Towards electric mobility in France: an opportunity for the electricity system

EVS 32

May 21, 2019

Foreword

- As the French electricity transmission system operator, RTE has a legal duty to ensure real-time adequacy between electricity supply and demand and to provide long-term scenario analyses to anticipate major changes in the power system, such as the development of renewable energies or the massive development of electric vehicles.
- In 2017, RTE published preliminary analyses showing that integrating up to 16 million EVs in the French power system would not create any difficulty provided that a small part of the recharging of the batteries occurred during the night.
- Following this report, many questions – covering various aspects – were directed to RTE:
    - *Ability of the power system during particular events (mass departures during the holiday season)*
    - *Influence of different parameters (recharging speed, capacity of batteries…).*
    - *Economic value of smart charging*
    - *Carbon footprint EVs including the emissions of the power system*
    - *Opportunities for the power associated with second life batteries*
    - *…*

A working group gathering all mobility and energy stakeholders

- To address these issues, RTE conducted a large study, within a working group steered by AVERE-France and RTE (French TSO) :
  - Energy utilities (generators, providers, DSO, flexibility aggregators)
  - Car manufacturers
  - Charging station providers and operators
  - NGOs
  - Start-ups providing smart charging solutions
  - Academics, consulting
- Technical and strategic parameters of EV development were discussed in order to define a set of hypothesis
- The main results are presented in a report published last week, and available on RTE's website:

https://www.rte-france.com/sites/default/files/rte_-_mobilite_electrique_-_principaux_resultats_-_vf.pdf

A broad range of parameters covering multiple EV development patterns

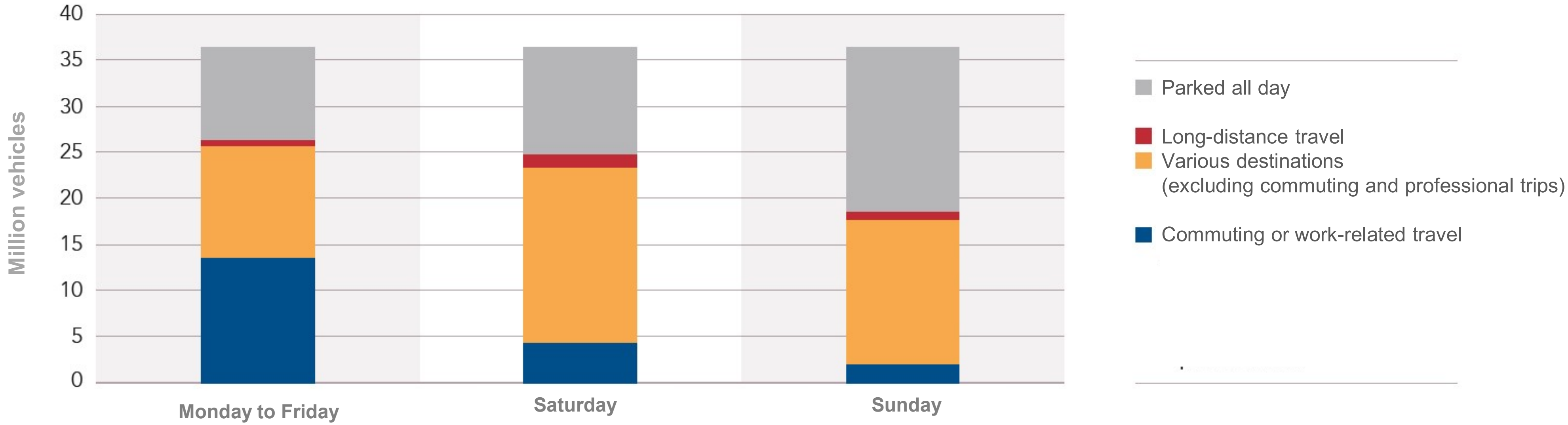
Vehicle fleet	Electromob. adoption dynamics	Heavy duty vehicle fleet	Rate of PHEV	Battery capacity	Charging station accessibility	Charging station power	Mobility need	Connection behaviour	Charging management
Low trajectory 7M units	**Homogenous development**	**Low trajectory** ~50 000 en 2035	**Low PHEV** 22% PHEV	**Low capacity** 56kWh - 330 km	**Low access**	**Low power for charging station** Average power at home: 5.2kW	**Average without long distance** km 11500	**Low frequency** 45 % ASAP	**No management**
Medium trajectory 11.7 M units	**Early adoption working population**	**Median trajectory** ~110 000 en 2035	**Average PHEV** 38% PHEV	**Average capacity** 73kWh – 440km	**Average access**	**Average power** Average power at home : 7.3kW	**Average with long distance** km 12500	**Average frequency** 65 % ASAP	**Low Management** 40% 0% V2G
High trajectory 15.6M units		**High trajectory** ~150 000 en 2035	**High PHEV** 46% PHEV	**High capacity** 89kWh – 530km	**High access**	**High power** Average power at home : 6.7kW	**High without long distance** km 14000	**High frequency** 85 % ASAP	**Average management** 60% 3% V2G
Including autono-mous vehicles 8.4M + 1M units							**High with long distance** km 15300		**High management** 80% 20% V2G

Five widely contrasting scenarios to test the impacts of EV development

Scenario	Description	EVs
Crescendo	**Standard projections**: Substantial development of EVs, with marginal evolution of travel habits and other parameters, following actual trends	Between 11.7 and 15.6 million EVs in France in 2035
Opera	**High flexibility:** This scenario explores opportunities offered by EV flexibility, with generalised smart charging and V2G	
Forte	**Stress for the power system :** The most challenging scenario for the power system : little development of smart charging, no V2G, long-distance travels with EVs...	
Alto	**Development of electric autonomous vehicles:** 1 million autonomous EVs replace 7 million traditional cars, combined with higher modal shift towards electric public transport	1 million autonomous EVs + 8.2 million “classic EVs” in 2035
Piano	**Low-carbon mobility:** The development of electric mobility goes with substantial modal shift towards electric public transport	11.7 million EVs in 2035 + modal shift

Mobility parameters : a detailed representation of travel habits based on the latest national travel survey

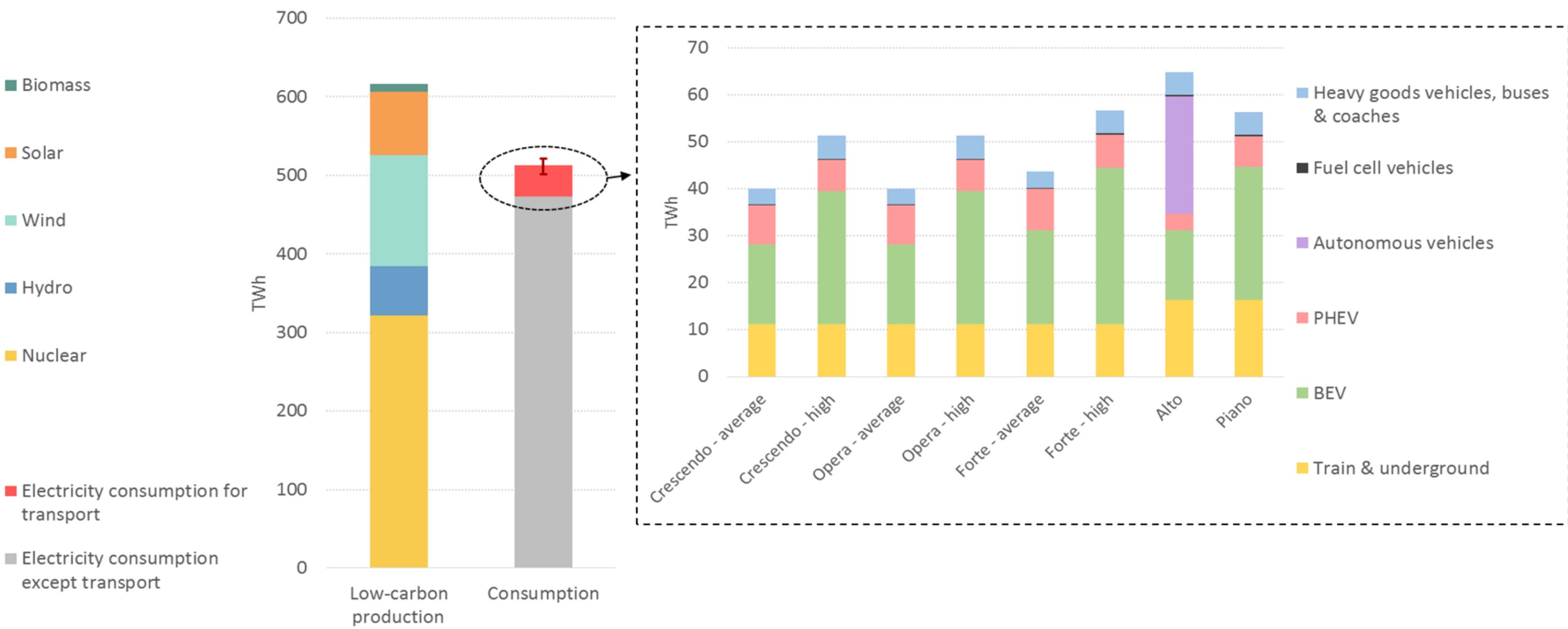
- Detailed representation of travel habits is essential for a robust estimation of the impact of electric vehicles on the power system (energy used, connection times…)
- Based on the latest French national travel survey available, RTE analysed travel habits for different types of vehicle users, and estimated several projections according to possible EV penetration scenarios
- Today, only 30% of passenger cars are used for commuting or work-related travel on a given working day ; 28% of passenger cars are parked all day long



Low-carbon electricity generation is able to cover all electricity demand, including with a high development of EVs in 2035

- In the long-term French energy plan, the low-carbon electricity generation (nuclear and renewables) will widely be enough to meet French electricity demand « in energy », including EVs, which represent **between 5% and 10% of the French electricity consumption in 2035** (lower than 50 TWh).

- The analysis needs to focus on peak demand and adequacy.

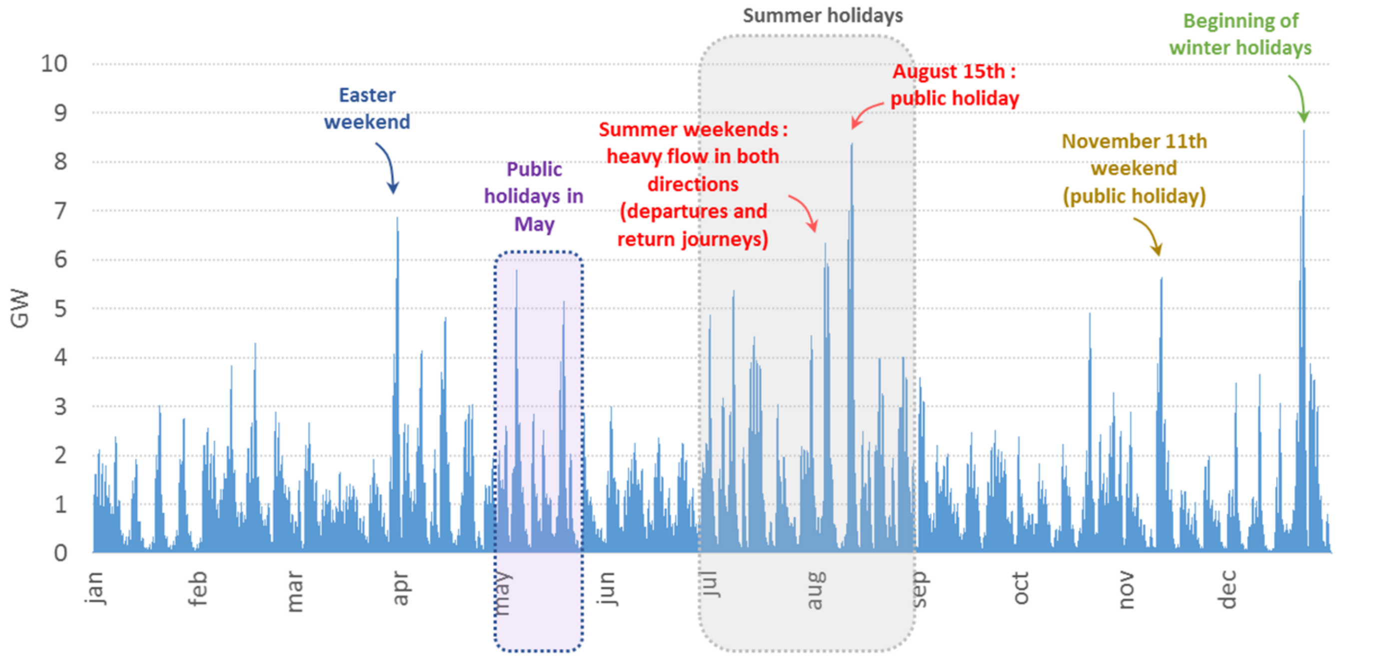


Long-distance travel causes no concerns for the electric system

- Long-distance travel represents 20% of total travel distances by car.

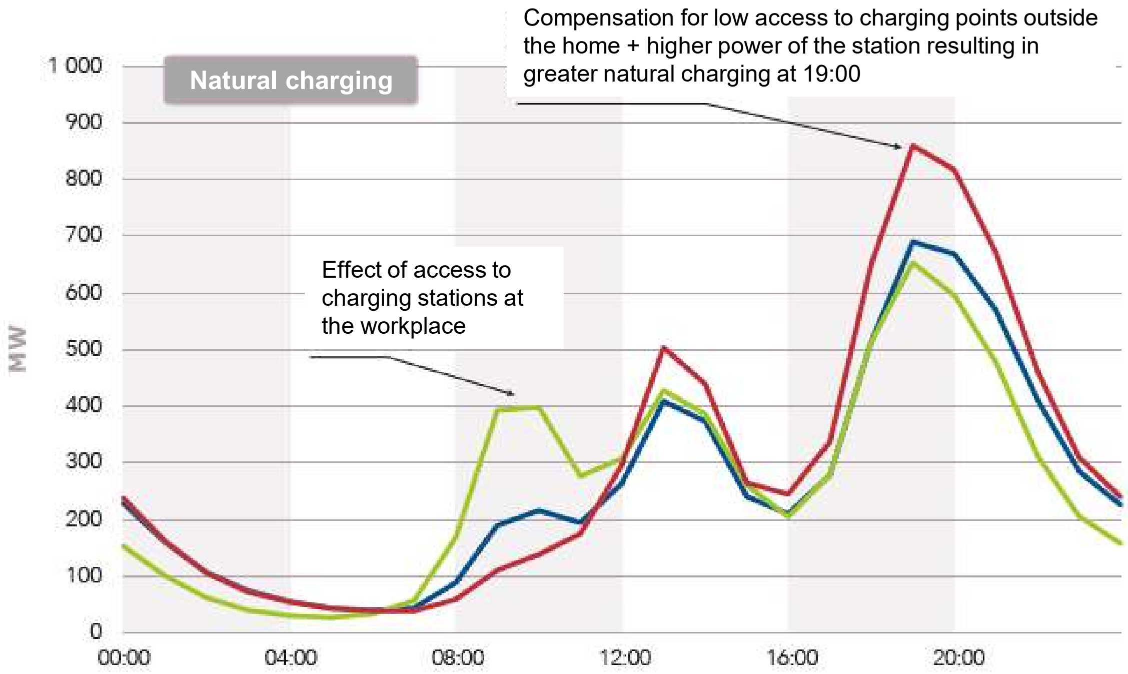
- Peak electricity demand related to long-distance travel may exceed **8 GW** in some particular days (as a comparison total power peak demand in France can reach ~100 GW during cold days in winter).

- Long-distance travel is particularly high at **week-ends and public holidays**, when total electricity demand is low and adequacy between electricity production and use does not raise any concern.



Daily travel has a greater impact on power demand

- 80% of total distances travelled by vehicles concern daily travel. Load curve of EVs will depend mainly on the accessibility of charging stations during the day and the dynamics of adoption by the population. Other parameters are not as crucial.
- Without any demand management, maximum load is observed between 7 and 9 p.m., when adequacy margins of the electricity system are low.
- During cold snaps, EV load could be 3 GW higher than with normal temperatures.



Hypotheses of the Crescendo scenario
- Medium access to charging points outside the home (28%)
- Medium power of the charging stations
- Mixed connection habits according to the users (65% systematic, 35% occasional)

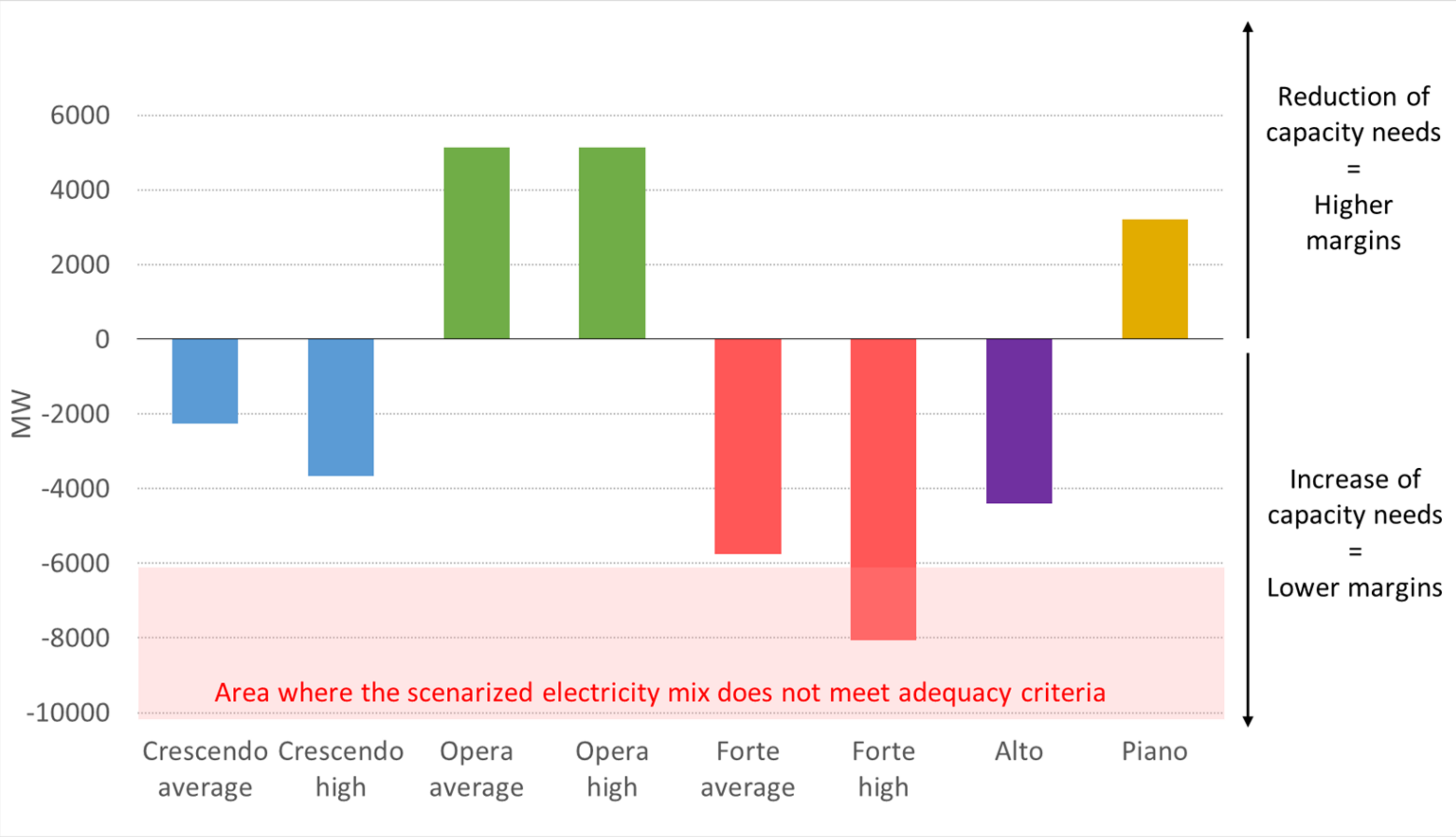
Hypotheses of the Opera scenario
- High access to charging points outside the home (45%)
- Medium power of the charging stations
- Systematic connection for most of the users (85%)

Hypotheses of the Forte scenario :
- Low access to charging points outside the home (16%)
- High power of the charging stations
- Systematic connection for most of the users (85%)

With a minimal level of smart charging, the power system is able to ensure the charge of EV, at any moment

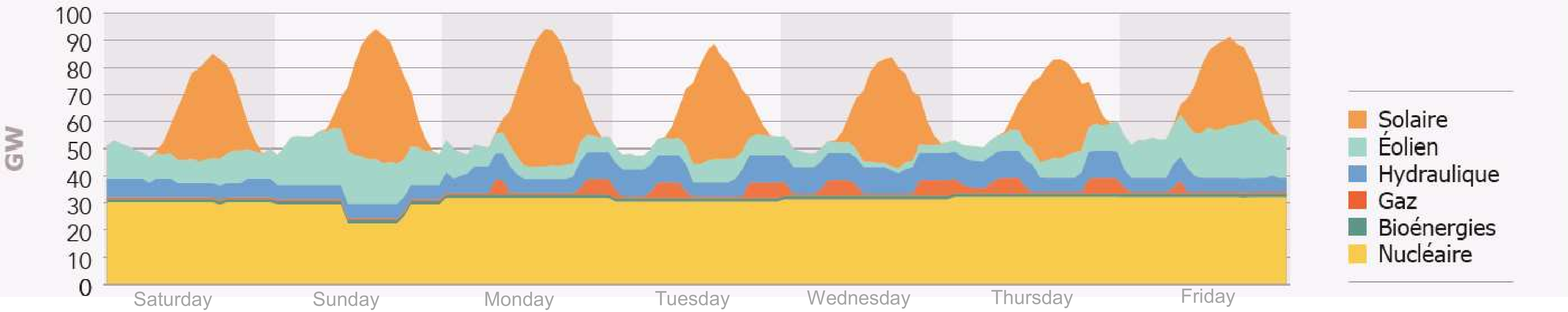
- **Impact of EV on system margins depends on the modalities of EV development**: localisation of EV charging station, EV buyers, etc.
- The determining factor is the level of development of smart charging and V2G
- Even in the worst case scenario, only ~50% of smart charging (even with simple ways) is enough to ensure security of supply.

Impact of electric vehicles on adequacy margins, compared to a scenario without EVs

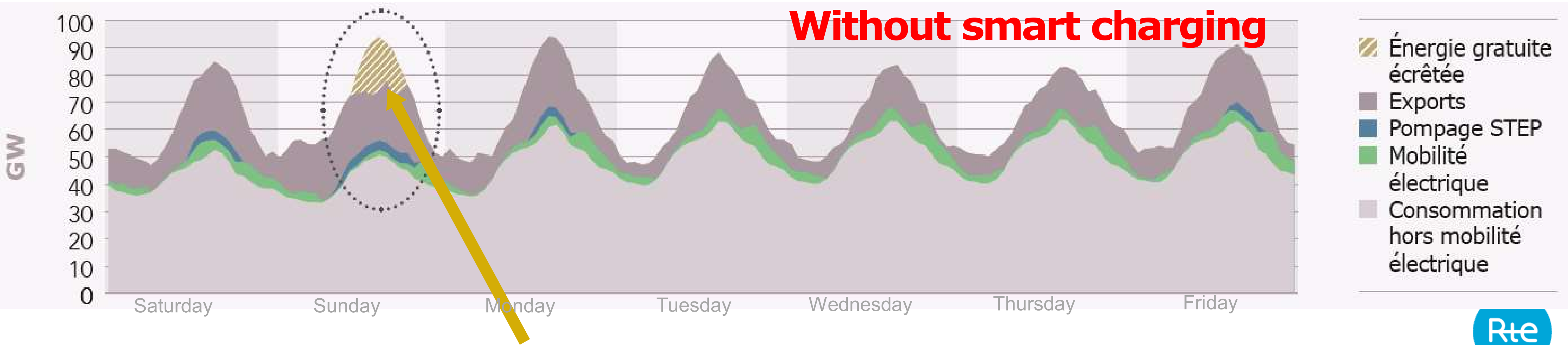


Smart charging and V2G push renewable energy integration

Electricity production over a week in July

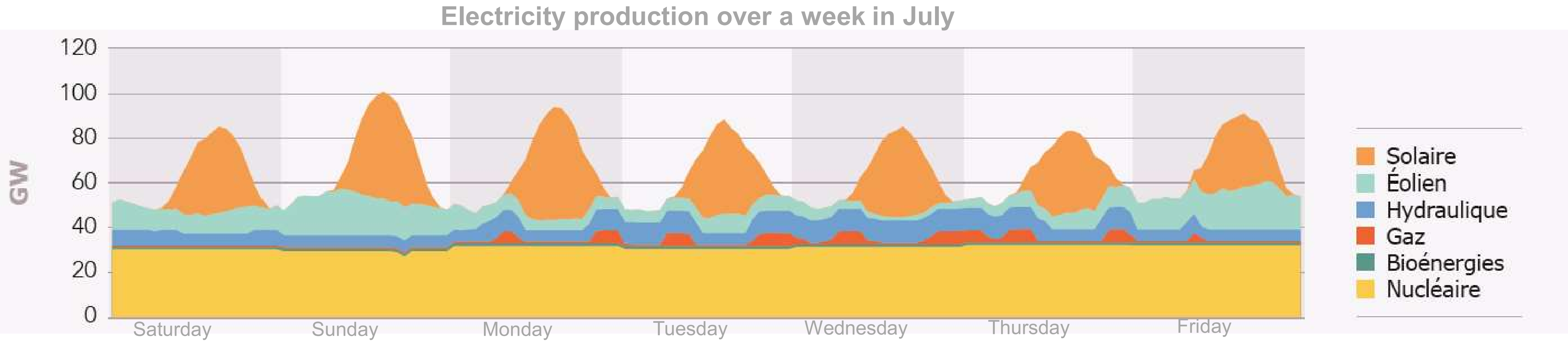


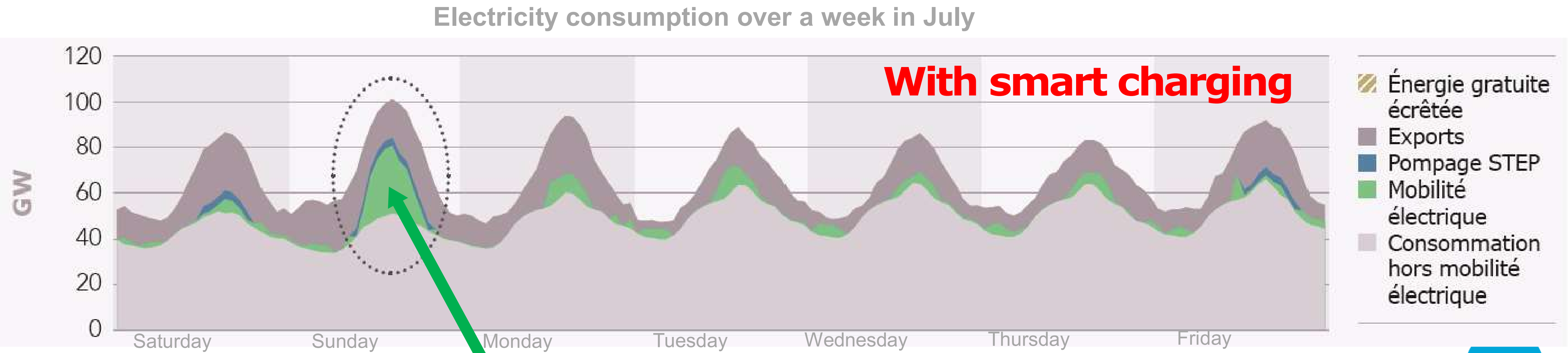
Electricity consumption over a week in July



Spillage of renewable energy due to low consumption

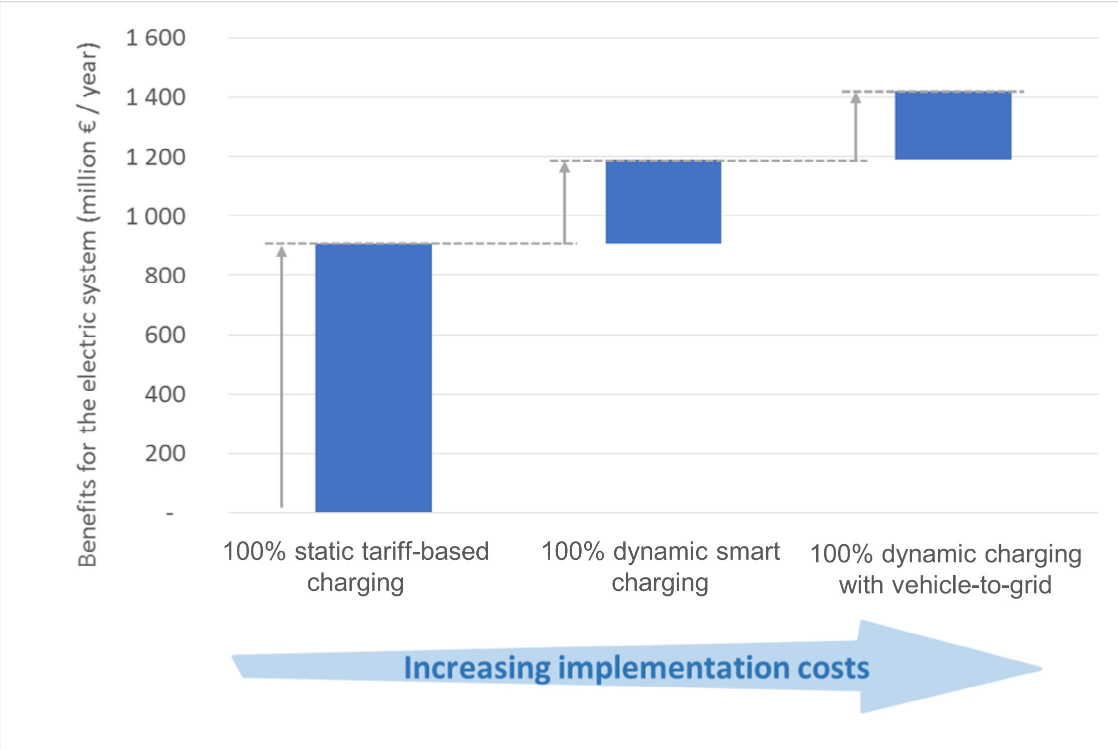
Smart charging and V2G push renewable energy integration

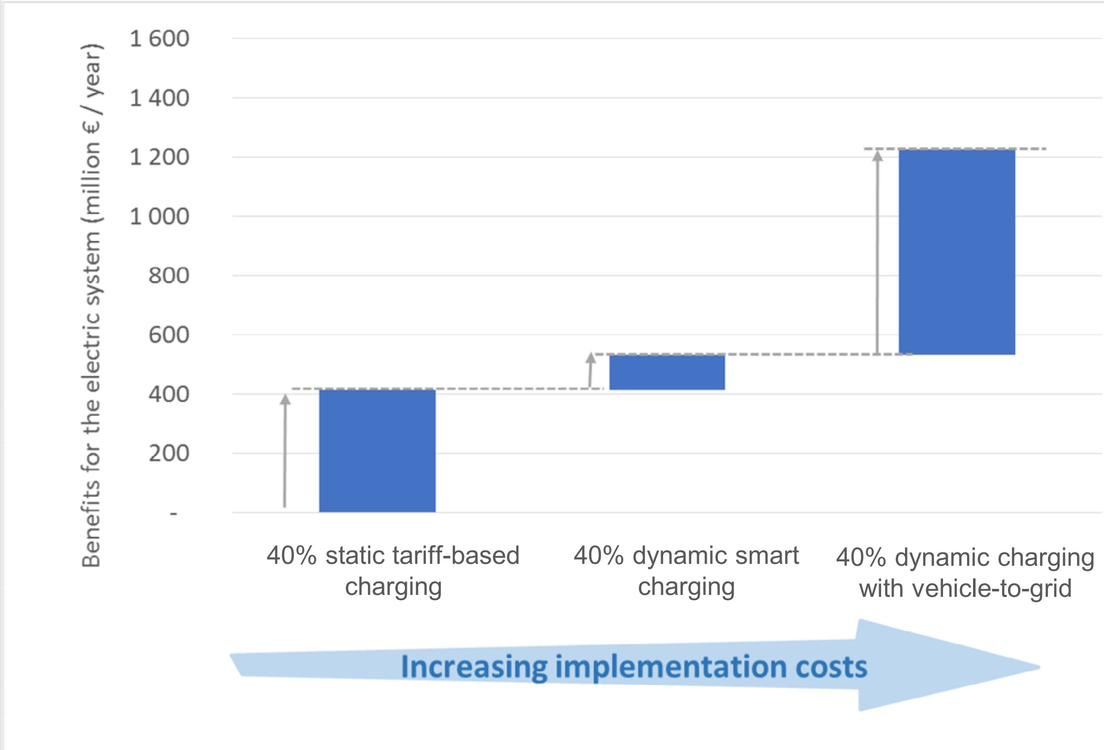




Increased charging of EVs on week-ends avoids renewable energy spillage and modulation of nuclear plants

Economic value of different types of EV flexibility

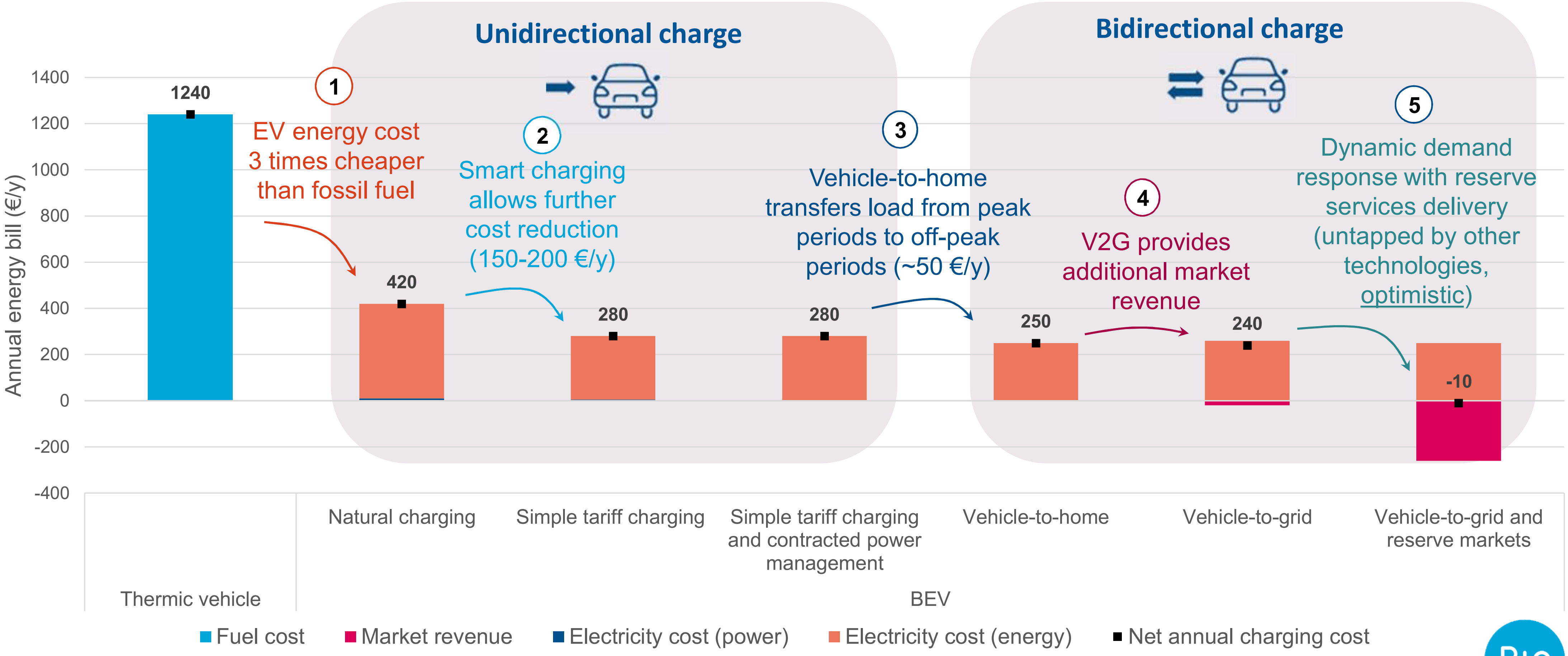




- Economic value of smart charging is related to a better use of electricity production
- **A large part of total benefits can be attained using simple smart-charging** (static tariff-based)
- **Economic gains associated with V2G are high**, even though they are dependent on deployment level of smart charging

Annual energy cost is 3 to 5 times cheaper than with fossil fuel

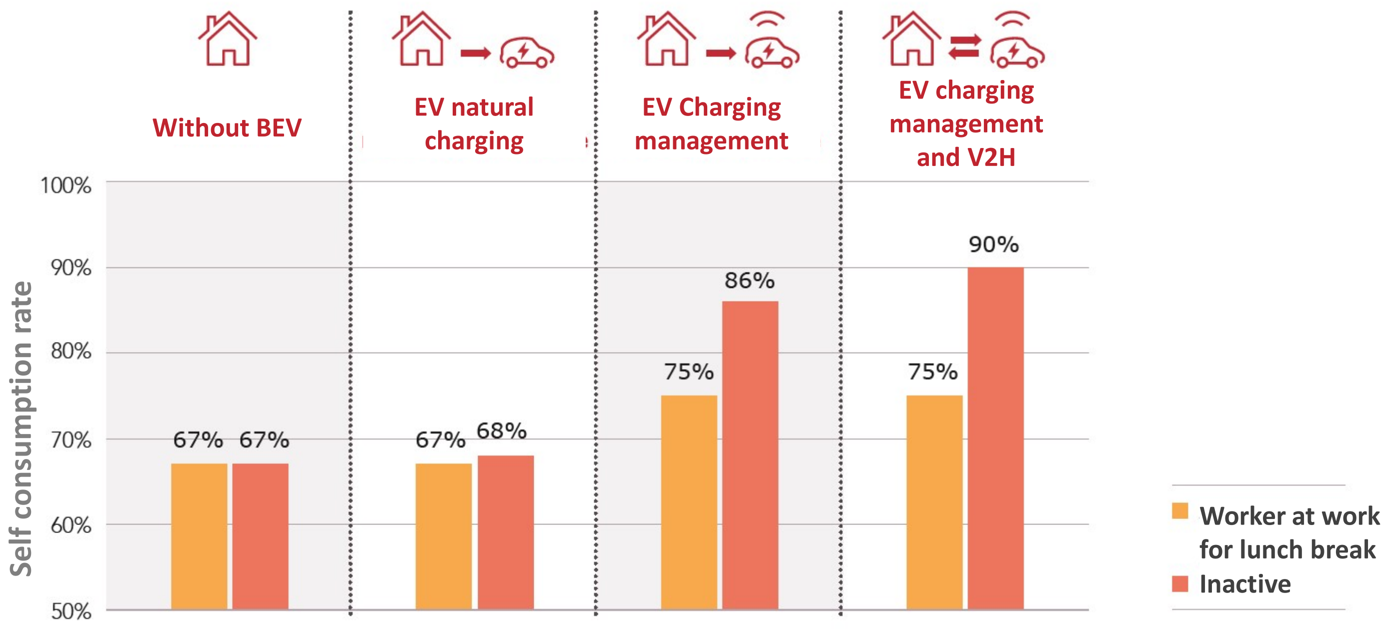
Annual energy expense for a vehicle travelling 14.000 km / year



BEV charging management improves return on investment in solar power self-consumption

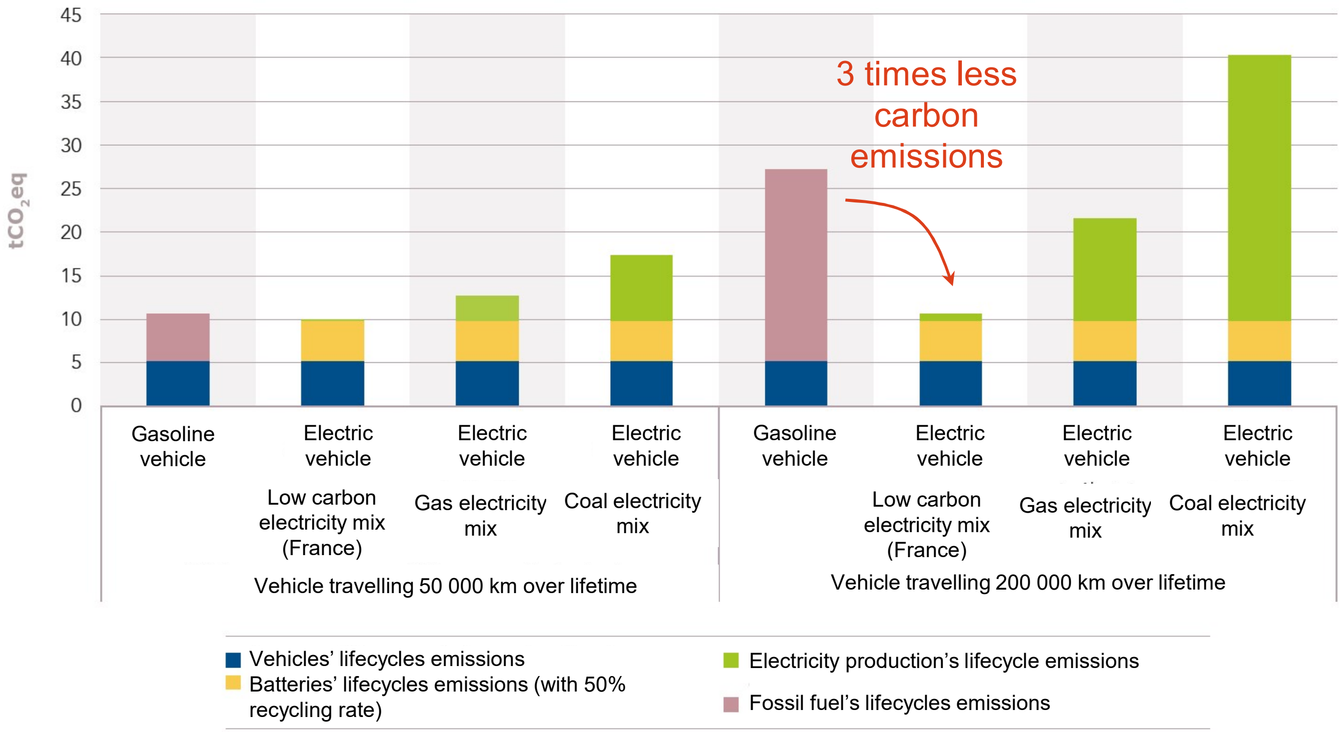
- Although not widely adopted yet, self-consumption of solar energy is on the rise. For environmental reasons, public expectactions around combining solar energy panels and electric car recharging could be high.

- Such a combination is beneficial for the user when EV charging happens during production periods, thus **maximising the self consumption rate** and return on investment.
- The analysis showed that electric mobility could **increase the total solar power installed by 1 to 2 GW.**

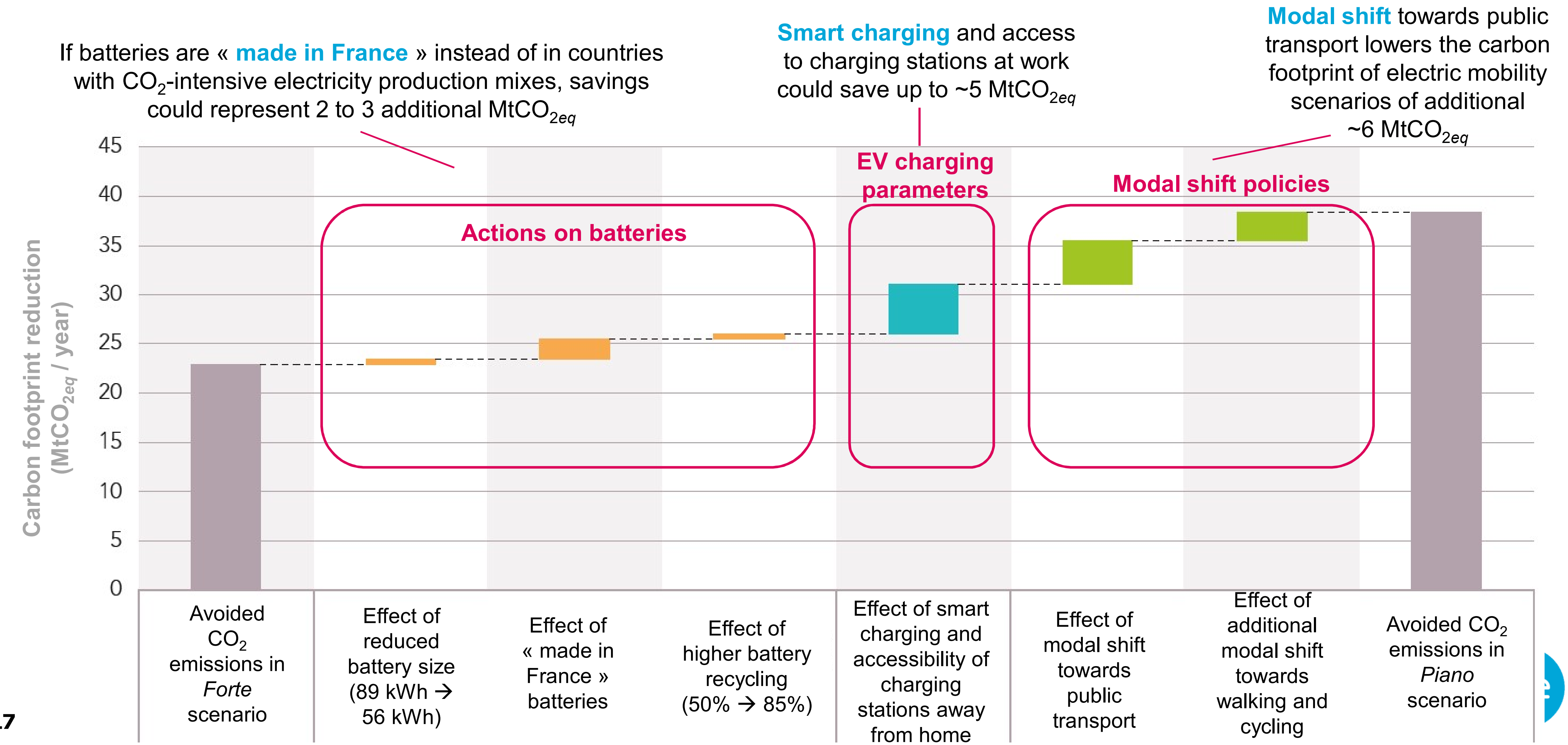


Electric mobility could significantly contribute to the reduction of road transportation’s carbon footprint

- Most recent studies about GHG emissions of electric vehicle concur: the reduction of emissions during use phase of the vehicle largely offsets the emissions due to battery’s manufacturing.
- Depending on the battery capacity, manufacturing location and recycling rate, **an electric vehicle is 2 to 4 times more carbon efficient than a thermal vehicle** (average run of 200 000 km over its lifetime).
- The study broadens the scope to the entire road transportation carbon emission, and concludes that **electrifying mobility (light and heavy vehicles) constitutes a major lever to reduce road transportation’s GHG emissions.**
- It is possible to **save between 20 and 40 MtCO2/y**, depending of the scenario



Strategic options to further improve the carbon footprint of transport sector are available



Conclusions and next steps

Main results

- **The French power system is ready for a massive development of EV**, without important requirement on smart charging. In the most challenging case, with 16 millions EV, security of supply is ensured with only ~50% of (simple) smart charging.
- **Smart charging and V2G are an economic opportunity** for the power system (helping to optimize the use of low-carbon electricity) and EV users (helping to reduce energy costs for EV users).
- **With a low carbon power mix, EV development in France reduces the GHG footprint of transportation** (even when including battery's LCA). Different choices (battery capacity, location of battery production, development of smart charging…) can help to reduce further the GHG emissions.

Next steps

- **The technical and economical issues have to be tested in a large scale** in order to provide guidance for the development of EV industry :
  - Test different smart charging solutions, including vehicle-to-grid
  - Check the appetence and social acceptability for EV users
  - Test and adapt regulatory framework to ensure relevant decision-making on the whole value chain

https://www.rte-france.com/sites/default/files/rte_-_mobilite_electrique_-_principaux_resultats_-_vf.pdf

Back-up

Which parameters may impact the integration of EV in the power system ?

Multiple key parameters to combine

Vehicle fleet
- Low trajectory: 7M units
- Medium trajectory: 11.7 M units
- High trajectory: 15.6M units
- Including autono-mous vehicles: 8.4M + 1M units

Electromob. adoption dynamics
- Homogenous development
- Early adoption working population

Heavy duty vehicle fleet
- Low trajectory: ~50 000 en 2035
- Median trajectory: ~110 000 en 2035
- High trajectory: ~150 000 en 2035

Rate of PHEV
- VHR bas: 22% VHR
- VHR average: 38% VHR
- VHR haut: 46% VHR

Battery capacity
- Low capacity: 56kWh - 330 km
- Average capacity: 73kWh – 440km
- High capacity: 89kWh – 530km

Charging station accessibility
- Low access
- Average access
- High access

Charging station power
- Low power for charging station: Average power at home: 5.2kW
- Average power: Average power at home : 7.3kW
- High power: Average power at home : 6.7kW

Mobility need
- Average without LD: 11500 km
- Average with LD: 12500 km
- High without LD: 14000 km
- High with LD: 15300 km

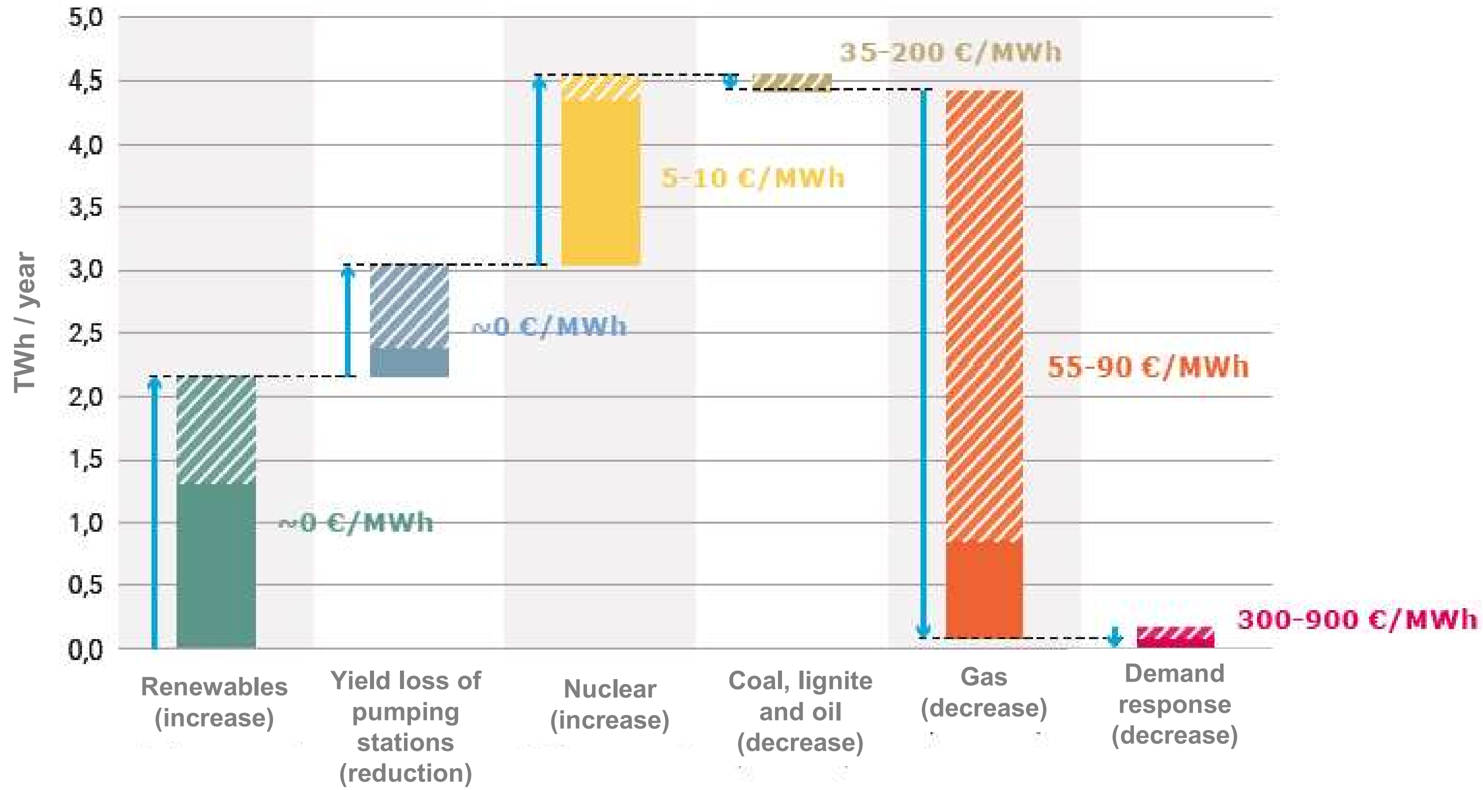
Connection behaviour
- Low frequency: 45 % ASAP
- Average frequency: 65 % ASAP
- High frequency: 85 % ASAP

Charging management
- No management
- Low Management: 40% 0% V2G
- Average management: 60% 3% V2G
- High management: 80% 20% V2G

The flexibility brought by Evs allows to maximise renewable energy use

- Thanks to smart charging, EV load can be placed at times of high renewable production, when prices are lower
- Reduced spillage means increased renewables integration
- Without smart charging, nuclear production needs to modulate

Electricity production from different sources in a smart charging scenario compared to a scenario without smart charging

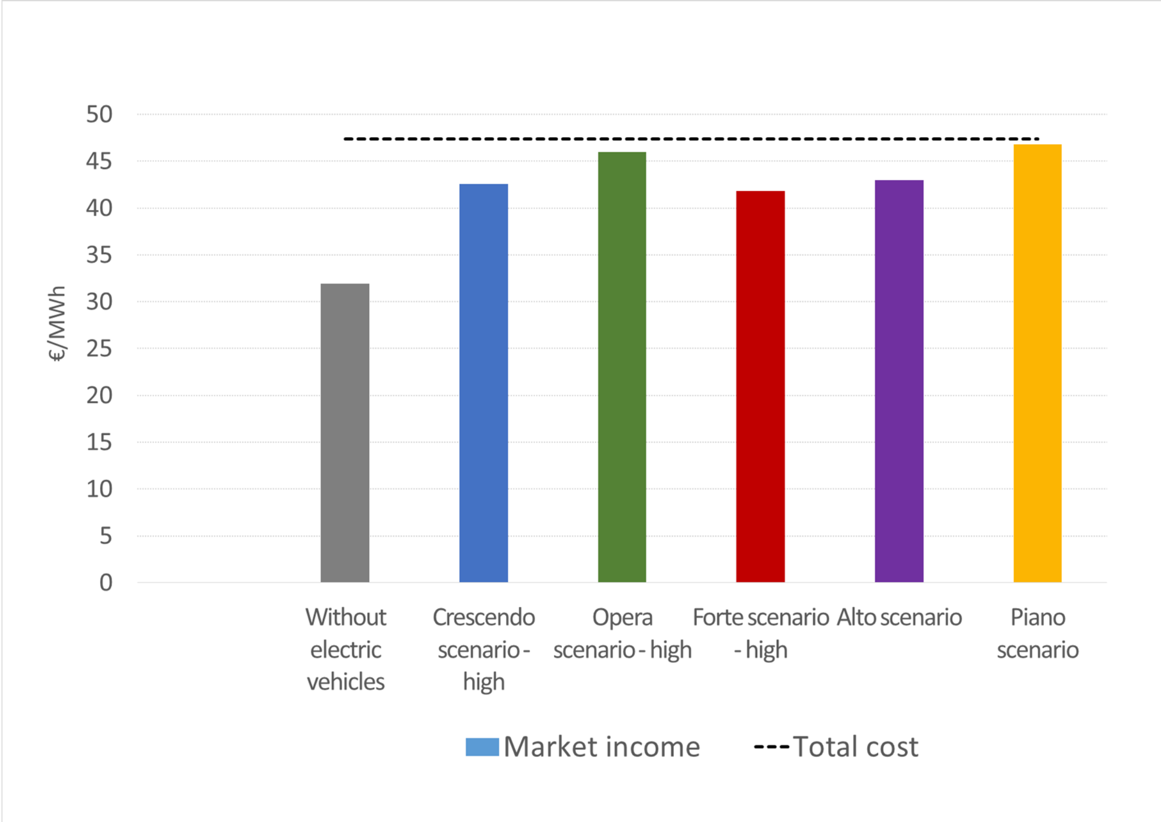


Increased flexibility means lower public subsidies for renewables

- Increased flexibility associated with EVs reduces spillage and situations of extra-low-price clearing of electricity markets

- Renewables income market increases : this curbs public sector subsidies needed for renewables

- For example, 400 million € less are needed for PV in *Forte* scenario (low level of smart charging, no V2G) compared to *Piano* scenario (high level (with 80 TWh PV production)



A range of possibilities to achieve cost-effective flexibility management

Functionnality : uni- or bidirectionnal charge

Unidirectional charging

The battery's charge can be modulated in time but the vehicle can not inject back to network.

Bidirectional charging

The battery draws from the network but can also inject (to the user's private network or the public network). The vehicle or the charging installation must be equiped with an AC/DC converter.

Management methods and valuation

Simple tariff-based management

Charging sets off upon tariff based time slots (off-peak/peak, or other). It can be automated (same as for water heaters) in order to be transparent for the user.

Dynamic market-based management

Charging and injection are dynamically managed, depending on hourly market prices and futur mobility needs.

Charging management and reserve services provision

Charging and injection are dynamically managed, depending on the electricity system adequacy needs, e.g. through automatic response to frequency deviation.

Combination with solar self-consumption

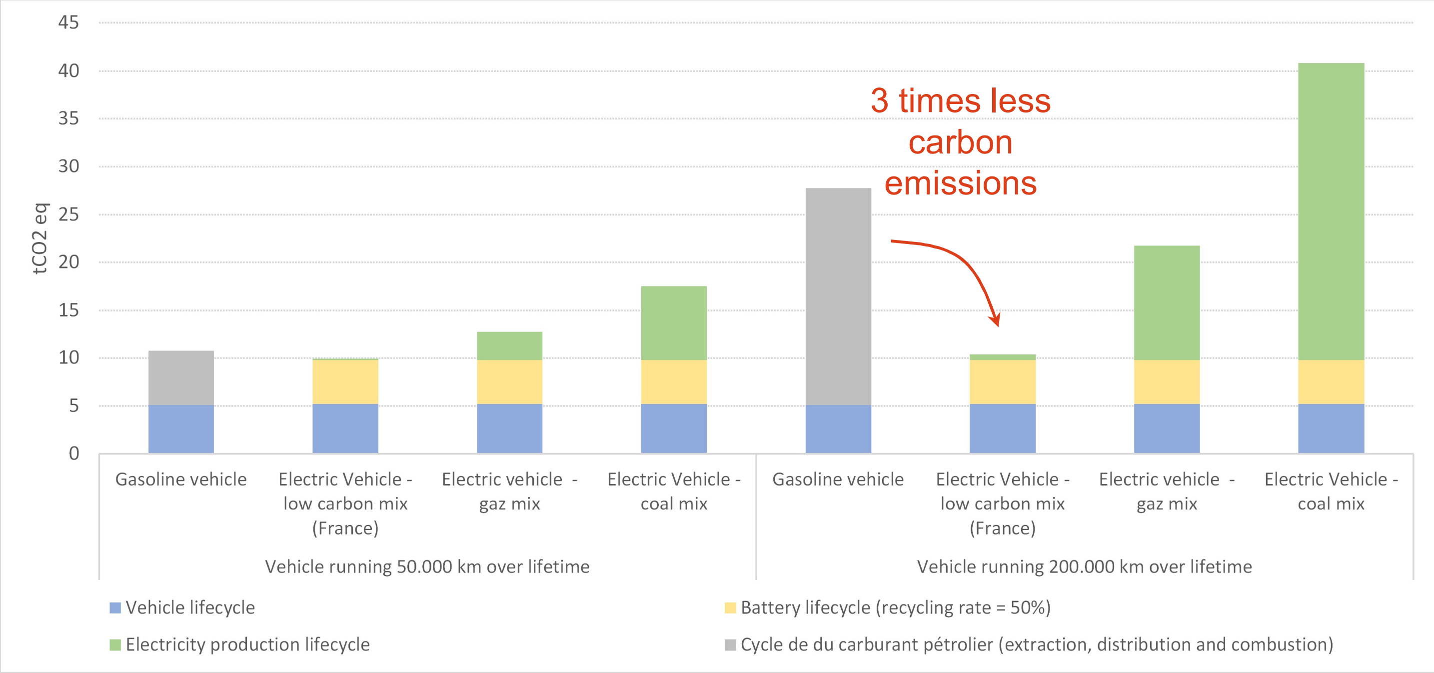
Charging and injection are set off to harness the maximum energy of a local solar power production plant

BEV's carbon footprint is better than thermic vehicle's, under certain conditions

- Production phase, BEV 's carbon footprint is significantly higher, due to the production of the battery
- In running phase, BEV's carbon footprint is significantly lower, provided the charging electricity is low carbon

In France, the lifecycle analysis for one vehicle is favourable, as soon as the vehicle runs over 50 000km over its lifetime.

On average they run 200 000 km during approximately 15 years.

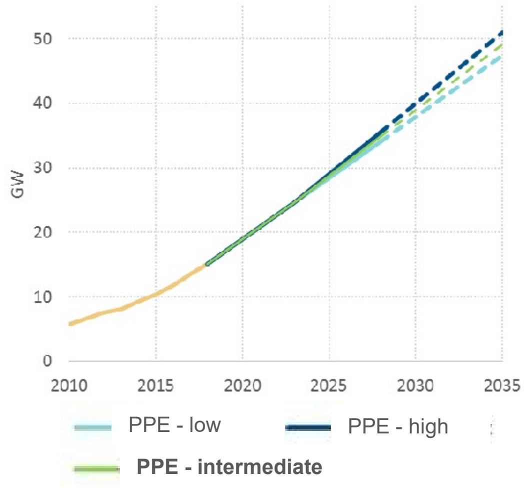


The electric mix is based on France long-term energy plan

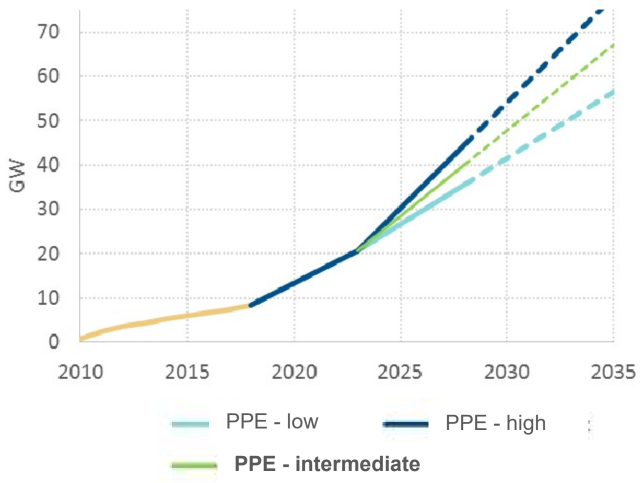
France long-term energy plan ("**Programmation Pluriannuelle de l'Énergie**", PPE) includes :

- Decommissioning of some nuclear power plants and ambitious renewable energy development :
  - Wind : x2,5 by 2028
  - Solar PV : x4 by 2028
  - Offshore wind: 5 GW installed by 2028
- High electrification of energy consumption
- The 2035 electric mix scenarised in this analysis is consistent with these ambitions :

Wind energy



Solar PV



Electricity production mix in 2035 :