# System value of V2G under slower EV diffusion

Update on the study "Potential of a full EV-power-system-integration in Europe and how to realise it"
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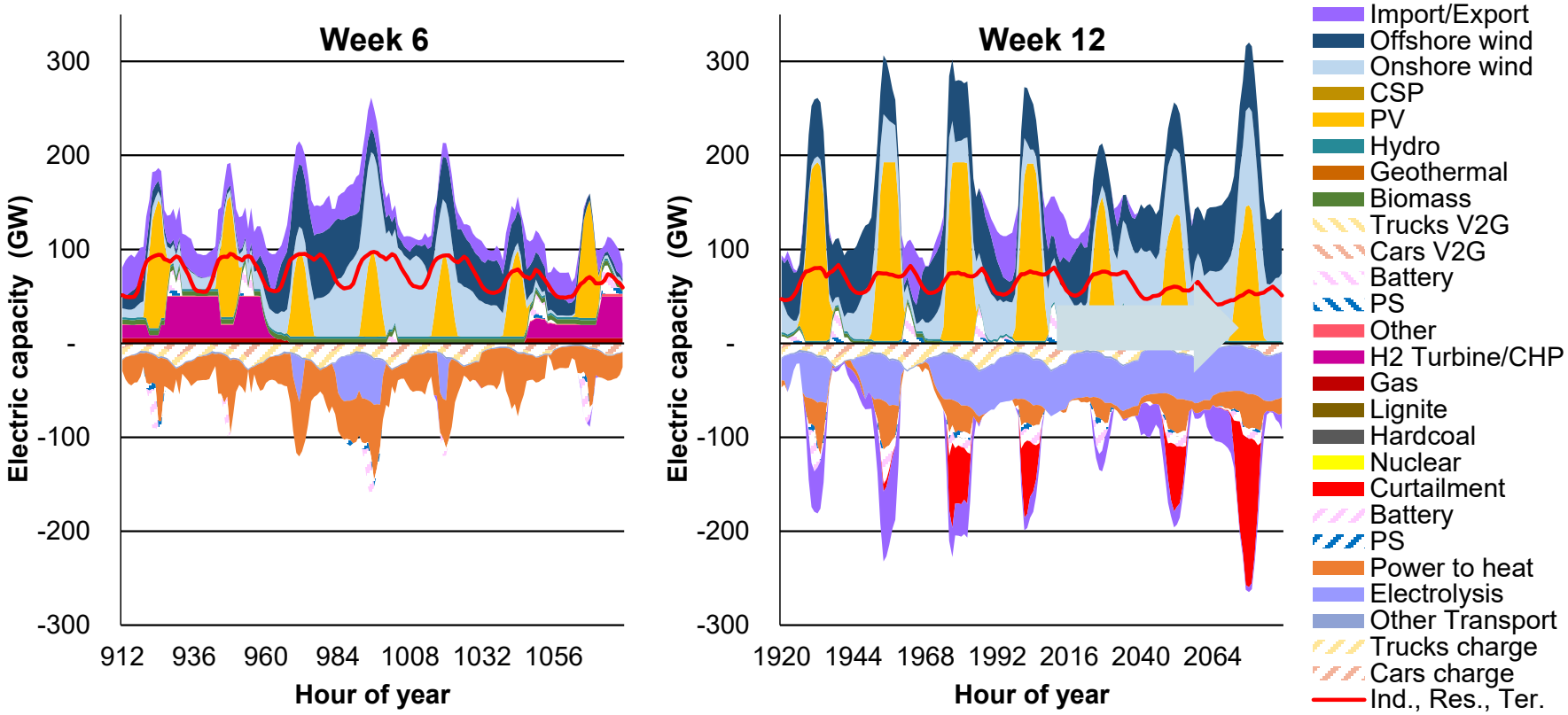
# Introduction

## Need for short-term flexibility and storage can be provided by EV batteries and V2G

Power System dispatch for two winter weeks in Germany 2040




- In 2040 mainly supplied by wind and PV.
- Flexibility needed to avoided curtailment and large backup plants.
- Storage shift midday solar to evening.

Unlocking V2G and demand-side flexibility is as critical as expanding renewable generation capacity.

# Scenarios

## What happens with slower EV diffusion in Europe?

Assessment of low EV market diffusion on flexibility value

| | | Slower EV diffusion | |
|---|---|---|---|
| | | **Base (289 TWh)** | **Worst-case (189 TWh)** |
| **Usage of EVs** | **Reference** (i.e. uncontrolled charging) | Reference Base | Reference Worst-case |
| | **Controlled Charging** (i.e. smart unidirectional charging) | CC Base | CC Worst-case |
| | **V2X** (i.e. smart and bidirectional charging) | V2X Base | V2X Worst-case |

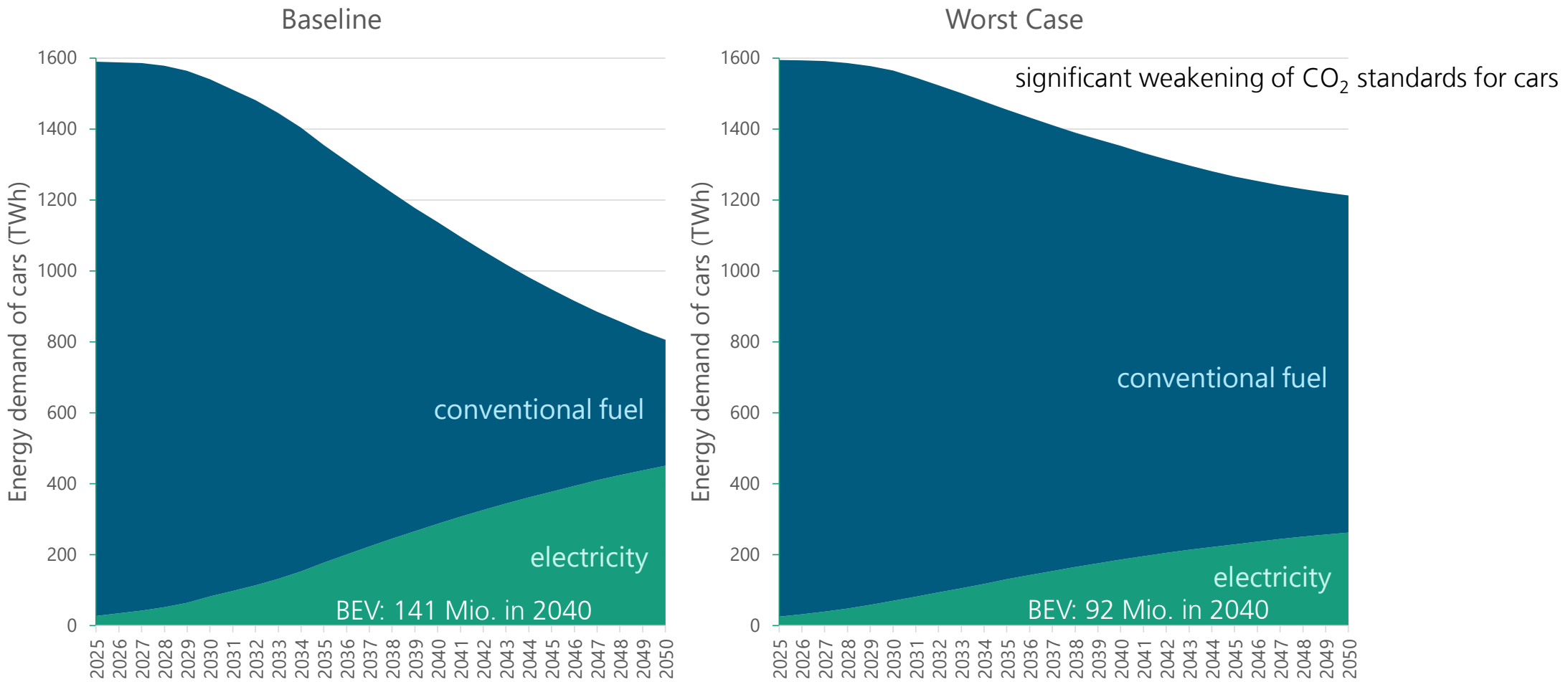
**Impact of reduced EV diffusion on flexibility provison (Base vs. Worst case)**

- **Reference - Uncontrolled charging**: EVs charge as soon as they are plugged in, adding to demand peaks and stressing the system.
- **Controlled charging**: Charging is shifted to hours with high renewable output and low prices, without feeding back to the grid.
- **V2X**: Bidirectional charging allows EVs to discharge electricity to the grid, turning the fleet into a large distributed storage resource.

Study quantifies the system value of charging strategies for **two EV market diffusions** for **2030/2040**.

# Assumptions

## Energy demand of passenger cars decreases much slower and less flexible electricity available




Source: T&E analysis of the car industry proposal and an almost 50% lower share of BEV sales in 2035 (European Union, the United Kingdom, Norway, and Switzerland)

# Value of flexibility and system costs

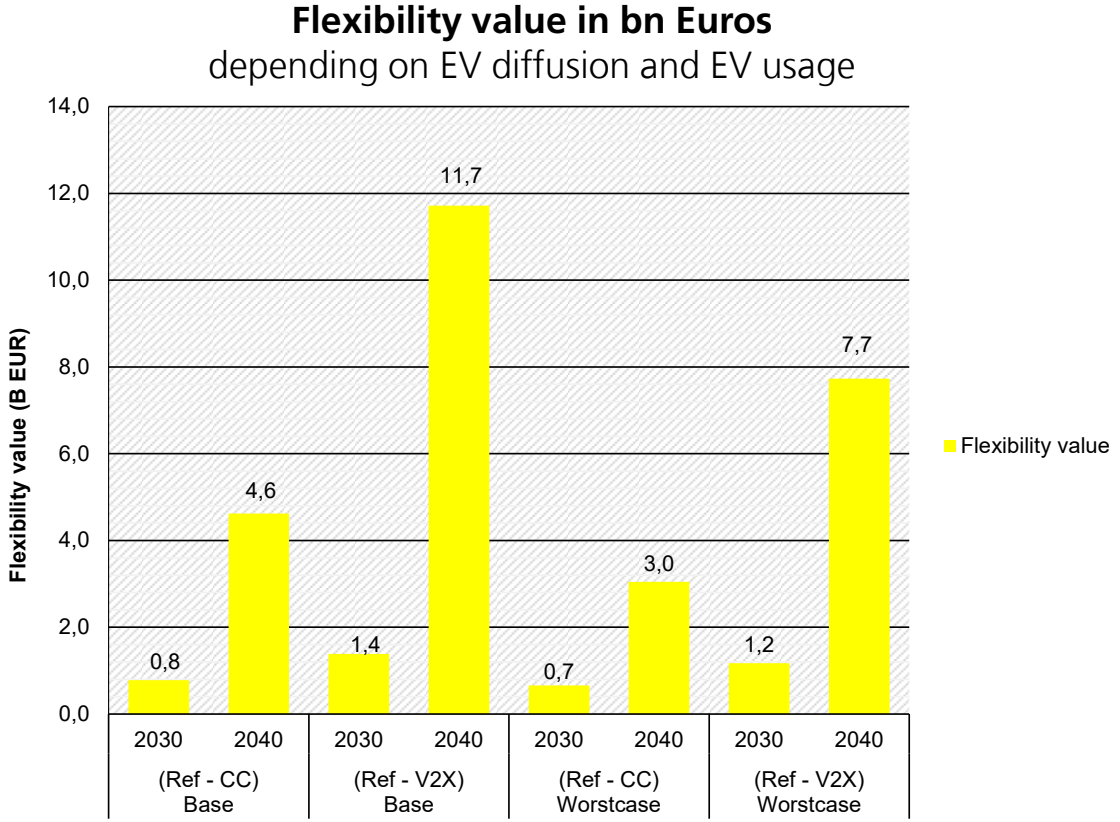
## How to evaluate the value of flexibility and the impact on system costs?

- Slower EV diffusion has two opposing effects:
  - **Less EVs reduce number of batteries and flexible electricity demand:** Operation of the power system becomes more expensive.
  - **Lower electricity demand:** Power system could need less supply-side investment; fuel costs of power system could be reduced.
- First effect: Quantify **flexibility value** of EVs with identical EV numbers but different charging modes (Reference vs CC vs V2X)
  - **Flexibility value** is defined as the difference in power-sector supply costs between inflexible charging and controlled resp. V2X charging, for a given EV stock.
- Second effect: Calculating **power system costs** and additional costs for **non-electrified cars** (Base vs. Worst-case)
  - **Net system cost = power-sector supply cost + conventional car fuel cost* + car $CO_2$ cost*** (excluding taxes and margins).

# Results: Flexibility value

## Flexibility value of EVs is reduced with lower EV diffusion.

- **Flexibility value** is defined as the difference in power-sector supply costs between inflexible charging and controlled/V2X charging, for a given EV stock.
- In the Base diffusion, controlled charging saves about **€0.8 bn/year in 2030** and **€4.6 bn/year in 2040**; V2X saves about **€1.4 bn/year** and **€11.7 bn/year**.
- Stronger diffusion of EVs still provides high flexibility value for the power system.
- **Per BEV** flexibility value (Base and worst-case scenario 2040)
  - controlled charging provides flexibility value of about **€93–95 per BEV per year**
  - V2X delivers around **€237–241 per BEV per year**.

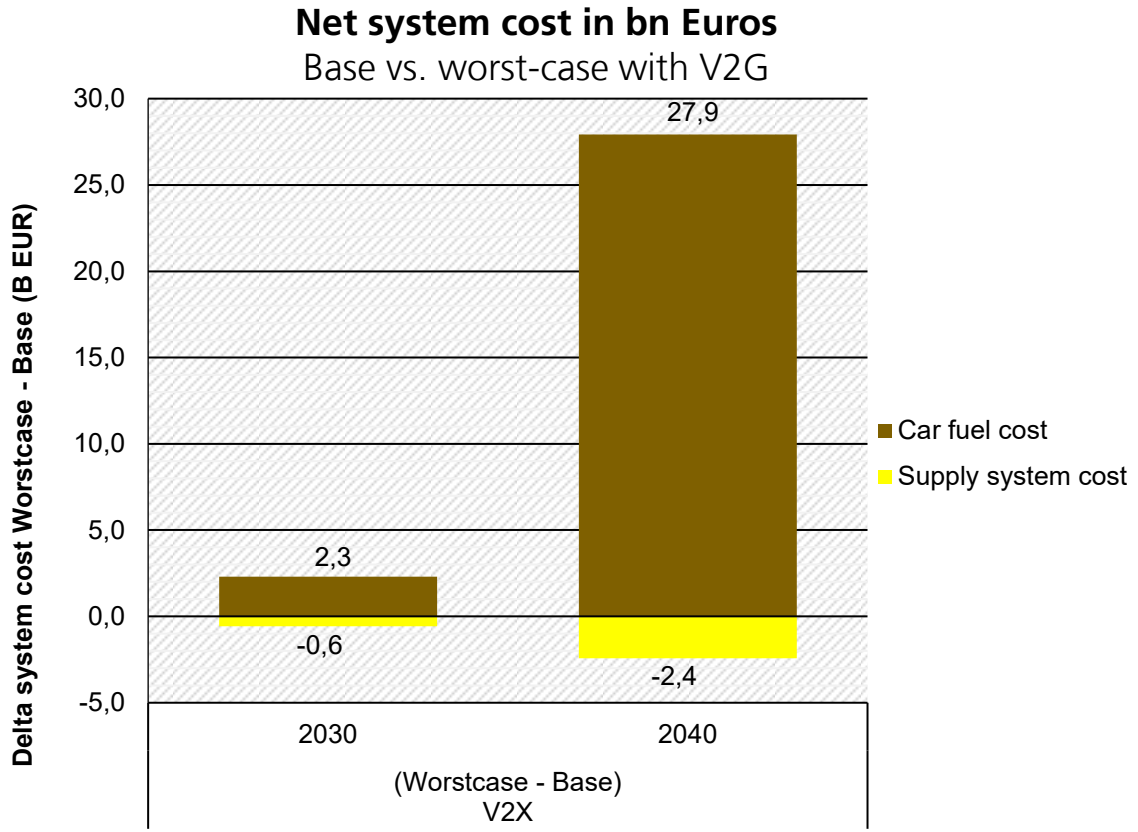



Worst-case EV diffusion reaches only €7.7 bn/year in 2040 (**€4.0 bn/year** below base scenario).

# Results: System costs

## Slower electrification increases total system costs by up to €25 bn/year.

- **Net system cost = power-sector supply cost + conventional car fuel cost* + car $CO_2$ cost*** (excluding taxes and margins).
- Lower EV uptake reduces power-sector costs but increases expenditure on oil and associated emissions.
- In 2030, the Worst-case EV diffusion saves **€0.6–0.8 bn/year** in power supply but increases fuel spending by **≈€2.3 bn/year**, **raising net system costs by €1.5–1.8 bn/year**.
- By 2040, the Worstcase is **≈€25 bn/year** more expensive overall.
- For the EU economy, a high EV uptake with controlled/V2X charging is therefore clearly cost-optimal.



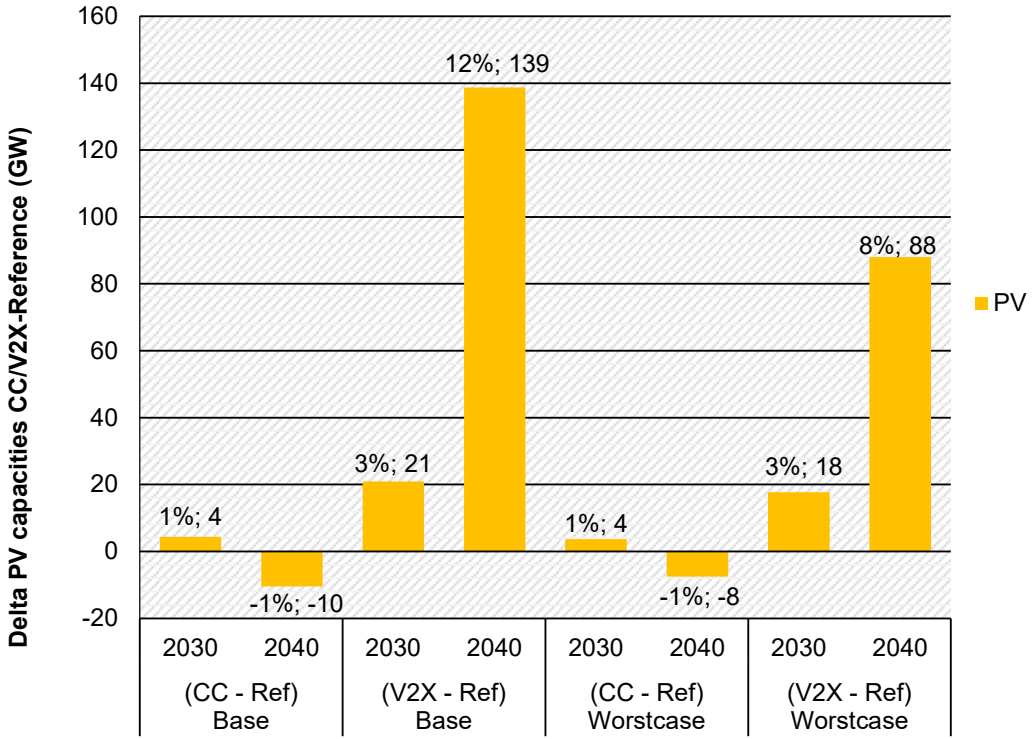

* estimated by multiplication of total conventional fuel demand with oil price and carbon price. No consideration of taxes, excise duties, or profit margins to keep costs comparable with Enertile's supply system costs. Upstream energy losses (fuel production) are neglected.

Savings in power system are overcompensated by additional fuel costs for not-electrified cars

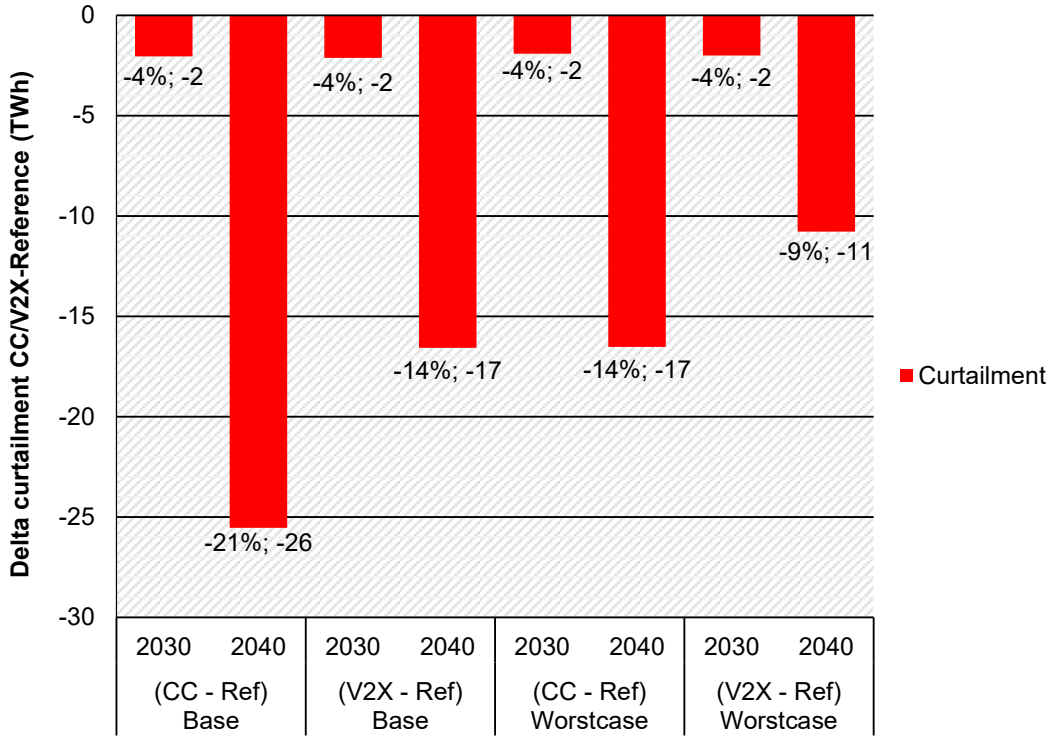
# Results: PV integration

## Smart charging and V2X cut curtailment and enable a more solar-heavy generation mix.

**PV Capacity in GW**
depending on EV diffusion and EV usage




**Curtailment in TWh**
depending on EV diffusion and EV usage



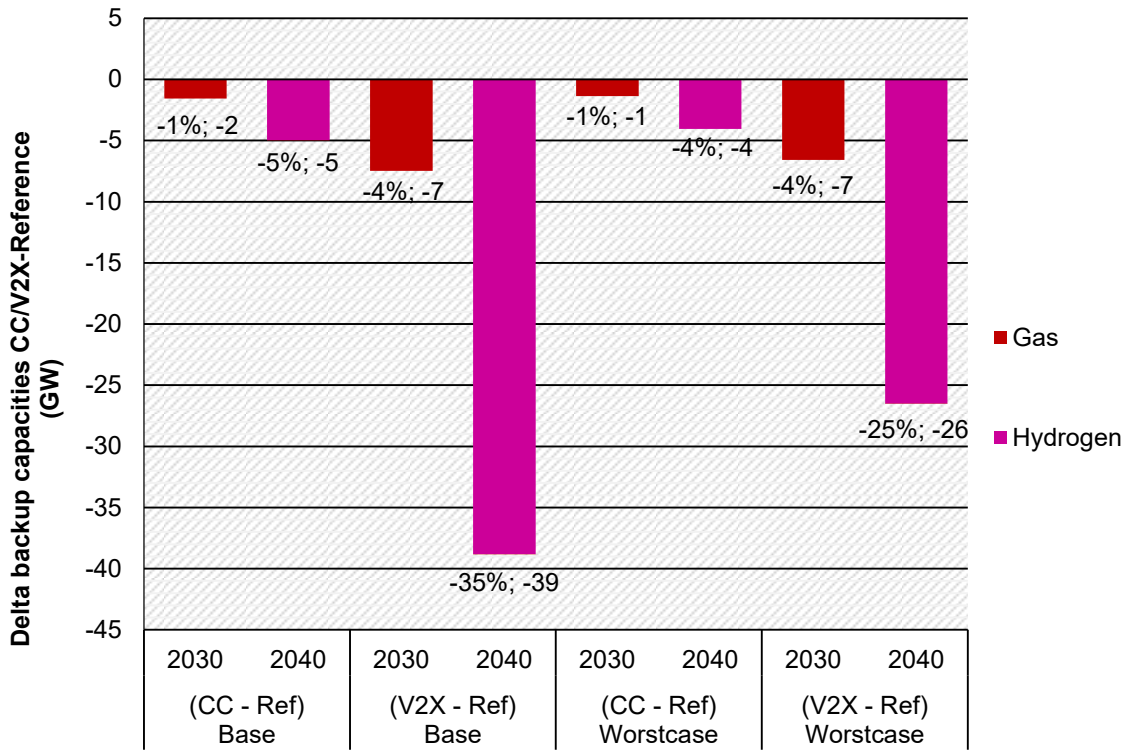

- controlled charging reduces renewable curtailment by up to around 20% in 2040.
- V2X time-shifts cheap PV generation into evening and night hours and makes additional PV capacity economic.
- PV replaces more expensive options such as CSP and parts of onshore wind, while limiting curtailment.

# Results: Back-up capacity

## Smart charging and V2X avoid tens of gigawatts of new backup capacity.

- With unmanaged charging, a renewables-based system requires large fleets of gas and hydrogen turbines to meet residual peaks.
- Smart charging already reduces the operation and capacity needs of these plants by shifting EV load to low-residual-load hours.
- Enabling V2X allows part of this peak demand to be covered by vehicle batteries instead of peaking plants.
- Across the EU27+UK+CH+NO, this means up to **7 GW fewer gas plants in 2030** and up to **39 GW less hydrogen backup capacity in 2040**, while maintaining security of supply.

**Back-up capacity in GW**
depending on EV diffusion and EV usage




Worst-case EV diffusion only reduces 26 GW of hydrogen back-up capacity (13 GW below base scenario).

# Electric vehicles flexibility value is limited with lower EV diffusion

**Delaying electrification and slow down EV uptake raises total system costs**

- EV flexibility value is reduced by €4,0 billion per year by 2040 in worst-case scenario.
  - base EV diffusion scenario reaches €11.7 billion per year compared to only €7.7 billion per year in the worst-case.
  - Flexibility value increases from €150 to €240 per BEV under V2G conditions from 2030 to 2040 indicating high marginal value of each additional BEV that would be added to the power system.

- Renewable integration is slowed down with lower EV diffusion.
  - Lower diffusion of EVs results in 51 GW less PV capacity enabled by V2G.
  - By 2040, EV flexibility from V2G would allow up to 139 GW of additional PV at EU27+UK+CH+NO in the base EV diffusion scenario compared to dumb charging. This value of additional PV would be reduced to only 88 GW of additional PV enabled by V2G in the worst-case EV diffusion scenario.
  - Capability to absorb midday solar generation and shift it to evening demand is substantially reduced.
- Net-system cost can be **≈€25 bn/year higher in worst-case scenario**

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