Mobilidade Eléctrica

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INESC PORTO - POWER SYSTEMS UNIT
ELECTRIC VEHICLES INTEGRATION - FRAMEWORK

MERGE – Mobile Electric Resources for Grids of Electricity

- 4,5 M€ European project, funded by EU 7th Framework Programme
- European consortium with 16 partners from 8 countries, involving R&D institutions, utilities and consultants
- INESC Porto: scientific leader

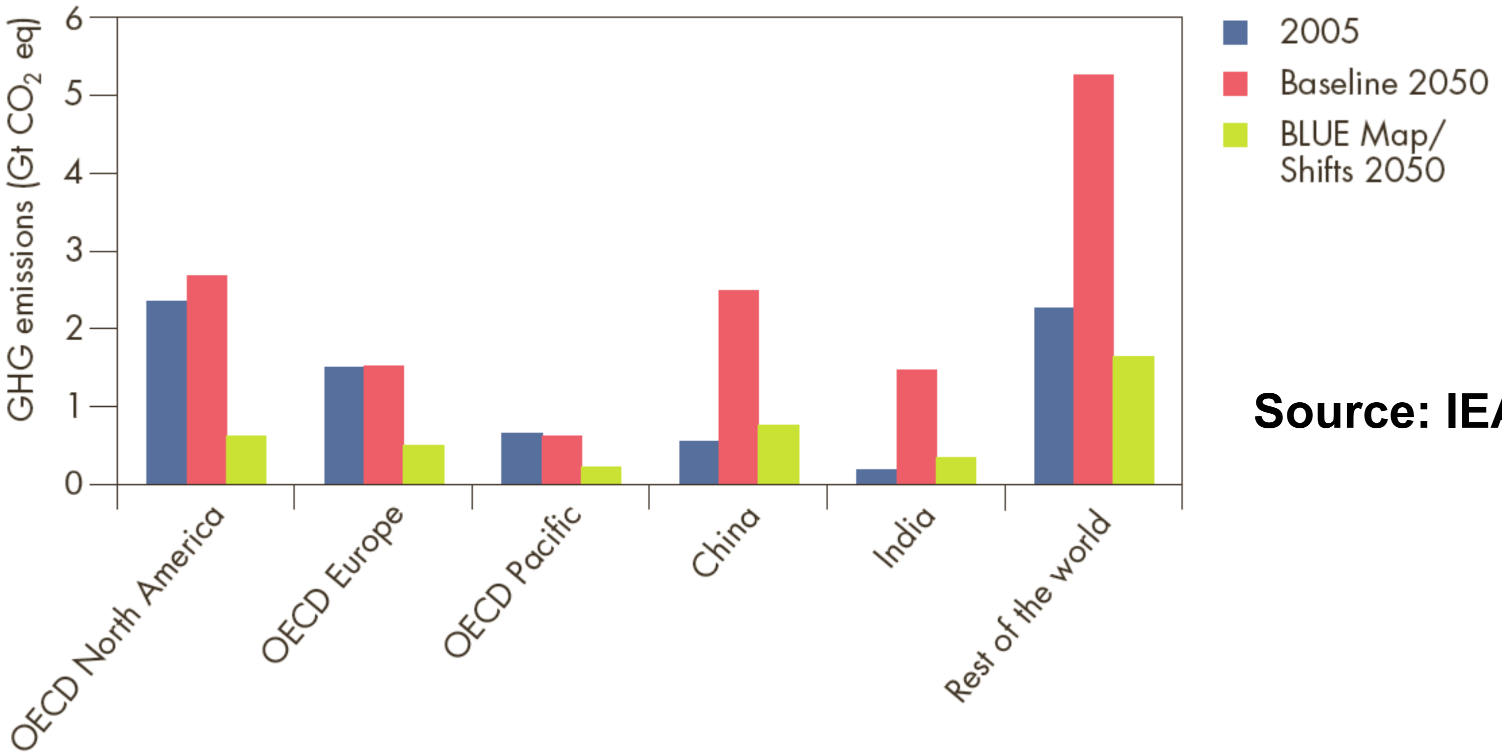
REIVE - Redes Eléctricas Inteligentes com Veículos Eléctricos

Smart Grids with Electric Vehicles

- 2,6 M€ national project, funded by the Portuguese government FAI
- Participation of Portuguese scientific partners, utilities and manufacturers.
- INESC Porto: project management and scientific leader

INTRODUCTION:
THE NEED TO MAKE A MOBILITY SHIFT TOWARDS ELECTRIC MOBILITY

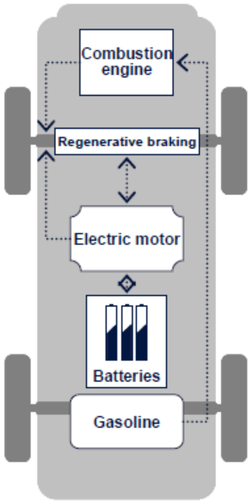
Transport GHG emissions by region and scenario, 2005 and 2050

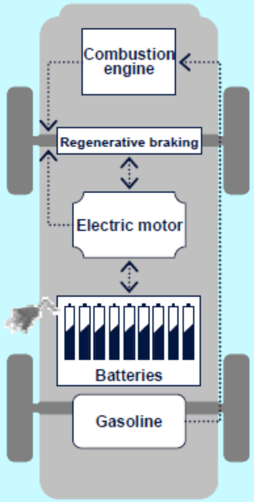


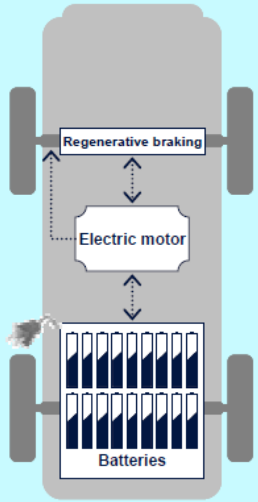
Source: IEA

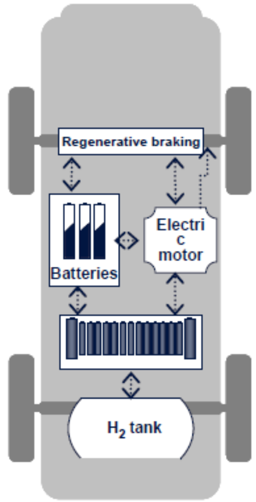
The Intergovernmental Panel on Climate Change concluded that emissions must be reduced by 50% to 85% by 2050 if global warming is to be confined to between 2°C and 2.4°C

DIFFERENT TECHNOLOGIES IN ELECTRIC VEHICLES







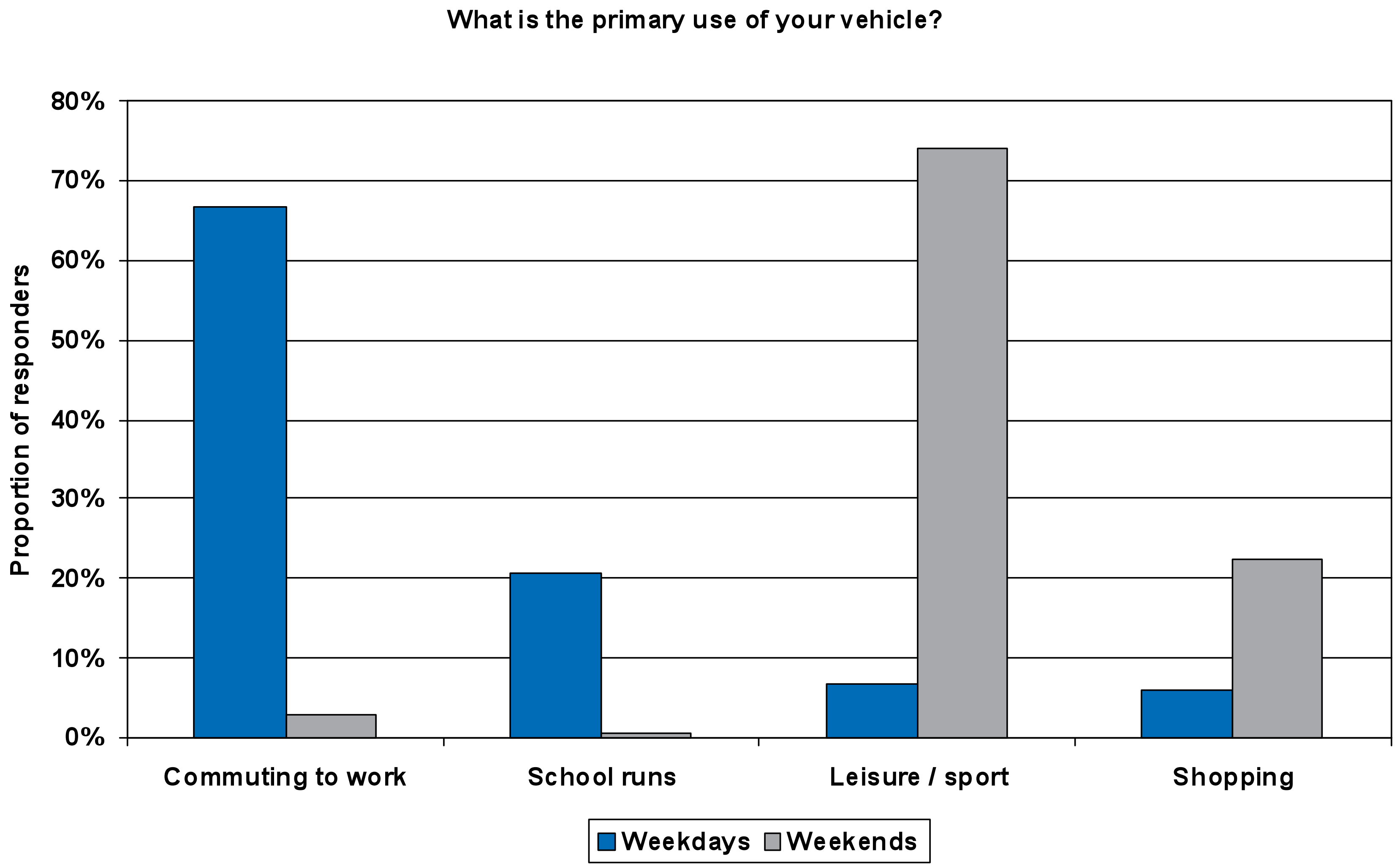


Hybrid electric vehicles (HEVs)	Plug-in hybrid electric vehicles (PHEVs)	Battery electric vehicles (BEVs)	Fuel cell electric vehicles (FCEVs)
Commercial year: 2008	Commercial year: 2010	Commercial year: 2011	Commercial year: 2020
Segment: medium-high	Segment: medium-high	Segment: low-compact	All segments
1 – 1,5 kWh	10 – 15 kWh	20 – 30 kWh	

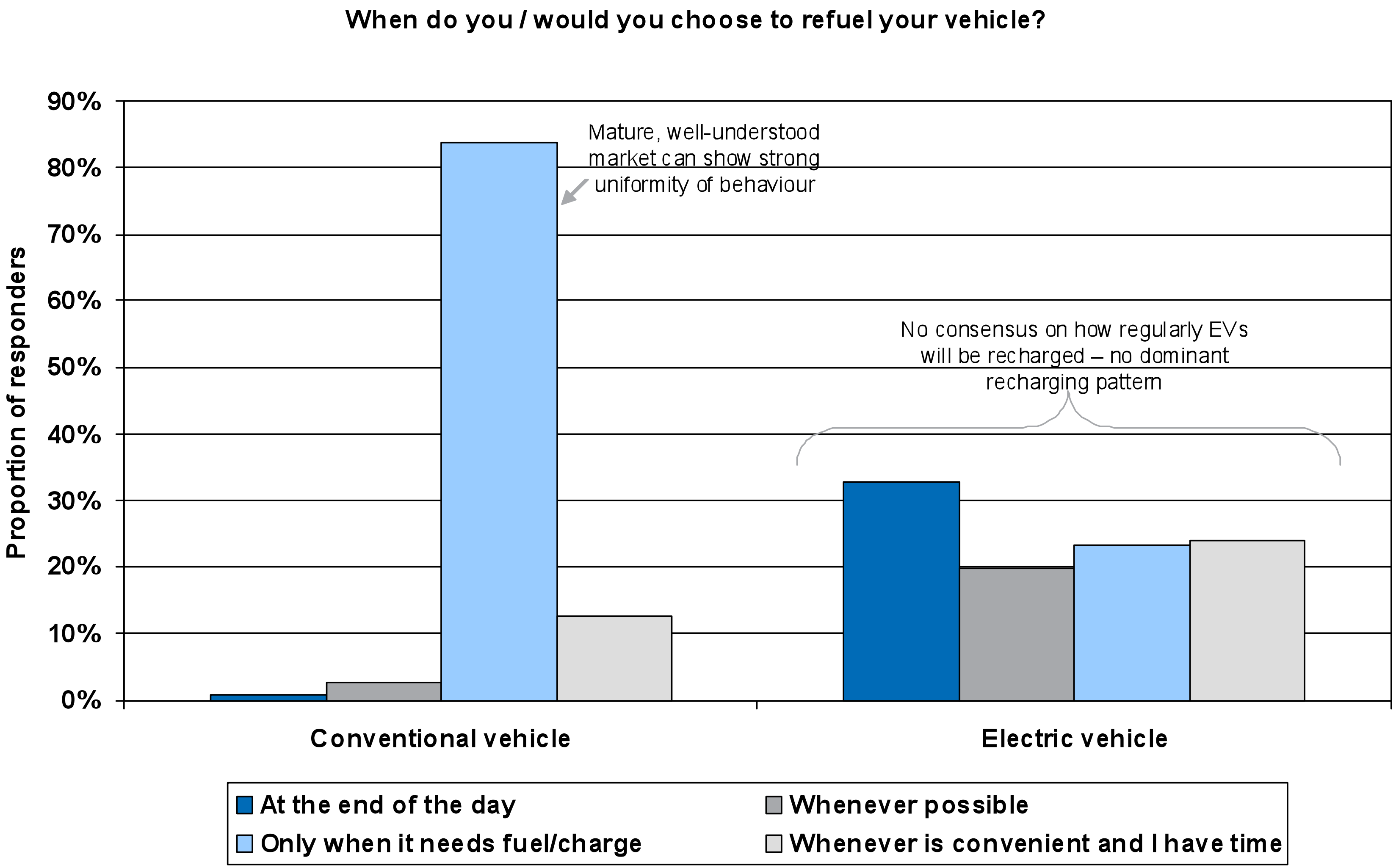
BEHAVIORAL ISSUE RELATED WITH EV ACCEPTANCE AND THEIR IMPACT IN THE DEVELOPMENT OF THE INFRASTRUCTURES THAT WILL SUPPORT EV

- Need to understand the behavior of EV drivers → Surveys
- Design of charging infrastructures
- Impacts in Power System operation
- Definition of management solutions with implications on battery charging modes

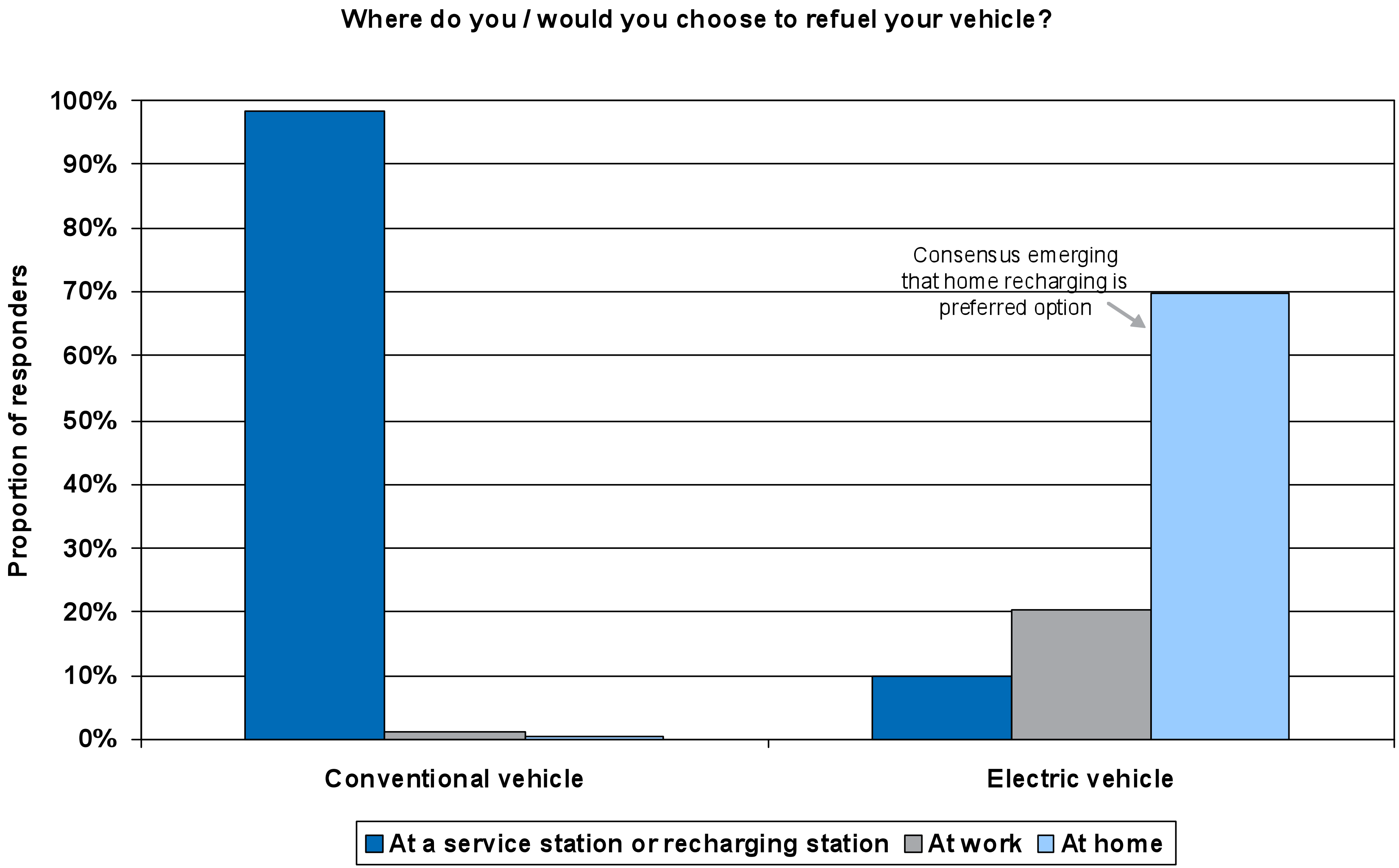
RESULTS FROM THE MERGE PROJECT:
VEHICLE USAGE AND USER PREFERENCES



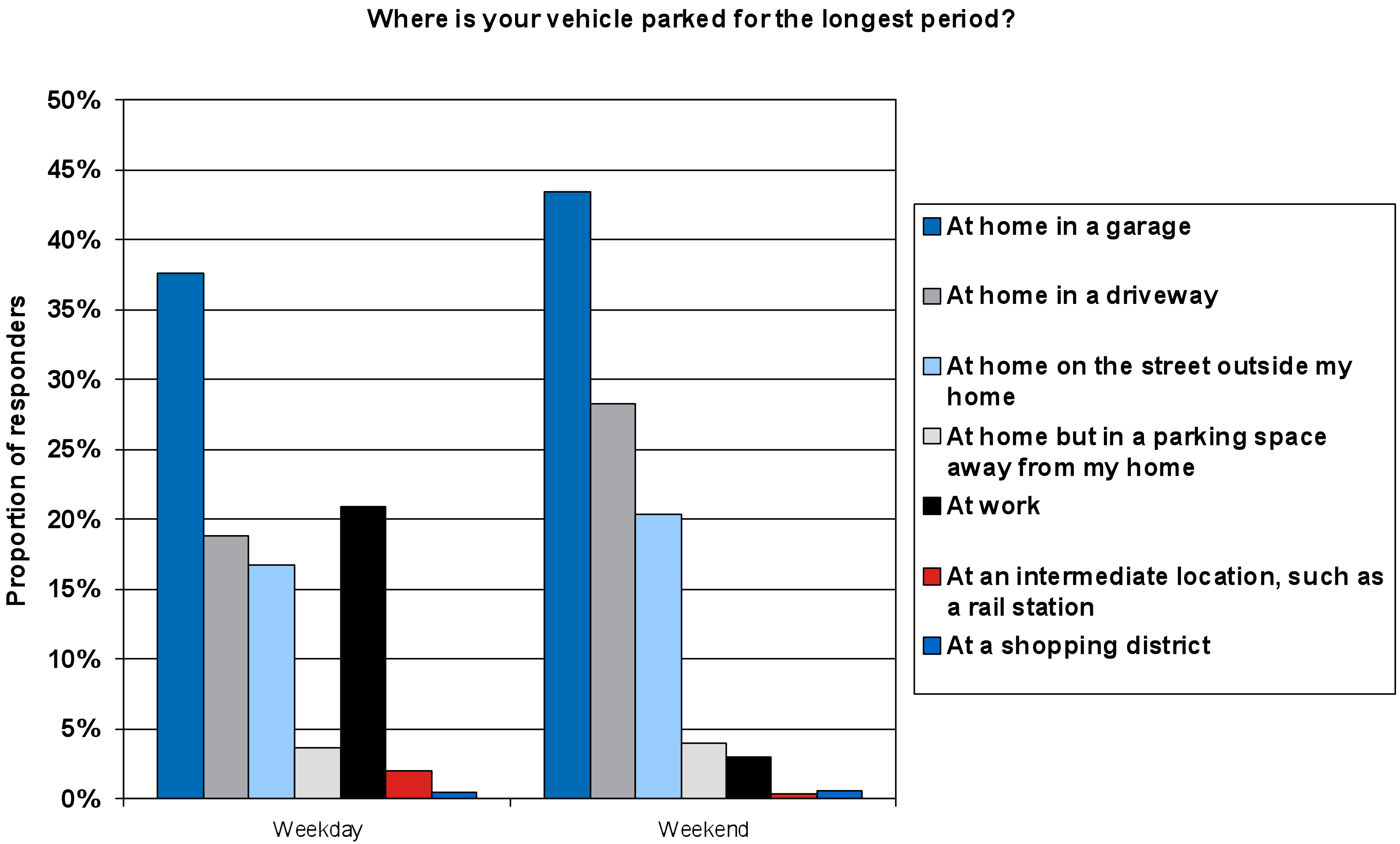
RESULTS FROM THE MERGE PROJECT:
REFUELLING AND RECHARGING REGULARITY/TIMING PREFERENCES



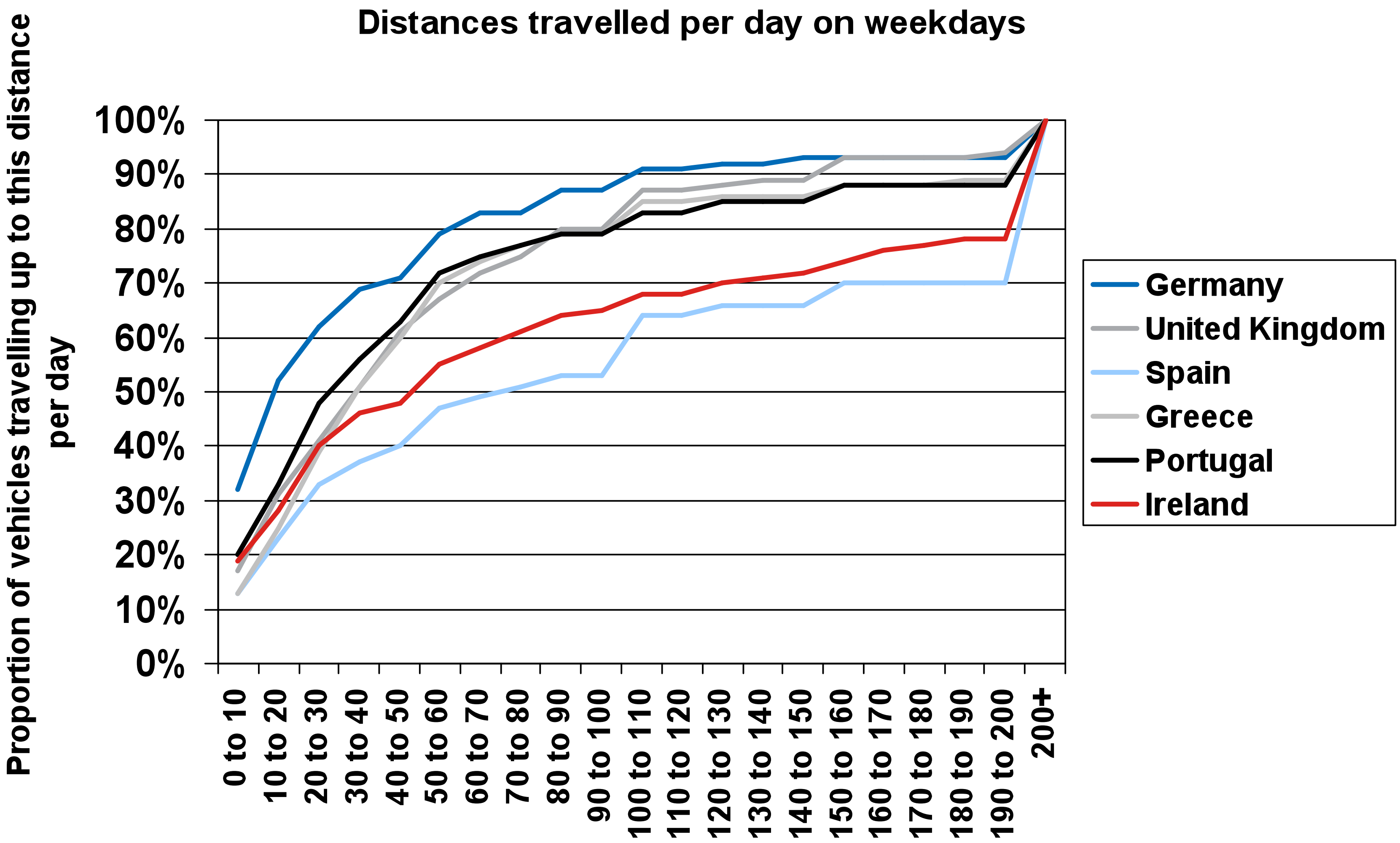
RESULTS FROM THE MERGE PROJECT:
REFUELLING AND RECHARGING LOCATION PREFERENCES



RESULTS FROM THE MERGE PROJECT:
LOCATION OF VEHICLE FOR LONGEST PERIOD OF INACTIVITY



RESULTS FROM THE MERGE PROJECT:
VARIATION OF DISTANCES, IN KM, TRAVELLED PER DAY ON WEEKDAYS, BY COUNTRY



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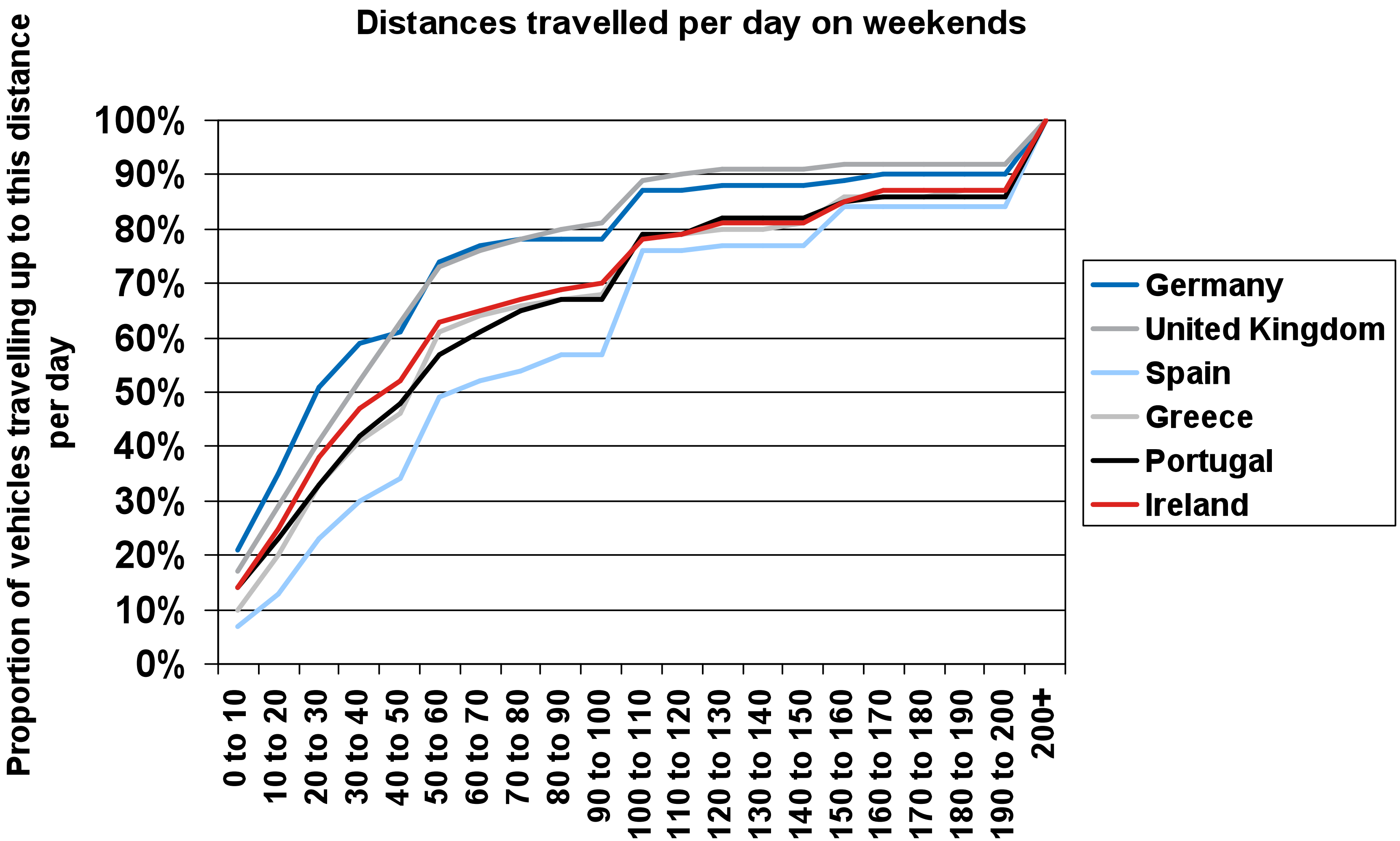
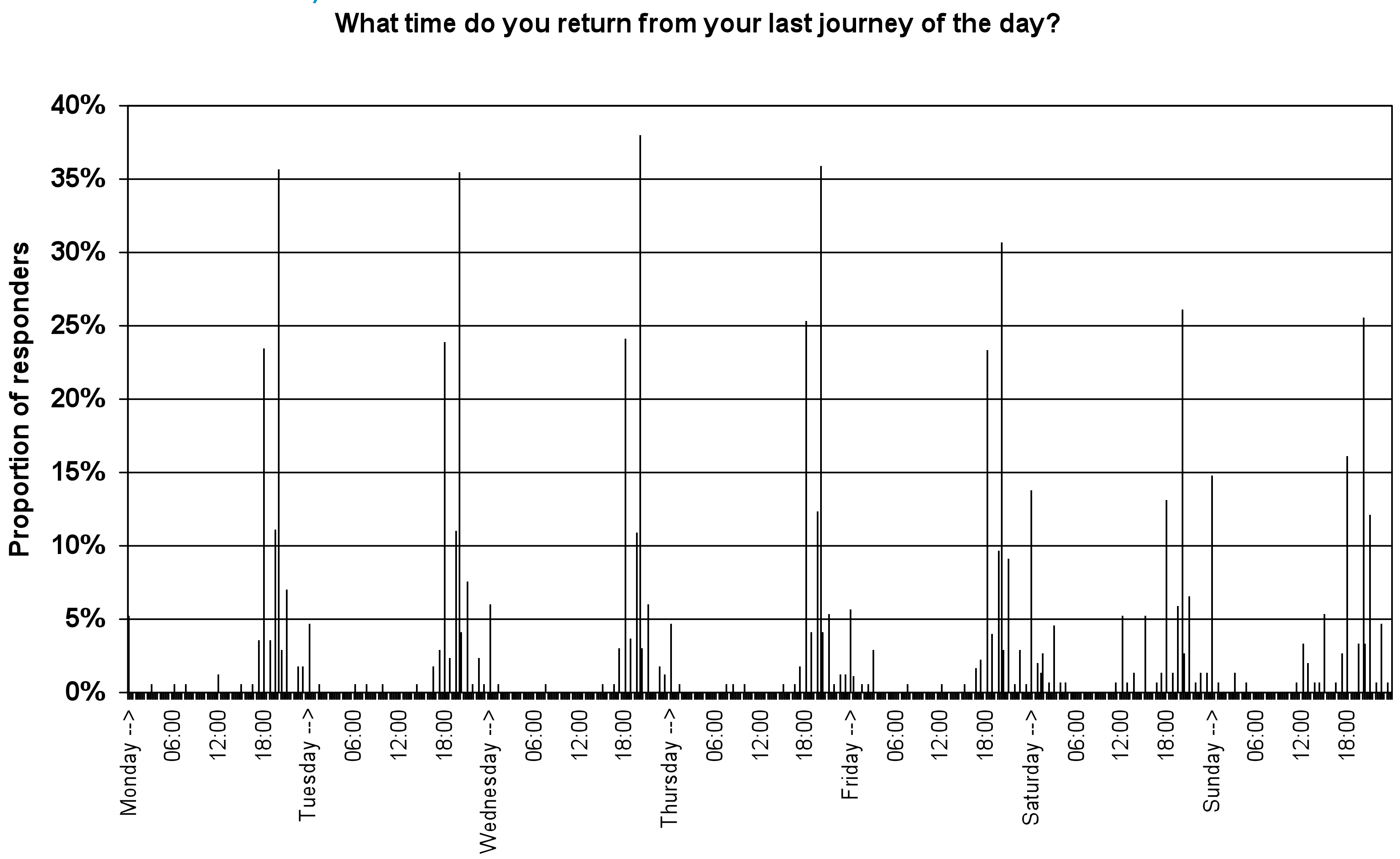


RESULTS FROM THE MERGE PROJECT:

PROFILE OF TIME OF RETURN FROM LAST JOURNEY OF THE DAY, PORTUGAL



RESULTS FROM THE MERGE PROJECT:
Behavioral issues related with EV acceptance

MAIN CONCLUSIONS

- 75% of the existing vehicles only have a daily mileage of less than 60km.
- Drivers prefer to have a vehicle that they would be capable to fuel at home or own premises than a gasoline station
- Early market of EV needs to focus on car owners with the opportunity to charge EV batteries at home and or workplaces

EV are specially suited for commuting in urban areas

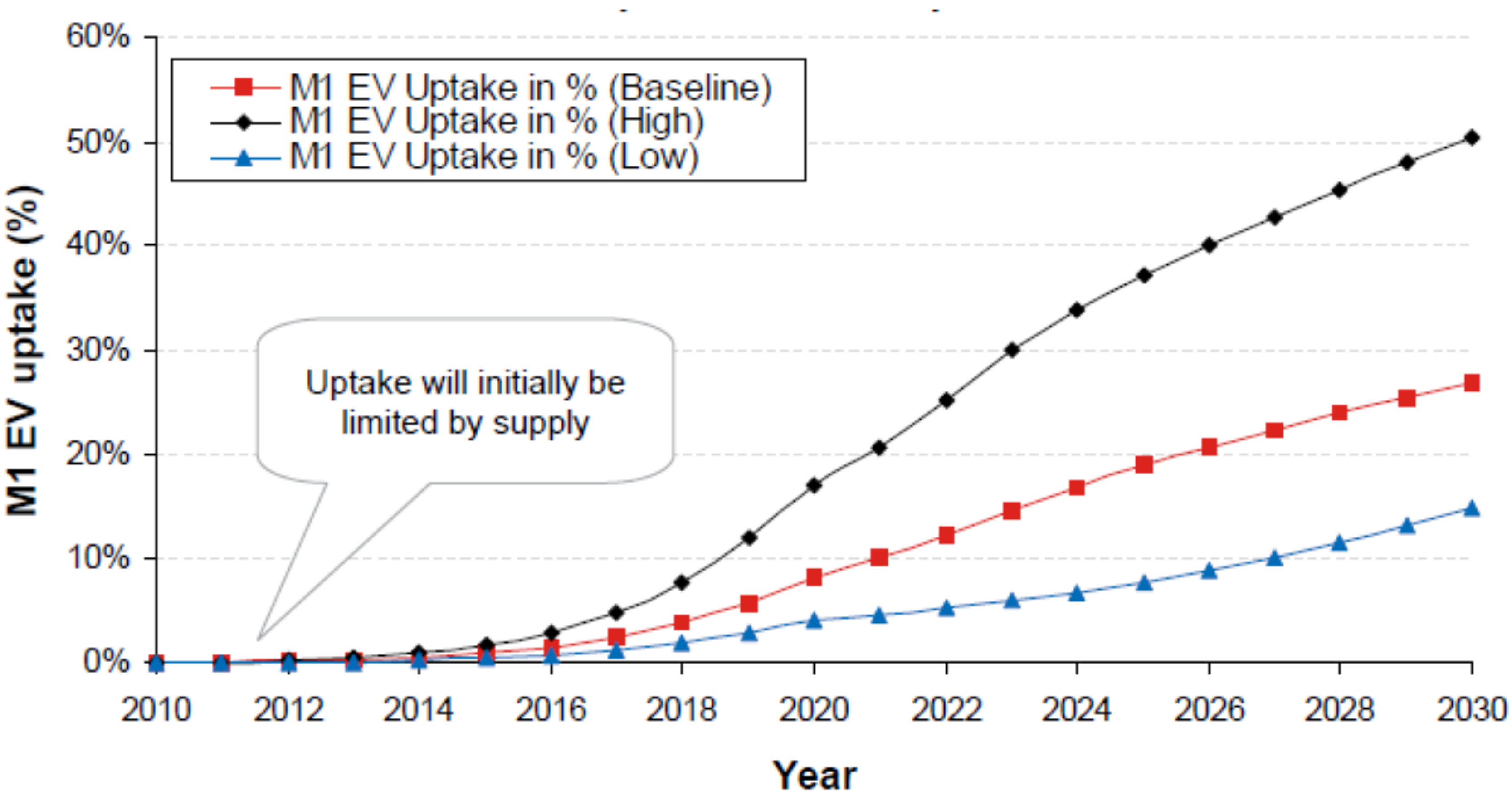
VEHICLE SEGMENTS

- The European Commissions Mobility & Transport: Vehicle categories defines vehicle segments: http://ec.europa.eu/transport/road_safety/vehicles/categories_en.htm

CATEGORY	DESCRIPTION	
L7e	Quadricycle - Four wheels, with a maximum unladen mass of 400kg or 550kg for a goods carrying vehicle (not including the mass of the batteries in an EV) and a maximum net power, whatever the type of engine or motor, of 15kW	
M1	Passenger vehicle, four wheels, up to 8 seats in addition to the driver's seat	
N1	Goods-carrying vehicle, four wheels, with a maximum laden mass of 3,500kg	
N2	Goods-carrying vehicle, four wheels, with a maximum laden mass between 3,500kg and 12,000kg	

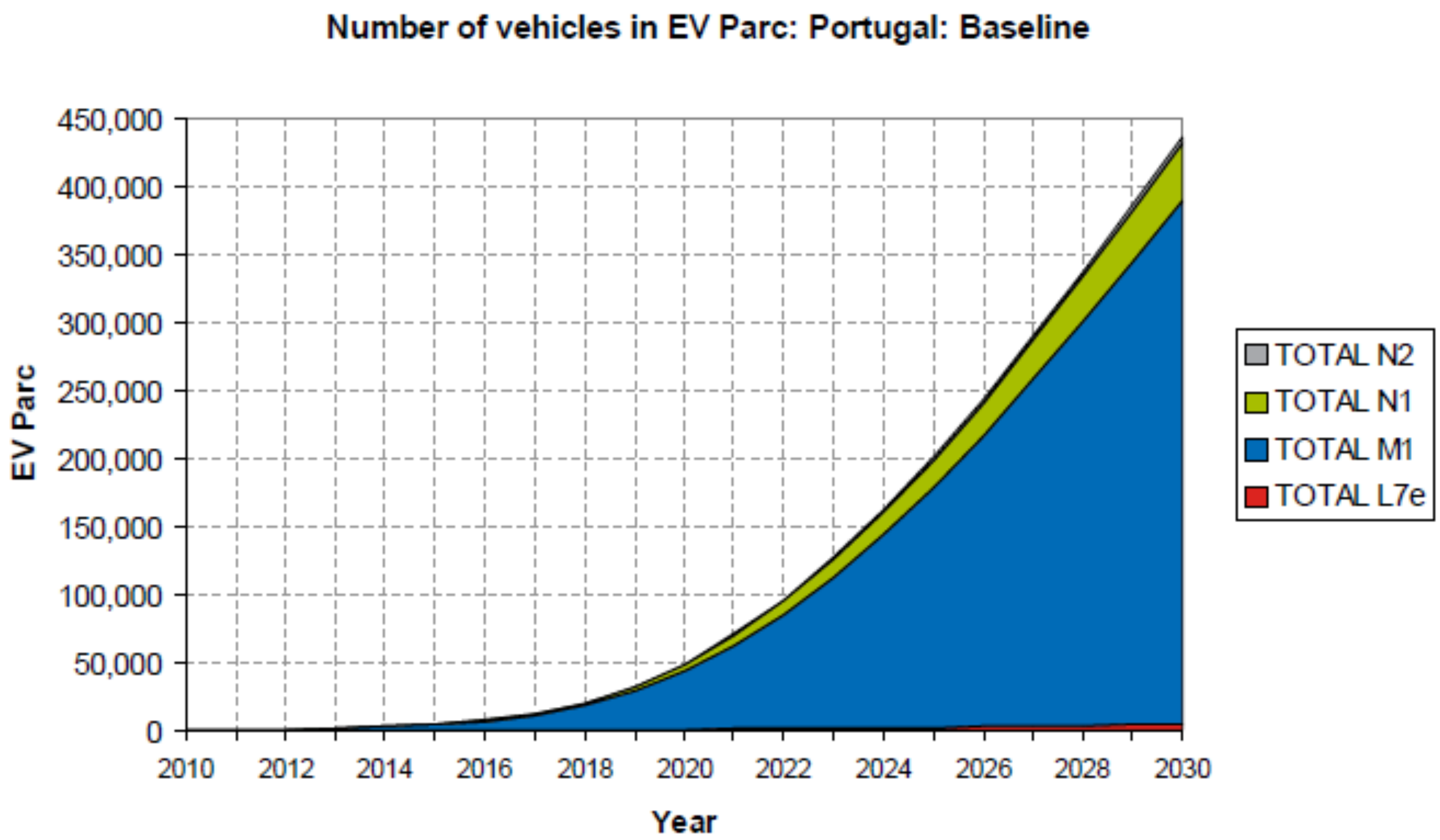
PENETRATION SCENARIOS FOR ELECTRIC VEHICLES – M1

• Three key scenarios were proposed: High, Baseline and Low for M1 category based on EV targets that have been sourced from the public domain



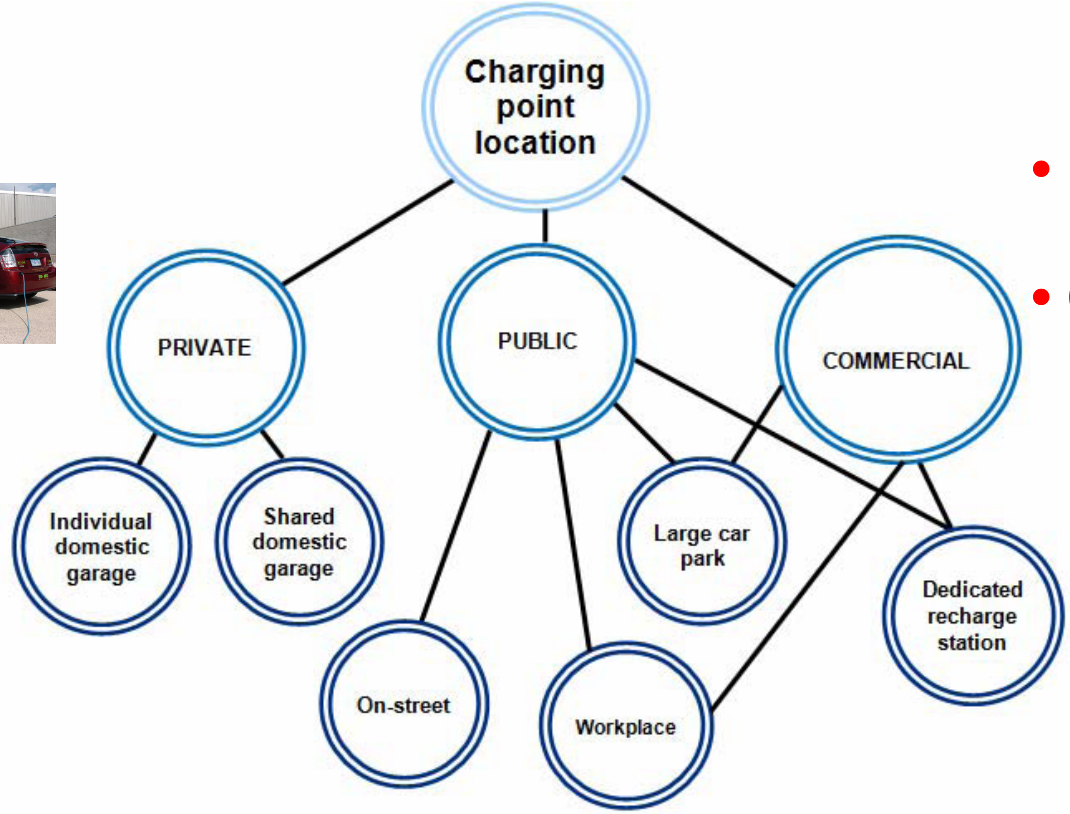
EV CAR PARK VS TIME IN PORTUGAL

- The proportional split of L7e, M1, N1 and N2 vehicles over time, using the baseline uptake scenario



RESULTS FROM THE MERGE PROJECT:
Conceptual Framework for EV Integration Into Electric Power Systems - *Type of charging points*

Charging points can present different characteristics according to the location



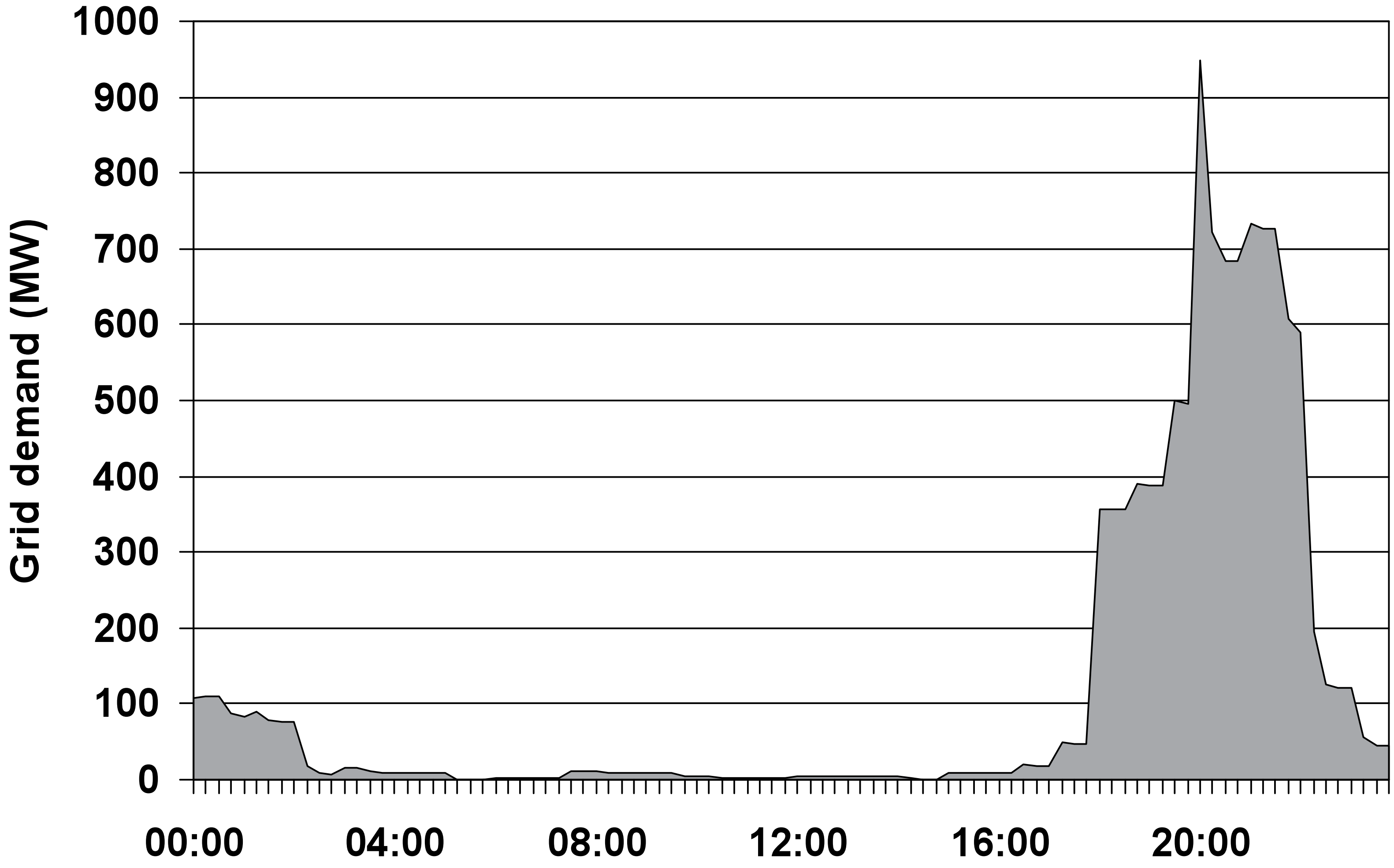
- Dumb charging
- Controlled charging

Fast Charging

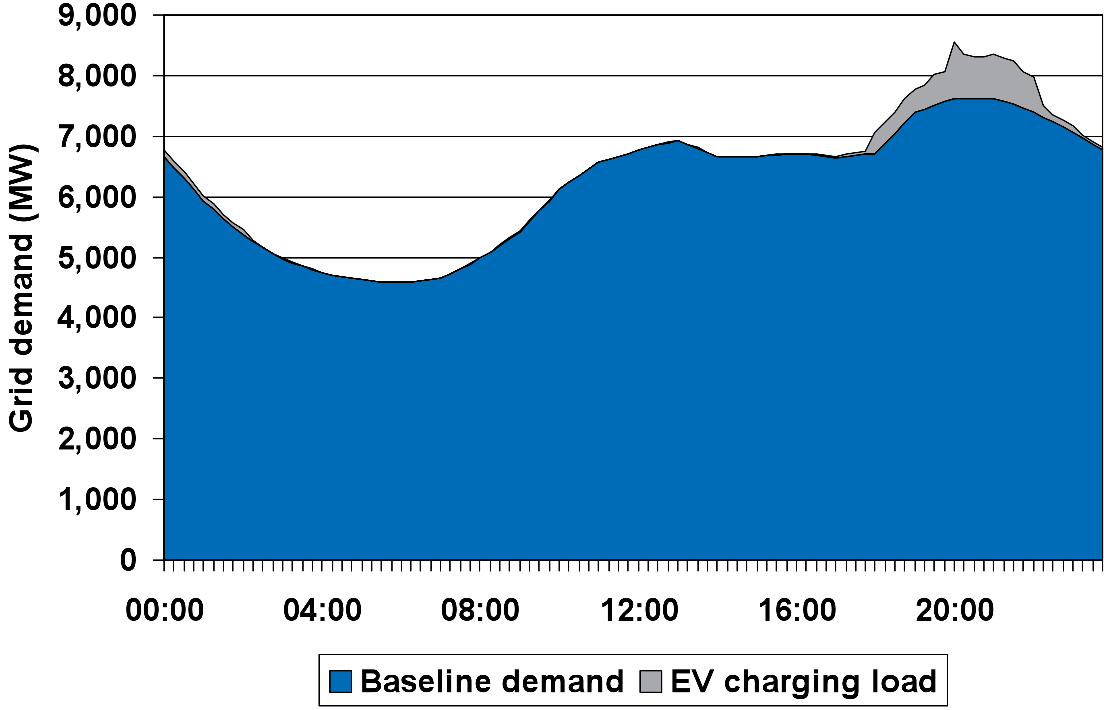
RESULTS FROM THE MERGE PROJECT:
EV CHARGING LOAD FOR DUMB CHARGING SCENARIO, PORTUGAL

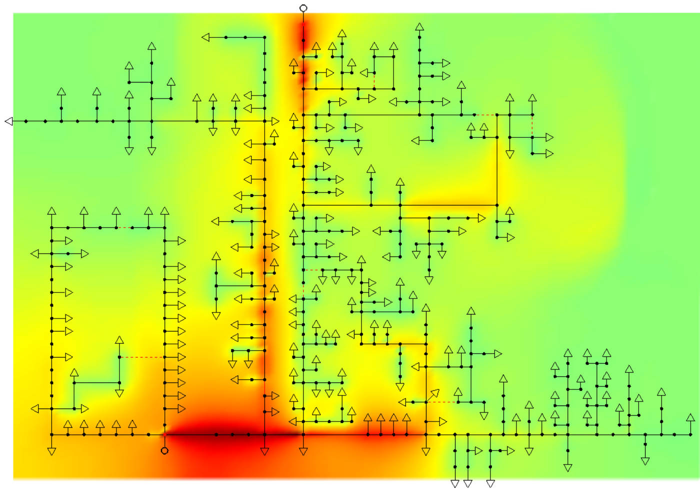
- The dumb charging scenario considers:
  - The profiles of times to return from last journeys of the day;
  - 10% penetration of EV in the total vehicle fleet;
  - An average daily distance travelled of 40 km;
  - A charge rate of 3 kW.

EV CHARGING LOAD FOR DUMB CHARGING SCENARIO, PORTUGAL (10% EV)



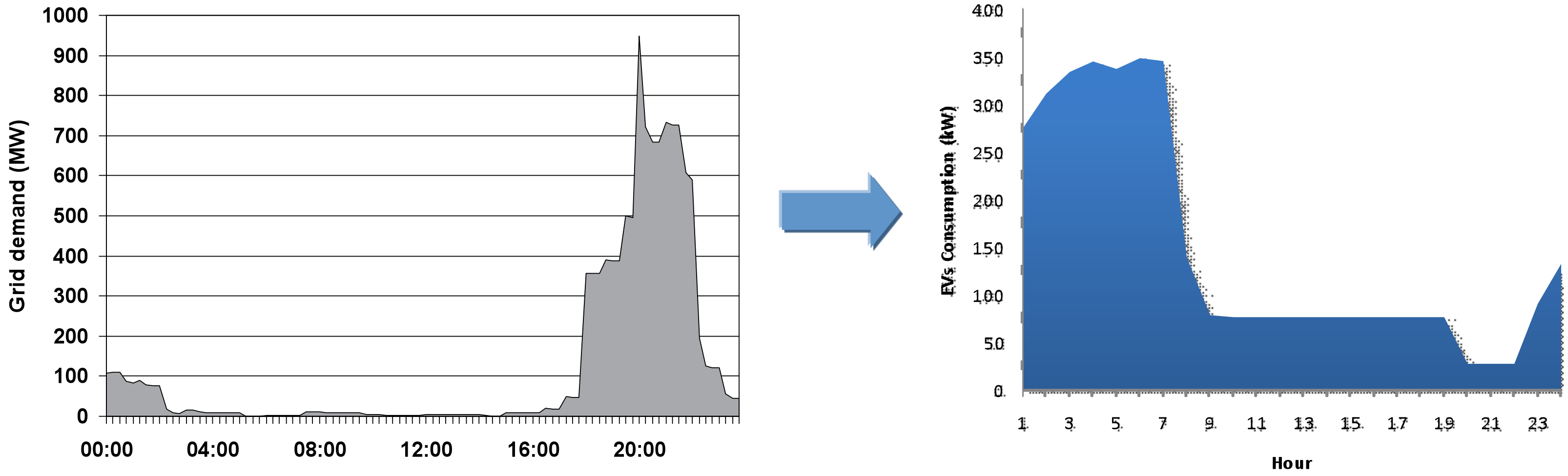
EFFECT OF DUMB CHARGING SCENARIO ON PORTUGAL'S ELECTRICITY DEMAND (10% EV)





SMART CHARGING IS REQUIRED

- Developing the Smart Charging concept → moving charging to valey hours (night periods)

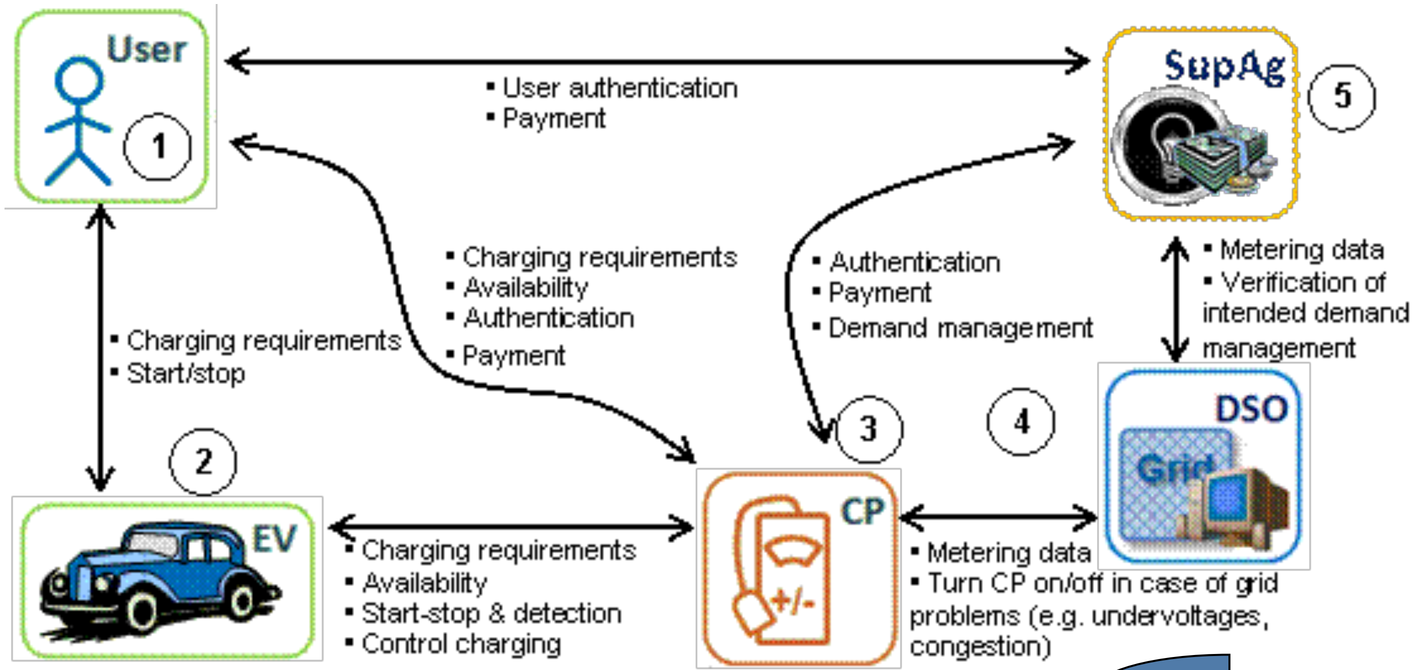


RESULTS FROM THE MERGE PROJECT:

Conceptual Framework for EV Integration Into Electric Power Systems

Overview of the different information flows

An ICT model was developed, identifying the involved parties and the associated information flows.

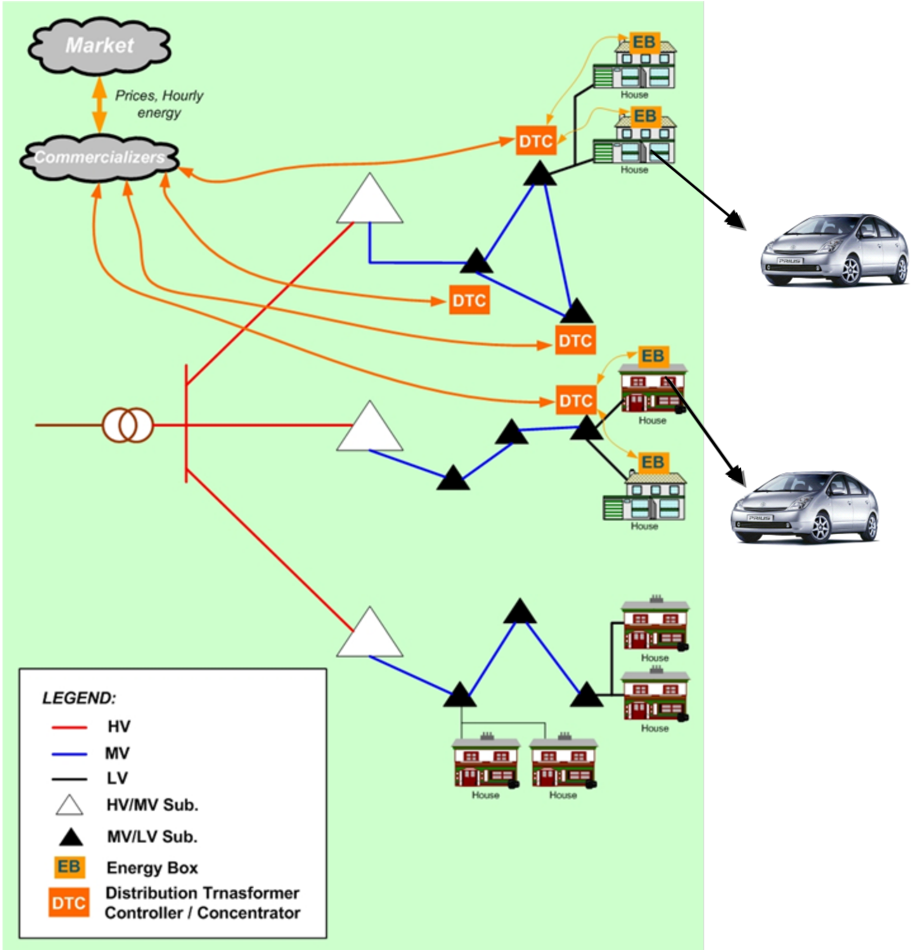


SMARTMETERING

Overview of the different information flows

Smart metering will provide the communication infrastrcture

The supplier / aggregator



- **A two level hierarchical control approach needs to be adopted:**
  - Local control housed at the EV grid interface, responding locally to grid frequency changes and voltage drops;
  - Upper control level designed to deal with:
    - "short-term programmed" charging to deal with branch congestion, voltage drops
    - Delivery of reserves (secondary frequency control);
    - Adjustments in charging according to the availability of power resources (renewable sources).

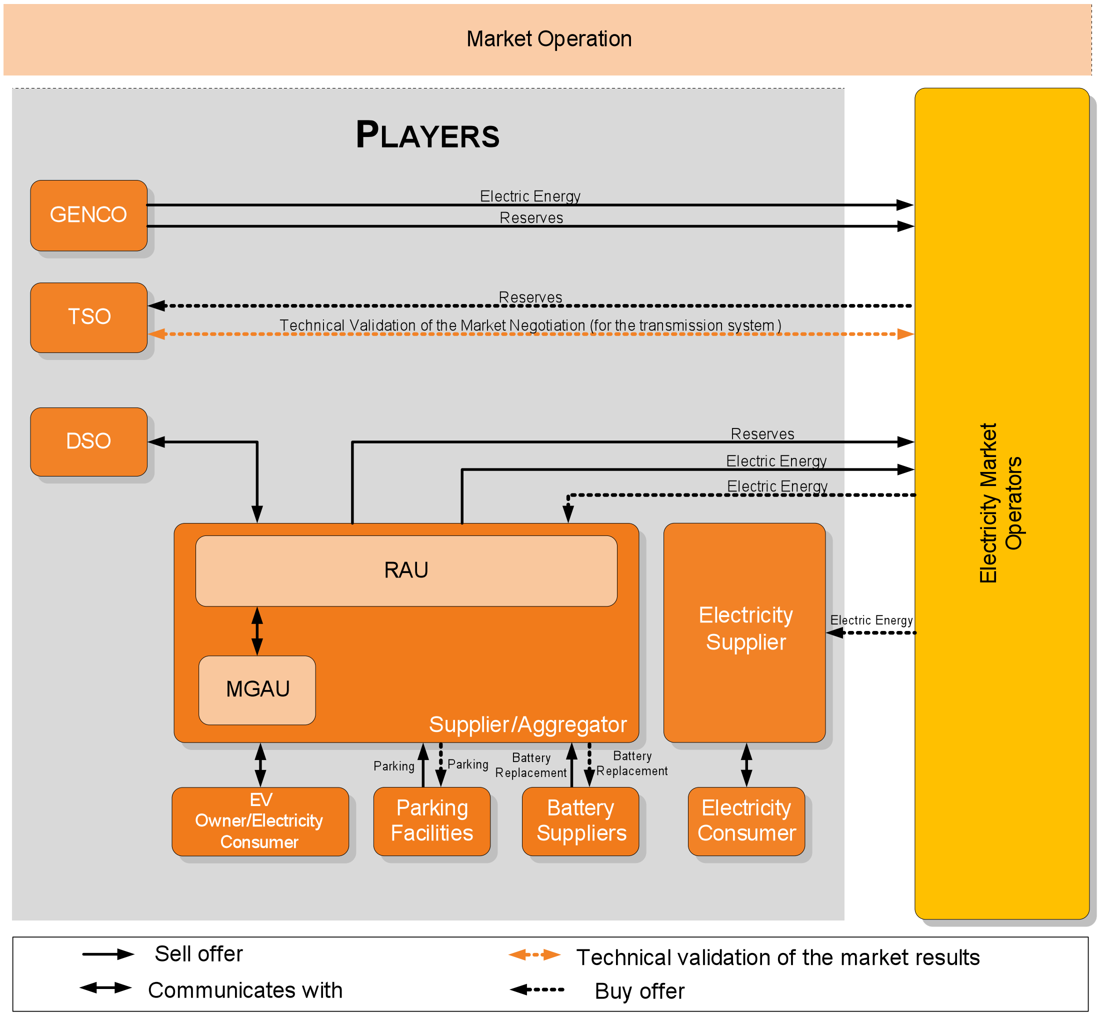
EV Voltage / Frequency support modes

- Voltage Control
  - Local Control
  - Coordinated Control
- Frequency Control
  - Primary Control (local control)
  - Secondary Control

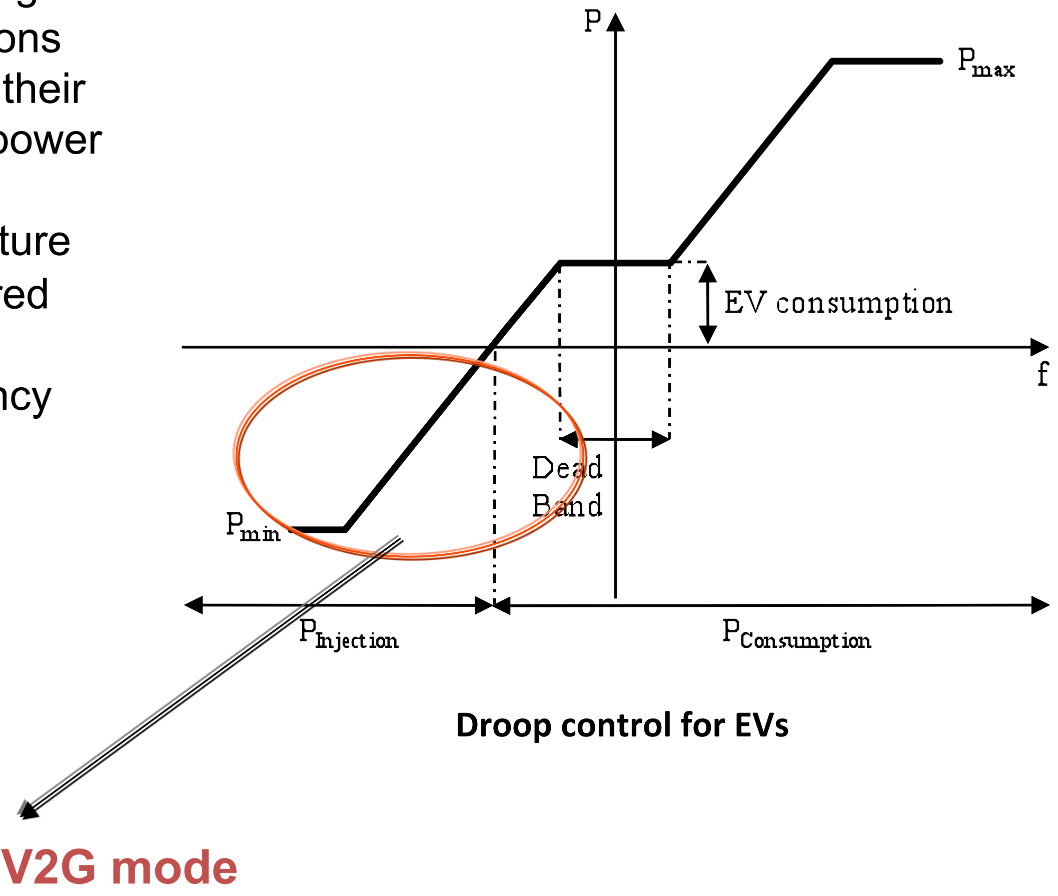
Conceptual Framework For EV Integration

- EV must be an active element within the power system

- The Upper Level control requires interactions with:
  - **An Aggregating** entity to allow:
    - Reserve management
    - Market negotiation

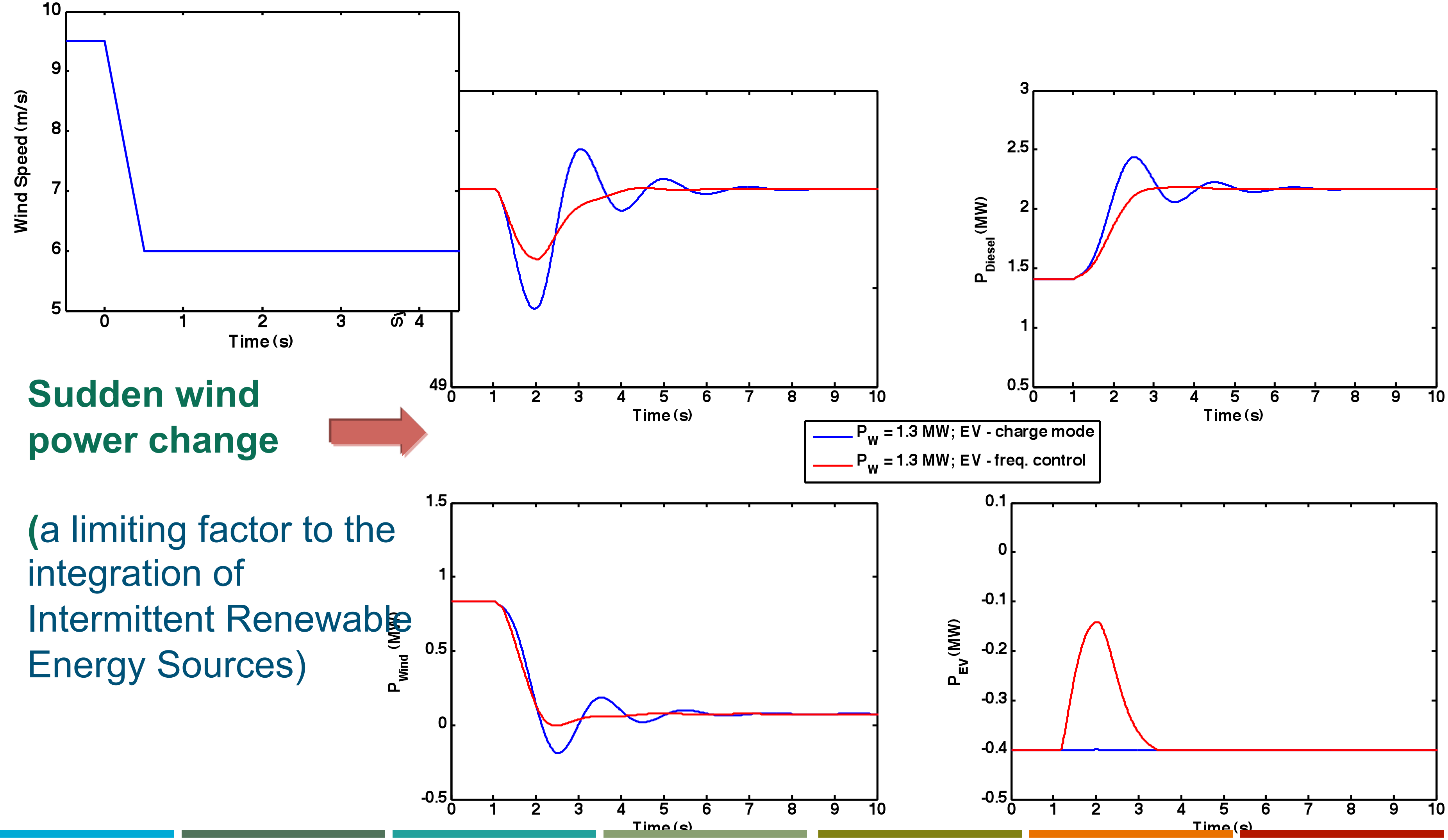


- For frequency control the envisioned response from EVs is shown in the figure:
  - When facing frequency deviations EVs may slow down/speed up their charging or even inject active power into the grid
  - A dead band for battery premature exhaustion prevention is required
  - P_{rated} MW/Hz proportional gain controls the reaction to frequency deviations



Droop control for EVs

Results - islanded systems



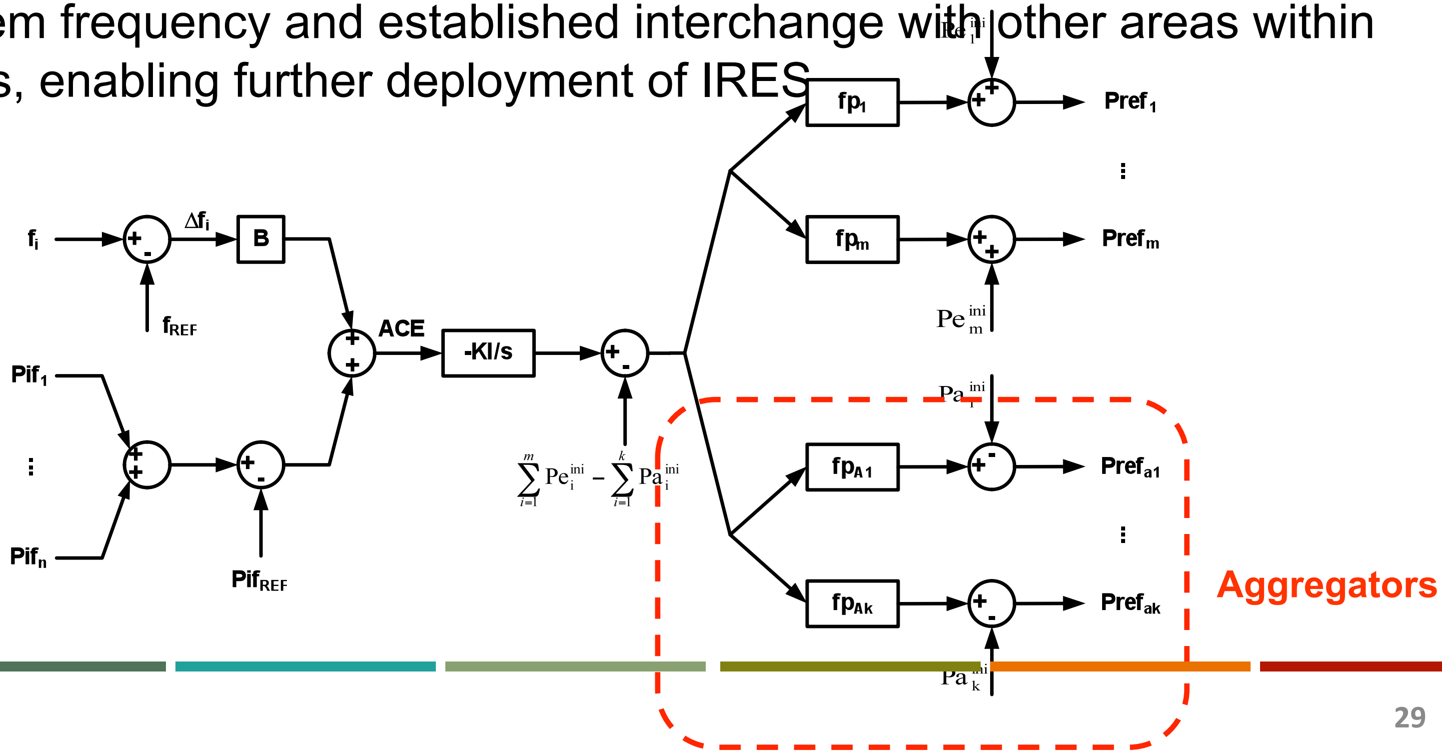
Sudden wind power change

(a limiting factor to the integration of Intermittent Renewable Energy Sources)

- Modification of the active power set-points of generators and EV

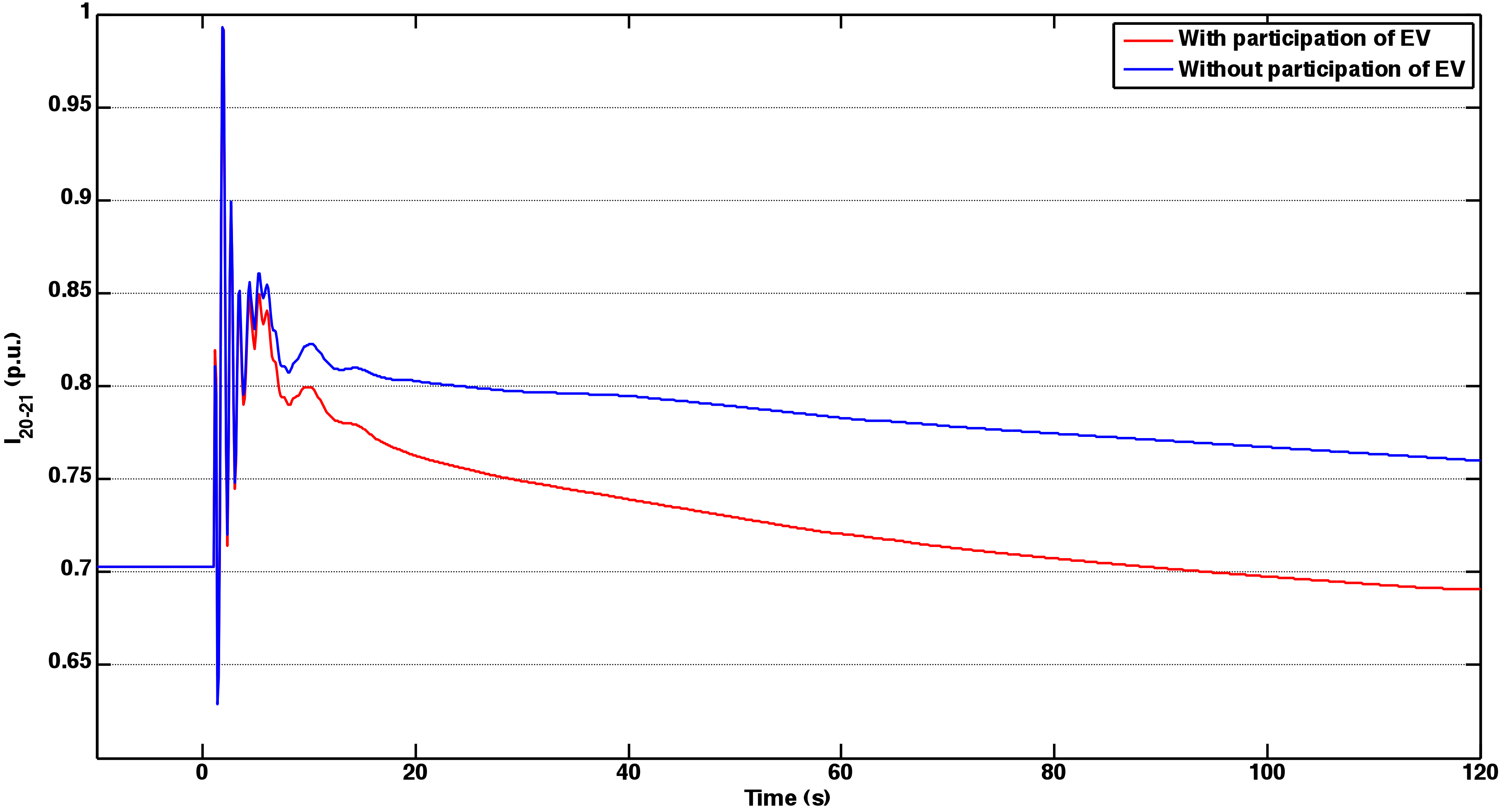
- Some modifications need to be introduced in conventional AGC systems:
  - redefinition of the partipation factors and
  - introduction of an additional block to communicate with EV aggregators

- These control functionalities to be provided by EV are intended to keep the scheduled system frequency and established interchange with other areas within predefined limits, enabling further deployment of IRES



Secondary Reserve - Results –

Electrical Current in one interconnection line



CONCLUSIONS

- 75% of the existing vehicles only have a daily mileage of less than 60km.

- Drivers prefer to have a vehicle that they would be capable to fuel at home or own premises than a gasoline station

- A public charging infrastructure will be needed together with adaptation in the home electrical installations to allow for home battery charging

- Smart charging solutions are required to avoid the need to reinforce the existing electrical grid and generation infrastructures