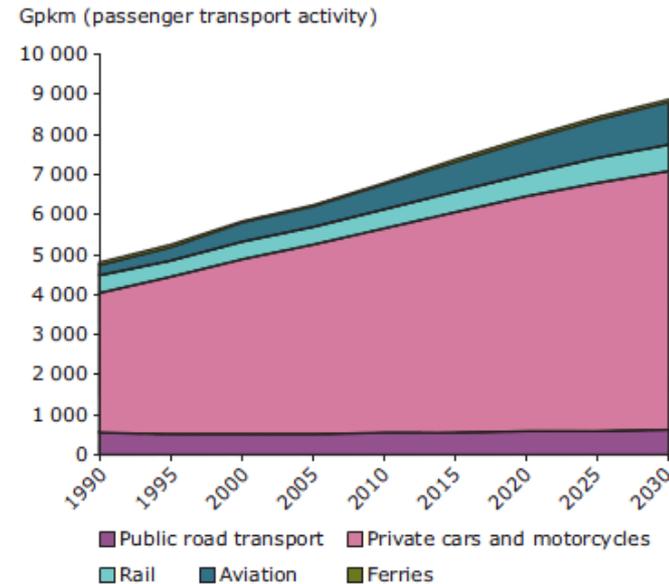

Figure 1 – Transportation Modes (Source: Eurostat, 2009)

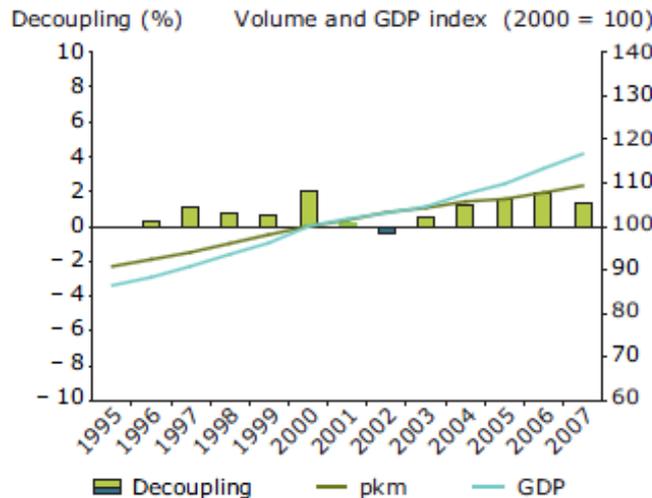Figure 2– Passenger Transport Activity

Figure 3 - Pkm evolution (Source: EEA (2010) - TERM 2009)

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OBJECTIVES

→ GHG emissions from the transport sector continue to grow (*i.e. 28% between 1990 and 2007*) and represent 20% of total EU_{27} emissions.

- What are the cost-effective conditions for a large-scale adoption of Electric Vehicles by EU_{27}, up to 2050?
- What is the expected impact of such option on the electricity portfolio?
- What can be expected on final energy shifts?
- What is the contribution to CO_2 emissions reduction of such an option?

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METHODOLOGY – PET MODEL

PET**36** is an optimisation techno-economic TIMES model covering the EU27 plus Norway, Iceland, Switzerland, and the Balkan countries. It is a 36 multi-region model of these countries energy systems linked through trade of the main energy forms and most of its national energy systems were validated by national teams. The model runs from 2005 to 2050, with 5 years interval.

The transport sector is disaggregated into
   aviation, navigation and freight and passenger transport
   trains, urban metro, buses, trucks, passenger cars and motorcycles.

Our focus: passenger cars,
         short (urban) and long distance.

PET**36** is driven by an exogenous country-specific mobility demand for pkm.
   ➢Each country has its own transport sector profile with varying long distance and short distance demands.
   ➢Transference of pkm between modes (*e.g. from cars to buses or trains) is an exogenous input and* therefore not subject to optimization.

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METHODOLOGY – MODELING TOOL

Possible future configurations of each country energy systems are represented in the model as a network of processes and commodities, the so-called Reference Energy System (RES).
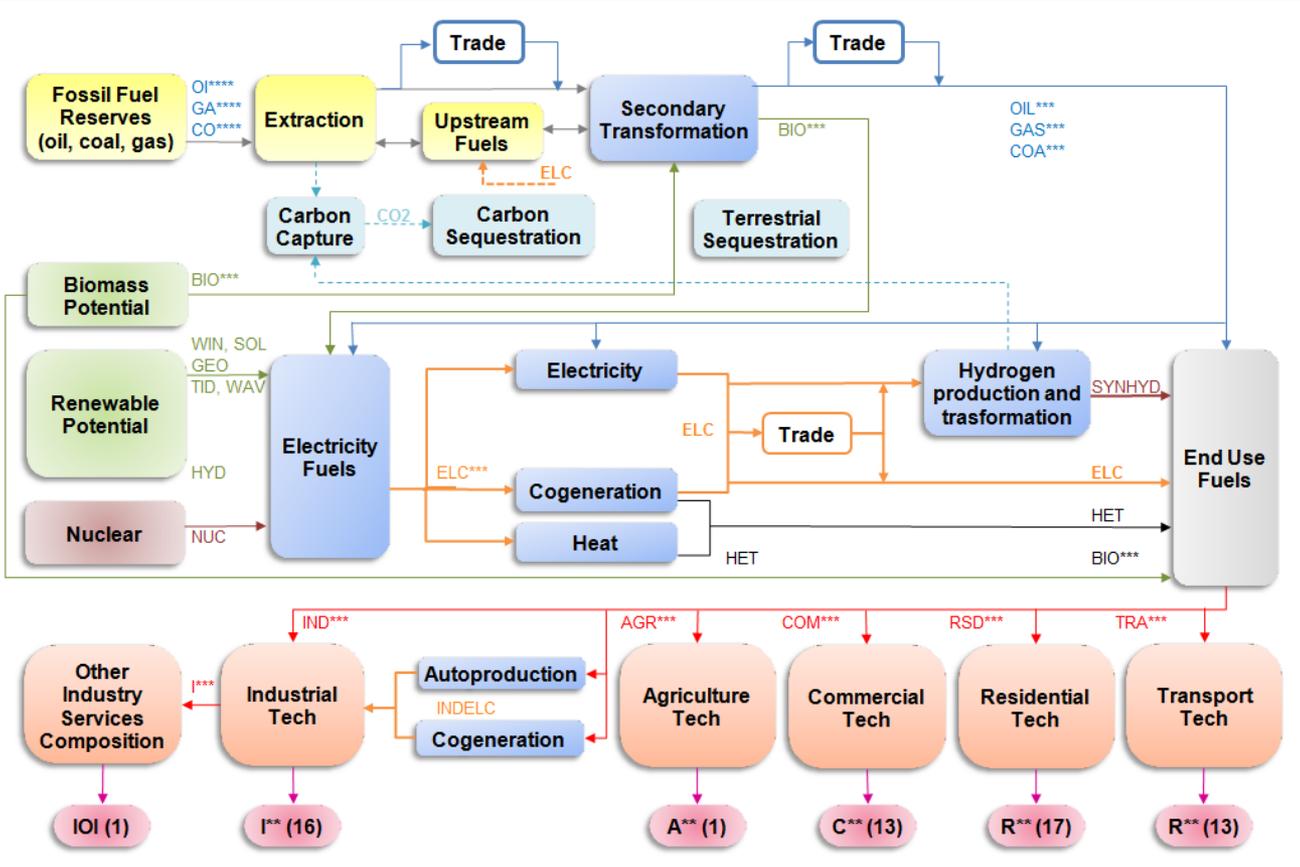
The model determines:

- optimal mix of technologies and fuels at each period,

- associated emissions,

- mining & trading activities,

- equilibrium level of the demand.

Figure 4– High level reference energy system of the PET country single models (Kanlo, 2010)

METHODOLOGY– Electric vehicle tech.

Selected economic and technical parameters of EV considered in PET[36] model

Technology	Investment cost (1000 €₂₀₀₀)		Short distance Efficiency (MVkm/PJ)		Long Distance Efficiency (MVkm/PJ)	
Car/Year	2010	2050	2010	2050	2010	2050
Electric Car 15kWh	23.54	13.95	2.78	3.56	2.22	2.85
Electric Car 30kWh	28.60	16.72	2.31	3.27	1.85	2.61
Electric Car 60kWh	66.59	22.26	1.85	2.85	1.39	2.41

It was assumed that from 2025 onwards EV are able to supply long distance mobility similarly to any other car, since it is also assumed that by then the battery technology will evolve to allow quick replacement at any "charging station".

REF SCENARIO

METHODOLOGY – SCENARIOS

	Scenario	Assumptions on EV	CO$_2$ cap (-50% in 2050/1990)
	REF	None	no
A)	CAP		yes
B)	-30%	Reduction of 30% on EV investment cost compared to REF from 2020 to 2050	no
	CAP-30%		yes
B)	-70%	Reduction of 70% on EV investment cost compared to REF from 2020 to 2050	no
	CAP-70%		yes
C)	URB	EV supply a minimum of 12% of urban individual cars pkm from 2030 to 2050	No
	CAPURB		yes
D)	CAP75%	EV supply a minimum of 75% of individual cars pkm in 2050	yes

With the purpose to analyze:
A) the effect of a carbon cost (generated as a shadow price from a CO$_2$ cap imposition)
B) the possibility of an acceleration of EV cost reduction
C) the interdiction of non-clean vehicles in EU big urban areas
D) an optimistic perspective on EV rate in EU (impact on power production)

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METHODOLOGY – ASSUMPTIONS

→ EU 20% target on renewable final energy in 2020 & 10% in transport sector.

→ **No Nuclear** for: Austria, Cyprus, Denmark, Estonia, Greece, Italy, Ireland, Latvia, Luxembourg, Malta, Portugal; **Nuclear Phase out** after the decided extension of lifetime for: Belgium, Germany, Sweden, Spain; **Possible New Nuclear**- no lifetime extension: Bulgaria, Czech Republic, France, Finland, Hungary, Lithuania, Poland, Romania, Slovakia, Slovenia, United Kingdom. [before Fukushima]

→ Investment subsidies and feed-in tariffs to renewable energy as today in the MS.

→ REF scenario without Kyoto or post-Kyoto caps. Assumed that the current EU-ETS operates at a clearing price of $20€_{2005}/tCO_2$ in 2010. Carbon prices increase smoothly to $24€_{2005}/tCO_2$ for 2030-2050.

→ Fossil fuel prices from Reference Scenario of the World Energy Outlook 2008.

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RESULTS I

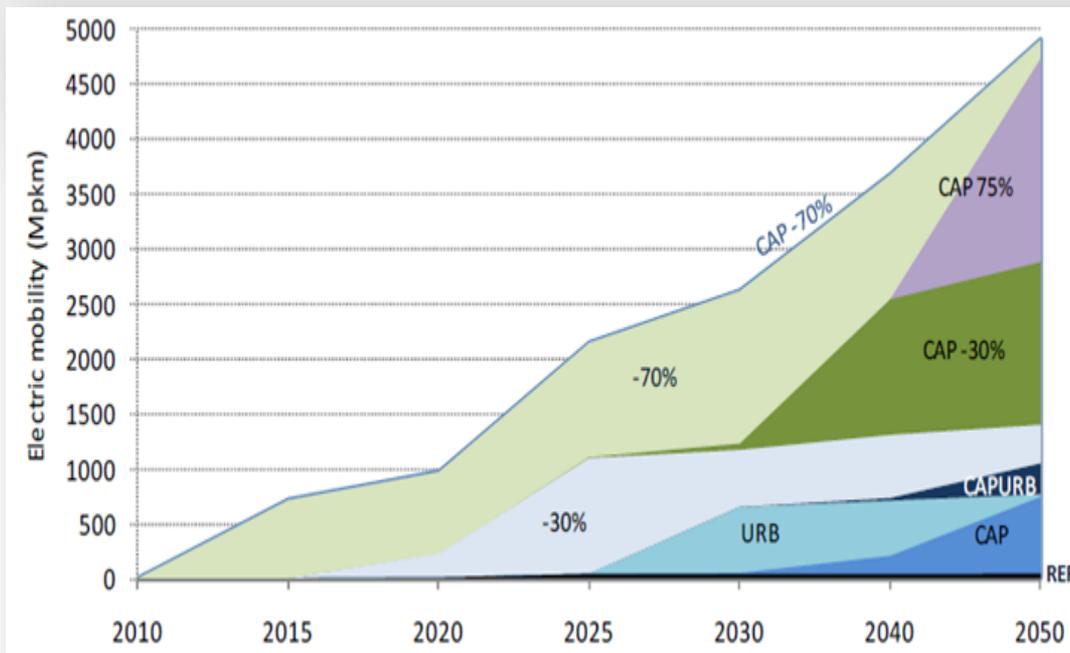## Mileage provided by EV in EU$_{27}$

Figure 5 – Electric Mobility (Mpkm) for EU27

- Without incentives EV are **not cost effective until 2020**. Only 1% of total car pkm until 2050.

- **CO$_2$ cap slightly increases EV competitiveness** from 2040 to 2050 (12% of pkm).

- A moderate cost reduction of 30% is enough to make EV more cost effective (22% of pkm). 46% if a CO$_2$ cap is added.

- A high cost reduction makes EV competitive already in 2015 (15% of pkm) and 77% pkm in 2050.

The CO$_2$ cap has an important effect in EV deployment for the no incentives (CAP) or moderate cost reduction (CAP-30%) scenarios, while it has no effect for the 70% cost reduction.

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RESULTS II

Share of mileage provided by EV in <u>2030</u> for -30% CAP-70% scenarios
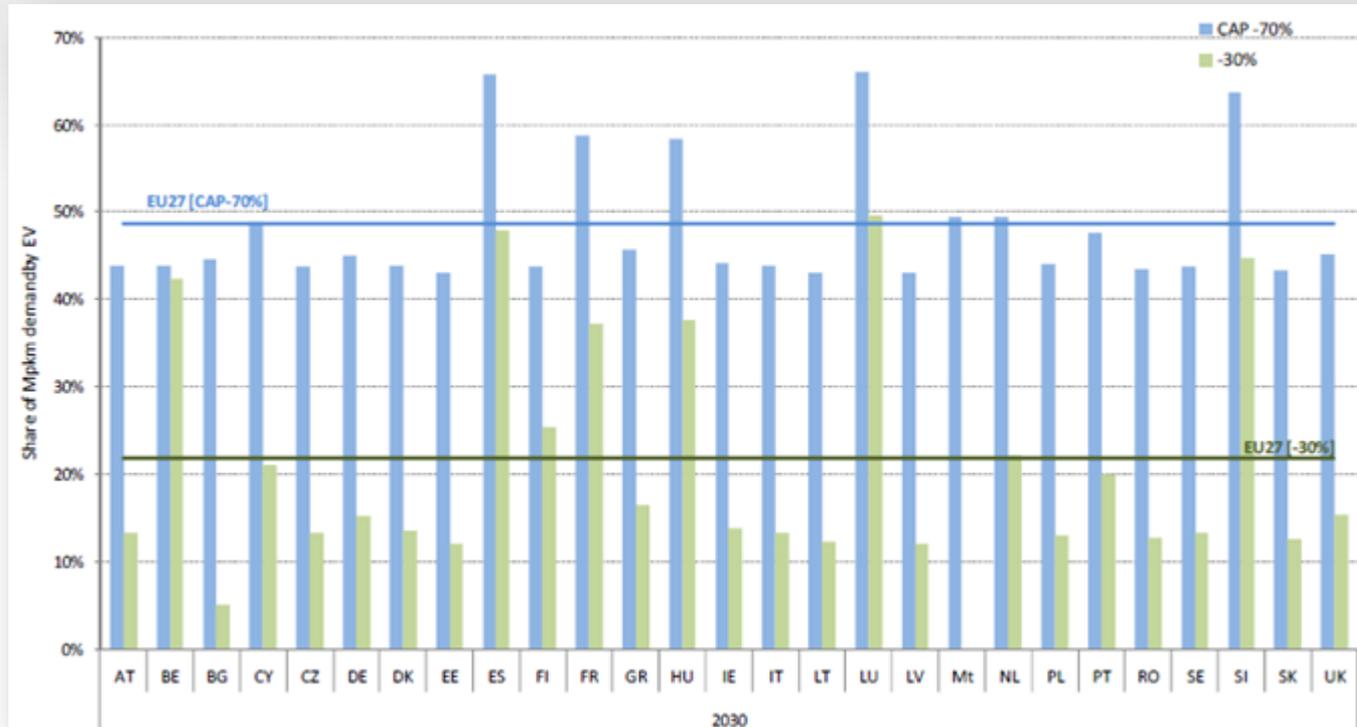
Figure 6 – Share of electric vehicles for the EU7, for two selected scenarios

Differentiated role of EV across EU$_{27}$ **depending on demand for long/short distance mobility & existing stock** with different efficiencies and fuel costs. (ES, LU *versus* MT).

The -70% cost reduction makes EV competitive at least to up 40% of delivered pkm in all MS.

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RESULTS III

Final energy consumption in passenger cars in 2030 and 2050

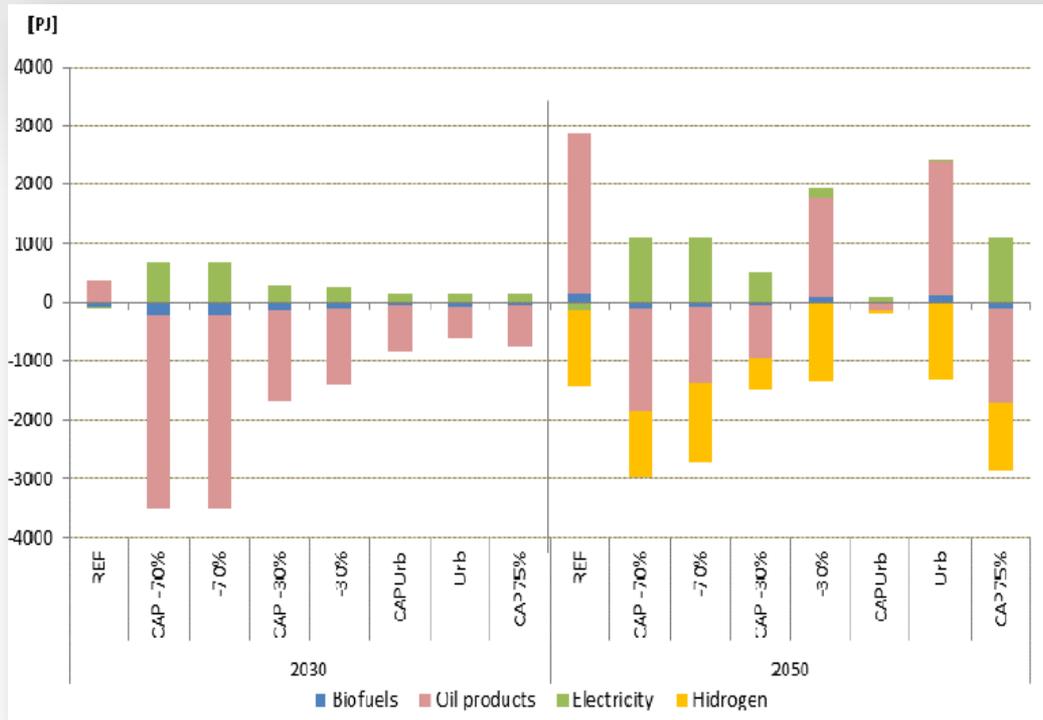**Figure 7 –** Impact of EV in final energy consumption of passengers cars computed as the difference to the Cap scenario for 2030 and 2050

- In **2030** there are no substantial differences between the CAP and REF as the cap is not very stringent yet.

- **Cost reduction** leads to a decrease of oil products consumption and increase of electricity. The same occurs with the simulated **urban pkm** scenarios, although at a less extent.

- In **2050** in the CAP scenario, H_2 accounts for 32% of cars final energy consumption, while EV cars use only 3%. **Without incentives, H_2 cars appear to be more competitive than EV.**

Higher shares of EV lead to **lower oil products** consumption and also to **lower H_2** consumption.

In the scenarios without a CO_2 cap and moderate EV incentives, the EV has lower penetration and it replaces hydrogen cars but not the cheaper oil products.

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RESULTS IV

CO$_2$ Emissions

CO$_2$ emissions from cars in CAP scenario – CO$_2$ emissions from cars in the other scenarios

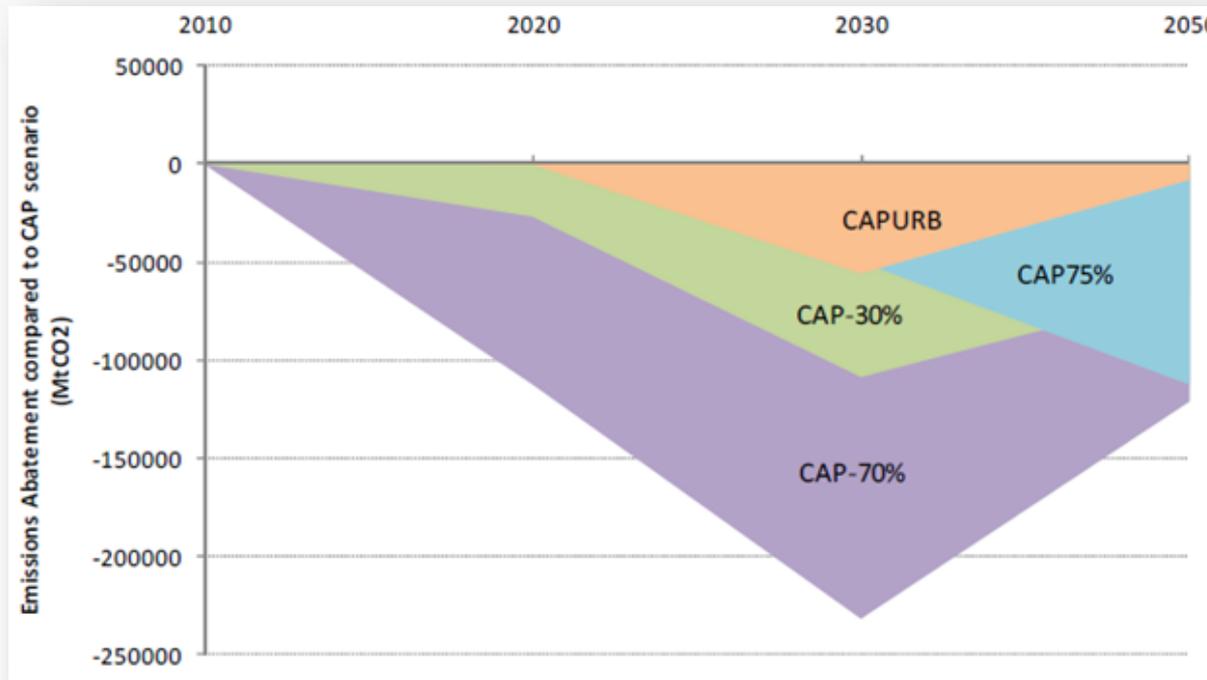➡ to assess the impact of additional incentives.

Figure 8 – CO$_2$ emissions abatement from the CAP scenario.

The **effect of incentives** in abatement is **more visible in 2030** than in 2050 because by then the CO$_2$ cap is so severe that overruns the incentives.

The **highest emission reduction occurs in CAP-70%**, which has the highest EV penetration. Abatement in this scenario is the highest of all scenarios both in 2030 (67% less than CAP) and in 2050 (47% less).

The scenarios without an emission cap are not included here as they have higher emissions than the CAP scenario.

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RESULTS V

Impact on electricity production technologies portfolio

Focus on year **2050** and on the **highest EV penetration rate scenario** (*i.e.* CAP-70%):

➢ increase (up to 13%) of generated electricity, supplied by:
   i. additional 63GW of renewable (mostly solar and biomass) when compared with the REF scenario.
   ii. significantly **increase of coal CCS plants** (from 0.07GW without EV to 185-200GW with EV highest rates), mostly in Germany and Poland.

Wind and hydro resources are being used near to its maximum availability already in the REF scenario, due to its high cost-effectiveness when compared with other electricity production technologies.

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Impact of CO_2 cap

✓ **Without (cost) incentives and no CO_2 cap EV delivers only 1% of total private car pkm - it is not a competitive technology**. It should be noted that additional costs from infrastructure and logistics (charging points for example) supporting EV are not considered.

✓ CO_2 cap slightly increases the competitiveness of EV after 2040, delivering up to 12% of total car pkm: **shadow cost for the CO_2 is sufficient to promote a modest EV penetration rate**.

Impact of cost reduction

✓ *Moderate* cost reduction (-30%): 21% of total cars pkm in 2025-2050. With CO_2 cap on top of that cost reduction: electric mileage up to 46% by 2050.

✓ *High* cost reduction (-70%): 2015 (15% of cars pkm) and 77% by 2050. CO_2 cap has no additional effect.

MAJOR FINDINGS II

Impact on fuel shift

✓EV cost reduction leads to a significant fuel shift : 2030, a **reduction of 20% to 46% of oil products in the passenger cars** in the *moderate* and *high* cost reduction scenarios respectively, when compared with the CAP scenario.

Impact on power technologies

✓ EV promotes CCS, solar, biomass, waves or geothermal technologies in the power sector, since wind and hydro resources are near its maximum availability in most of the EU countries (due to its cost-effectiveness).

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Thank you for the atention

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