Integration of vehicles and electricity networks: challenges and opportunities leading up to 2030

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RSE is a research organisation serving the electrical and energy sectors with projects of national strategic importance and general public interest.

EXECUTIVE SUMMARY

This study examines the technical and economic potential of full electric vehicle integration with power grids

- The study seeks to quantify the opportunities arising from *vehicle-grid integration* (VGI) within the scenario of the Italian national system leading up to 2030. We shall analyse the ability of electric vehicles to enhance the flexibility of the electricity system, identifying the main obstacles posed by current regulations and quantifying the benefits afforded by full vehicle integration. In particular, the main goals are to
  - ✔ examine the benefits of VGI in relation to the costs of developing distribution networks
  - ✔ quantify the impact of VGI on electricity system dispatching costs
  - ✔ assess the potential profitability of VGI for charging operators
  - ✔ identify the economic and regulatory leverage factors capable of promoting VGI solutions
- For this purpose, the analysis includes two detailed studies: one on distribution networks and the other on dispatching. Firstly, we quantified the impact electric vehicles would have in the absence of VGI, then, we examined the potential that can be unlocked by enabling VGI services in both contexts.

EXECUTIVE SUMMARY

The system scenarios and deployment of electric vehicles expected by 2030 are consistent with the policies of the FF55 package

- The system scenarios and the deployment of electric vehicles expected by 2030 are consistent with the policies of the FF55 package, with specific reference to the most recent Terna-Snam scenarios.
- The electricity system therefore has a capacity of 100 GW (as envisaged by the RES Decree – the Renewable Energy Sources Decree – 75 GW of which from photovoltaic generation and 26 GW from wind), an accumulation capacity of 15 GW with an approximate energy-to-power ratio of 6 hours, and an electricity demand between 362 and 366 TWh/year.
- With regard to electric vehicles, two possible deployment scenarios by 2030 were considered, one consistent with the goals of the Integrated National Energy and Climate Plan (PNIEC), the other with the policies of the "Fit for 55" package (FF55). The main reference for the presented results is the FF55 scenario, which envisages the following vehicle deployment scenario by 2030 (in millions): 1.2 PHEVs, 6.3 BEVs, 0.75 e-LCVs, 0.05 e-HCVs and 0.07 e-BUSES for local public transport.
- For each vehicle category, we estimated the 2030 levels of rural and urban penetration in each market area, the segmentation and spread of each segment, the main technological features and specific charging methods.

EXECUTIVE SUMMARY

Nine different charging modes have been mapped and analysed

- We mapped and analysed nine different charging modes: residential, workplace, urban public, high-speed public, in businesses, shopping centres and interchange car parks for LCVs, HCVs and Local Public Transport (LPT).
- For each charging mode, we defined a number of key parameters, such as the time of arrival at and departure from the charging station, the duration of the stop, the state of charge of the incoming and target vehicle, the conditions of vehicle use and the average distance travelled.
- The particularities of each charging mode were then further adjusted with reference to certain sub-cases, distinguishing between: holiday or weekday, hot or cold days, rural or urban context, and relevant market area.
- For each charging mode and sub-case, a probability distribution has been associated with each key charging parameter, with identified averages and variances.
- The available charging and flexibility profiles were then derived by applying the Monte Carlo method, i.e. simulating a large number of charging events through sampling.

EXECUTIVE SUMMARY

The impact of charging on dispatching costs is irrelevant

DISTRIBUTION NETWORKS

- The impact of charging on distribution networks was simulated by considering two network contexts, a rural one with long lines and medium loads, and urban settings with short lines and a high load density.
- The results showed an increase in the maximum load factor of grid elements caused by vehicle charging, with greater problems associated with short but intense overloads for elements with lower voltage levels. Voltage profile problems were also seen in rural grids: daytime over-voltages caused by local photovoltaic overproduction and under-voltages in the evenings caused by peripheral consumption peaks.

DISPATCHING COSTS

- Electricity system dispatching costs were assessed using a market simulator covering both the Day-Ahead Market (DAM) and the Dispatching Service Market (DSM), defined on an annual basis with hourly unit schedules.
- Estimated DSM costs for 2030 amount to €1.9 billion, to which is added a generation component from Non-programmable Renewable Energy Sources (NPRES) of 5.5 TWh/year; this estimate is reduced when DSM-related grid operations are considered. Electric vehicles have a negligible impact on DSM costs, as these are mostly driven by Non-programmable RES.

EXECUTIVE SUMMARY

VGI solutions and their benefits for distribution networks

- The charging impact is linked to intense and short-term overload events, especially with regard to the low-voltage sections of urban networks. In rural contexts, the biggest problem is related to voltage profiles, also due to the strong penetration of local RES.
- The promotion of intelligent charging modes, which implement *demand response* solutions guided by timely pricing signals, can reduce the impact on average load factors along the low-voltage sections of distribution networks by 13%.
- The use of storage facilities in conjunction with *quick* and *fast* charging infrastructure significantly reduces the number of elements on which violations occur (by 30%) and the corresponding energy overload levels on the relevant grid sections.
- The possibility of synchronising the charging energy demand with photovoltaic generation has a twofold benefit in terms of both overload events and voltage profile control.

EXECUTIVE SUMMARY

Benefits derived from enabling electric vehicles for dispatching

- The enabling of electric vehicles allows a 45% reduction in RES *overgeneration* linked to dispatching (2.5 TWh/year).
- Vehicles can play a key role in dispatching markets, contributing 15% of total reserves supplied and 26% of system balancing operations.
- The inclusion of vehicles in dispatching can reduce DSM-related costs by up to 40% (€800 million/year), mainly due to the natural directional flexibility of charging profiles, thus promoting the concentration of charging activity at times most favourable for the system.
- Electric vehicles mainly displace fossil fuel systems, contributing with their enablement to a reduction of 1.5 TWh/year, with approximately €30 million/year in averted social costs due to reduced emission of greenhouse gases and local pollutants.

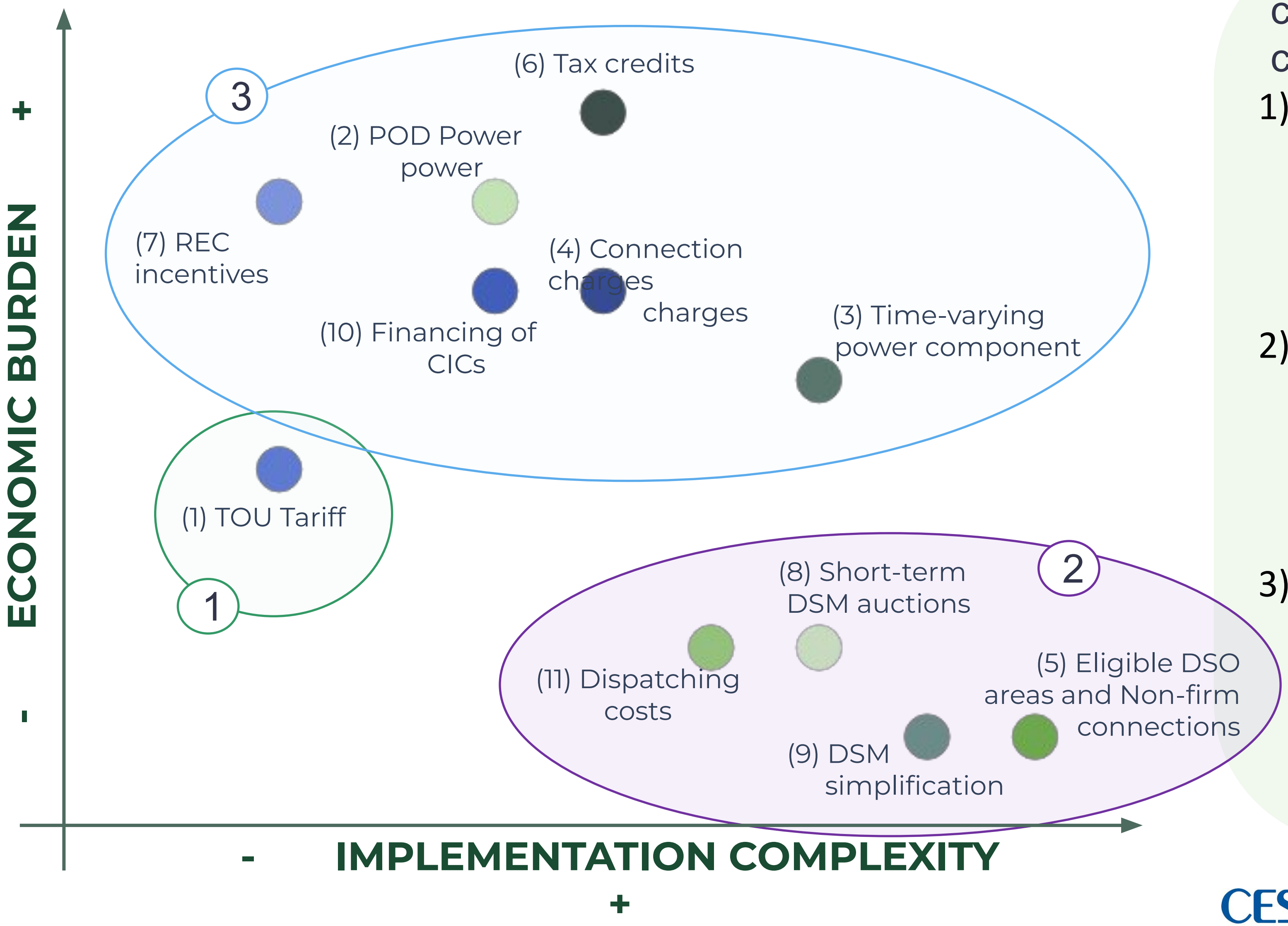
EXECUTIVE SUMMARY

Economic benefits for charging operators

- Using real vehicle traffic and parking data, we assessed the profitability of VGI solutions compared to a study case in a workplace context, including employee vehicles and fleet vehicles (90% and 10%, respectively). There were 22 AC charging points, each rated at 22 kW and all providing V1G features only (no V2G), with charges numbering between 35 and 50 per week.
- The observation period lasted six weeks, from March to June 2022, and the directional flexibility estimates were modelled using real charging profile data.
- Enabling VGI reduces morning load peaks, synchronising energy consumption with renewable production and ensuring more off-peak electricity demand during daylight hours.
- The simulations revealed a service provision of 3000 hours per year, with a predominance of down-side regulation (17 MWh - 1900 calls) over up-side regulation (11 MWh - 1000 calls).
- Charging operator's revenues mainly resulted from a lower charging energy cost, i.e. charging coinciding with downward adjustment. Estimated annual revenue amounts to approximately €2000, or €94/charging point, and a return on investment breakeven nine years after VGI implementation.

EXECUTIVE SUMMARY

Proposals for policy-related and regulatory actions



The presented proposals can be classified into three intervention categories:

1) reforming the energy component of network service tariffs (*'time-of-use'*) should be a simple matter and immediately applicable, with a minor impact on expected revenues;
2) a second group of interventions concerns regulatory aspects that have no impact on revenue, but are more complex to implement and therefore require a time for reform;
3) a third group of interventions involves a greater economic burden, with different levels of application complexity: a clear implementation roadmap must be defined for these interventions.

EXECUTIVE SUMMARY

Proposals for policy-related and regulatory actions

1) Defining EV charging tariffs on a time-variant basis would allow higher energy consumption at times more favourable to the electricity system. A 30% reduction in the F3 tariff and in stronger sunshine hours (noon to 3 pm) would save charging users approximately €18/MWh.
2) Enabling operation on a flexible maximum power basis during off-peak periods (F3) also for low-power PODs would allow higher power consumption during the most favourable periods for the system.
3) Enabling the power component to adapt on a time-varying basis for PODs with a committed power delivery greater than 30 kW would promote intelligent charging management. In such cases, the consumed power component of the tariff could be calculated as the weighted average of two separate tariffs applied to peak consumed power metered over different time periods (hour bands).
4) Connection charges should be calculated in such a way as to facilitate intelligent charging management, making them regressive, for the same power consumption, with respect to the number of charging points fed by a single POD.

EXECUTIVE SUMMARY

Proposals for policy-related and regulatory actions

5) At least annually, DSOs should define areas that are more or less suitable for the connection of new charging points by publishing maps in which such areas are ranked according to the level of complexity required for new connections. This could also include access to non-firm, i.e. flexible connections, facilitating fast and inexpensive connections, perhaps by stipulating specific constraints already in the connection contract.

6) The availability of transferable tax credits for DSM-approved co-installation of charging points, storage and photovoltaic systems would benefit smart charging projects and VGI solutions, also on low-power PODs.

7) The Renewable Energy Communities (RECs) framework should envisage specific incentives for the charging of electric vehicles from local renewable energy sources. This would be consistent with the so-called *energy efficiency first principle* promoted at European level and instrumental for the award of Energy Efficiency Certificates (EECs or white certificates), also in favour of energy from fossil sources.

EXECUTIVE SUMMARY

Proposals for policy-related and regulatory actions

8) Terna, the system operator, should procure the required reserves through short-term capacity auctions (on a daily, weekly or monthly basis). Adopting long-term models, as required by the ARERA Consultation Document 393/2022, could involve technological lock-ins, linking the system's operation to assets already remunerated but more costly than other resources with significant growth predicted by 2030.

9) To facilitate the participation of distributed resources in system balancing, it is necessary to: clearly subdivide the different ancillary services into different market products; avoid applying technical charges or participation obligations to system resources; allow portfolio management of resources, without excessive technical requirements for the qualification or observability of a resource; and remove unjustified technical constraints for the provision of certain services, such as minimum duration of supply or symmetry of reserve bands.

10) Non-repayable financing must be defined for the establishment of the CIC, as stipulated in the Italian Ministerial Decree of 30/01/2020.

11) The application of dispatching charges needs to be reformed, dropping the producer-consumer dichotomy in favour of a distinction between DSM-enabled and non-DSM-enabled actors.

TOPICS EXAMINED

The system context and charging scenarios by 2030

The impact of charging on the electrical system

Estimation of potential benefits derived from VGI solutions

VGI-driven business opportunities

Main findings of the study and policy proposals

INTRODUCTION

This study quantifies opportunities arising from *vehicle-grid integration* in the Italian national system scenario by 2030

GOALS

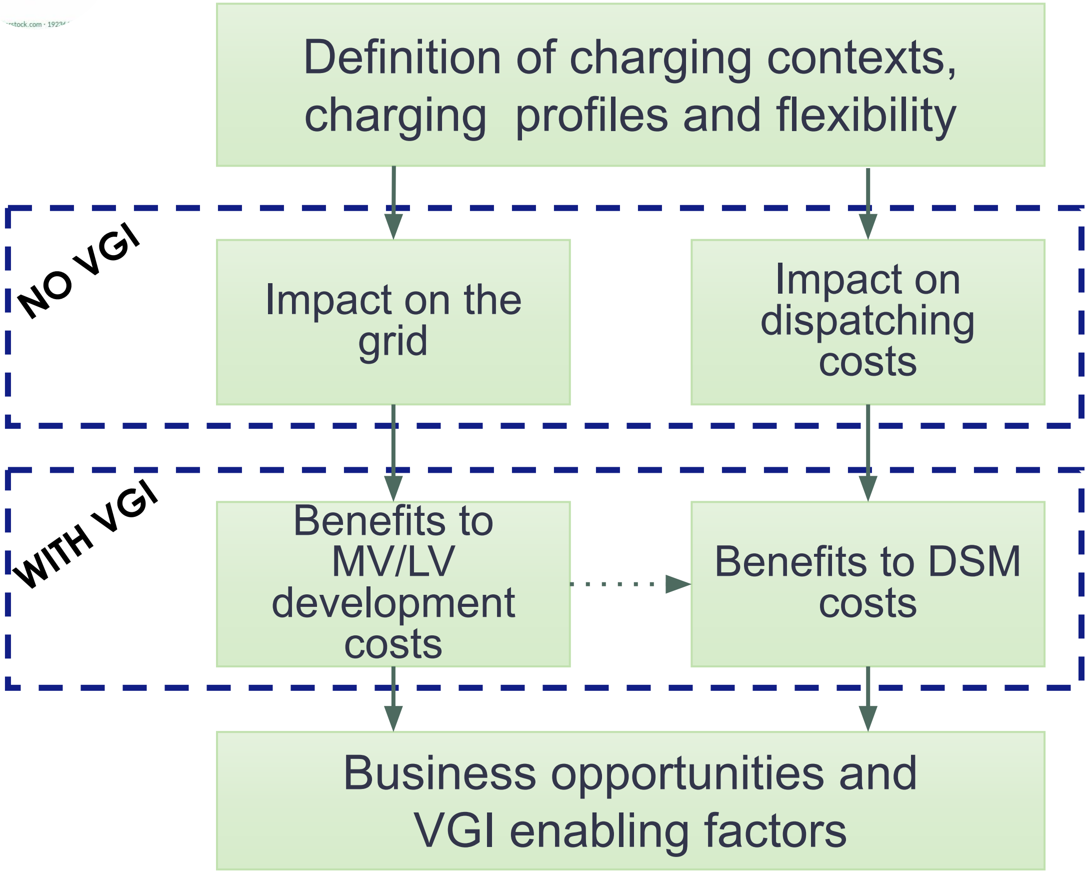
To examine the benefits of VGI in relation to the costs of developing distribution networks

To quantify the impact of VGI on electricity the dispatching costs

To assess the potential profitability of VGI for charging operators

To identify the economic and regulatory leverage factors capable of promoting VGI solutions

SCOPE OF ANALYSIS



Definition of charging contexts, charging profiles and flexibility

NO VGI

Impact on the grid

Impact on dispatching costs

WITH VGI

Benefits to MV/LV development costs

Benefits to DSM costs

Business opportunities and VGI enabling factors

INTRODUCTION

The study focuses on On-Grid VGI solutions, without dealing specifically with Off-Grid solutions.

ON-GRID VGI SOLUTIONS

- V1G – dynamic charge profile management
- V2G – bi-directional energy exchange with the grid
- BESS – electrochemical storage solutions
- RECs – synchronising production and consumption

OFF-GRID VGI SOLUTIONS

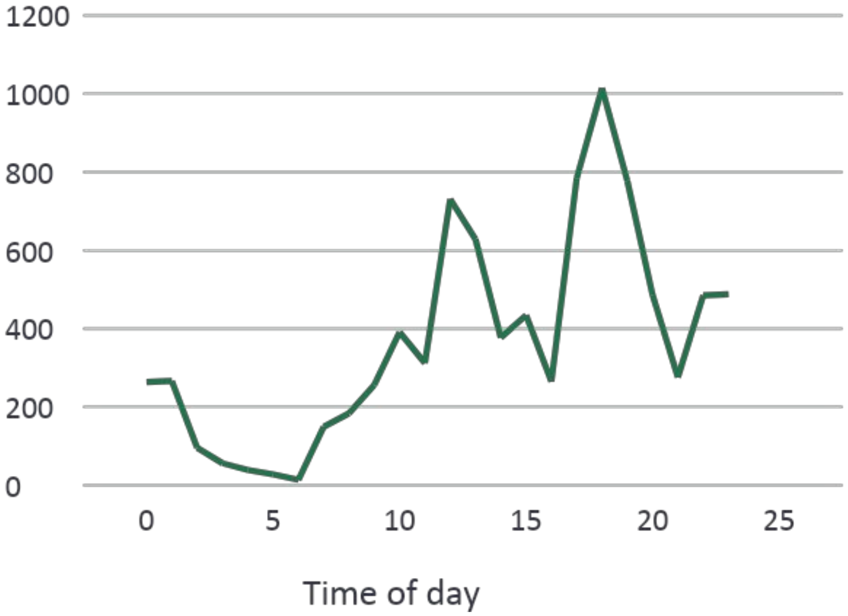
- ON DEMAND – charging with mobility
- BATTERY SWAP – on-the-go battery exchange

In terms of the circumstances relating to where and when electricity is drawn and when it is used to charge a vehicle, we can distinguish between two charging scenarios: on-grid and off-grid. In the first case, the two coincide, whereas in the second they are independent. An appropriate mix of solutions and technologies must be developed to address the transition to sustainable mobility.

INTRODUCTION

Possible VGI solutions include *smart charging* and appropriate synchronism between generation, storage and charging

UNCONTROLLED CHARGING [MW]



PROPOSAL

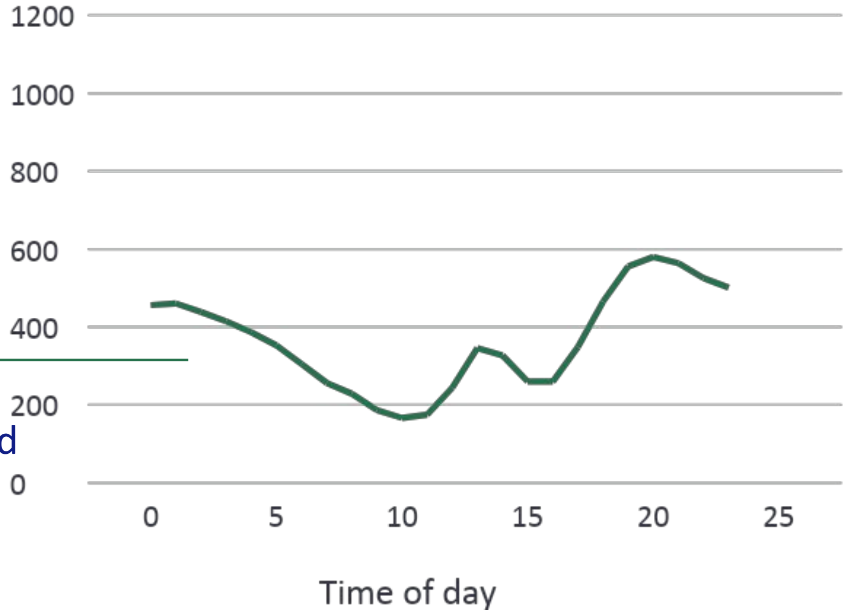
- Constant power delivery for the entire duration of the stopover
- The same energy is recharged

RESULTS

↓ 40% lower peak demand

Smoother consumption trend

SMART CHARGING [MW]



VGI solutions aim to make charging smarter, smoothing out peaks and streamlining functionality with generation profiles of non-programmable sources. Such results are frequently achieved in V1G mode, with charging configurations that are easy to control. Moreover, similar performance may be achieved using storage systems or more complex V2G solutions, which allow intelligent charging profiles to be obtained in less frequent situations that cannot be addressed with V1G.

TOPICS EXAMINED

The system context and charging scenarios by 2030

- **The Italian electricity system**
- segmentation and characterisation of the vehicles in circulation
- charging modes and expected flexibility profiles

The impact of charging on the electrical system

Estimation of potential benefits derived from VGI solutions

VGI-driven business opportunities

Main findings of the study and policy proposals

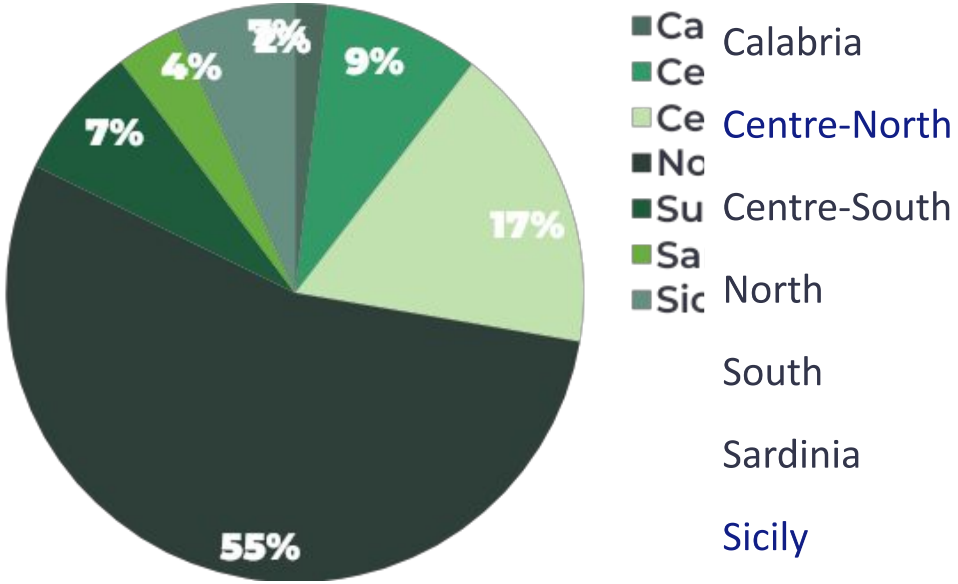
THE ITALIAN NATIONAL SYSTEM SCENARIO BY 2030

Italy's 2030 electricity system estimates are consistent with the fit For 55 targets, with 65% of demand covered by renewable energy sources

ITALIAN RES	Installed [GW]	Production [TWh]
Solar	75.4	101.4
On-shore wind power	18.4	43.0
Off-shore wind power	8.5	25.2
Hydroelectric	24.1	51.3
Other RES	3.8	22.6
Total	**130.2**	**243.5**

Storage	Installed [GW]	Capacity [GWh]
Distributed storage systems	4.0	16.0
8h Utility E/P	8.9	70.9
Utility CM auctions	2.1	8.1
Total	**15.0**	**95.0**

ZONAL ELECTRICITY DEMAND



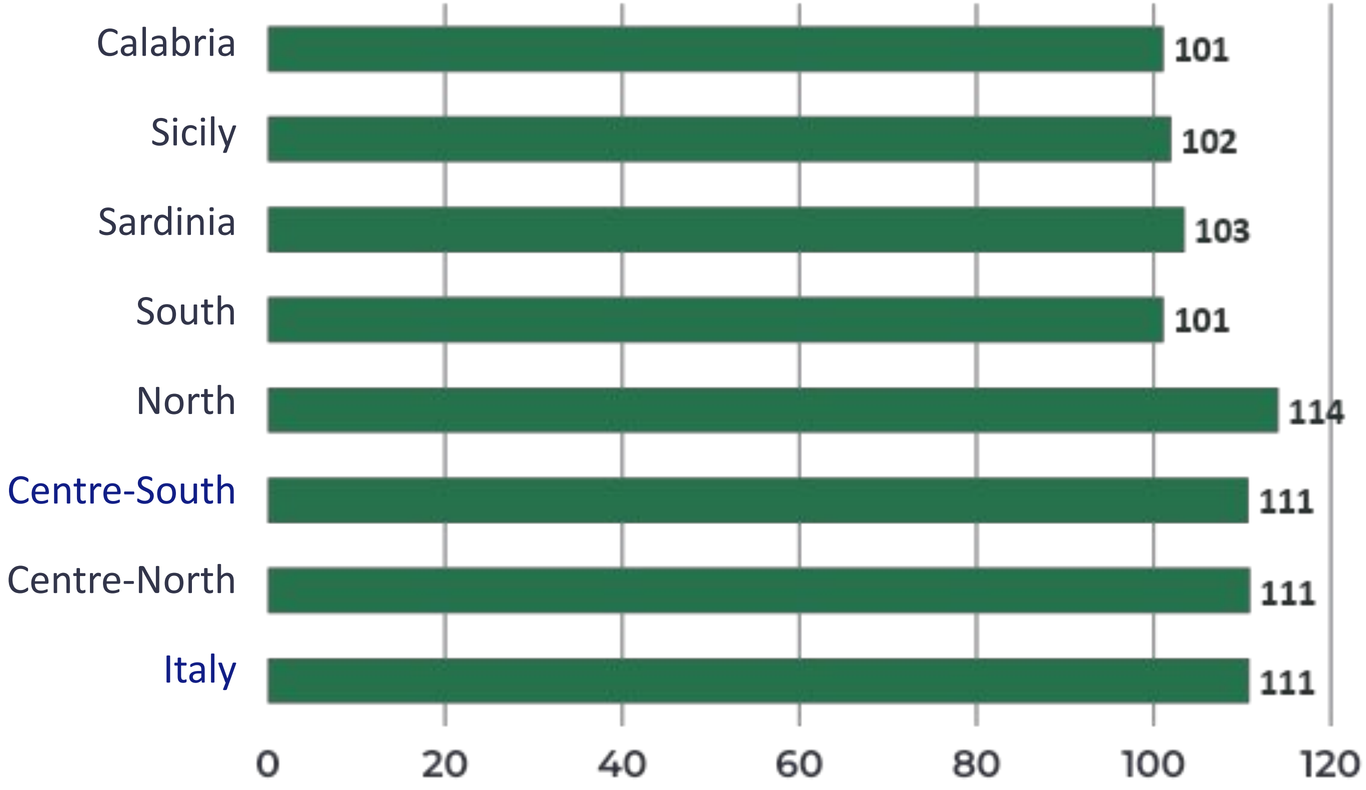
EV uptake scenarios indicate that Italy will need between 362 and 366 TWh

THE ITALIAN NATIONAL SYSTEM SCENARIO UP TO 2030

System simulations enable us to define market prices and coverage of the Day-ahead offer from each technology class

DAM Electricity budget [TWh]	
Total electricity demand	**366.0**
Total Domestic Production	**322.4**
RES production	**243.5**
Hydroelectric	51.3
Solar	101.4
Wind	68.2
Other RES	22.6
Overgeneration	**2.1**
Total Conventional Production	**81**
Thermoelectric	76.7
Other non-RES	4.3
Foreign balance (net energy imported)	48.1

ITALIAN DAM PRICING [€/MWh]



TOPICS EXAMINED

The system context and charging scenarios by 2030

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SEGMENTATION AND SPREAD OF ELECTRIC VEHICLES – VEHICLES BY 2030

We have defined two reference scenarios for the spread of operational electric vehicles in Italy by 2030

DEFINITION OF VEHICLES IN CIRCULATION:

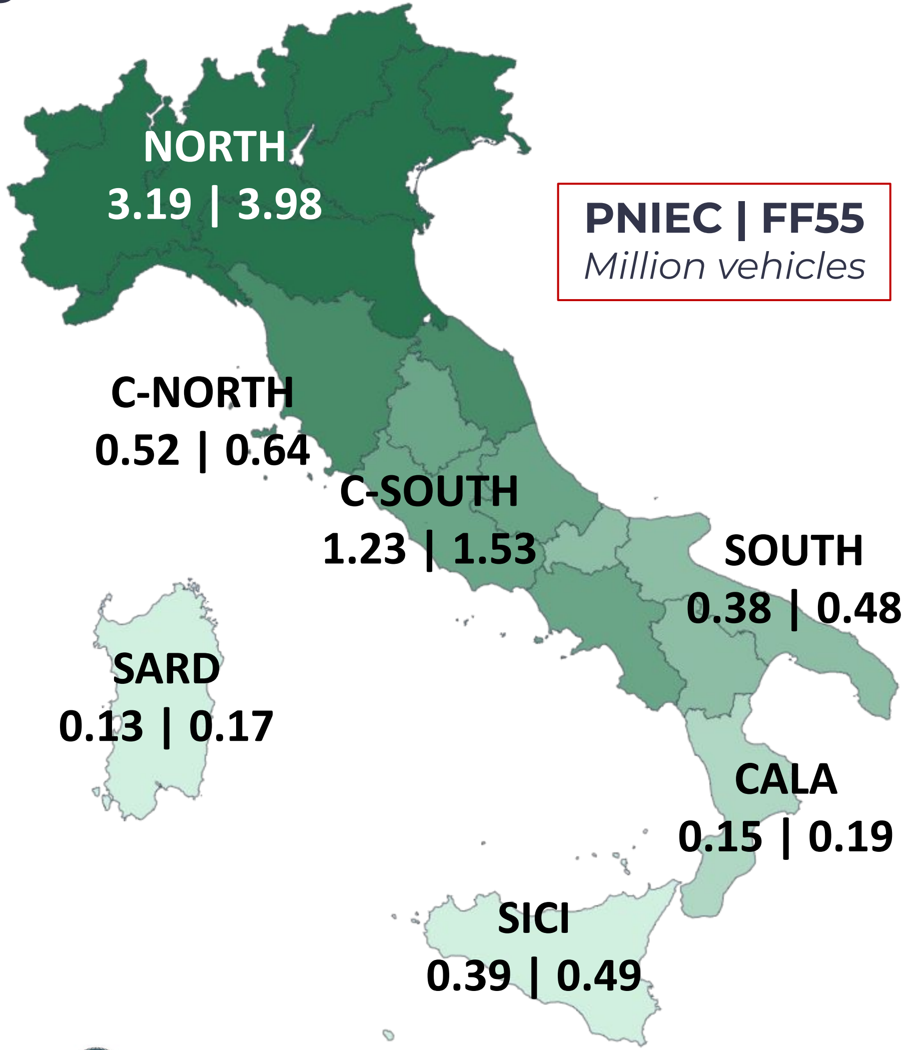
- definition of two EV uptake scenarios with regard to total vehicle circulation by 2030
- EV distribution by municipality, province and region based on several factors, including: current EV penetration, per capita income, air quality and availability of garage space
- breakdown of vehicles by business segment and definition of main characteristics based on current business data and outlook

BASIC SCENARIO – Consistent with PNIEC policies

[Million]	URBAN CONTEXT	RURAL CONTEXT	TOTAL
BEVs	0.85	3.15	4
PHEVs	0.43	1.57	2

ACCELERATED SCENARIO – Consistent with Fit For 55 policies

[Million]	URBAN CONTEXT	RURAL CONTEXT	TOTAL
BEVs	1.34	4.96	6.3
PHEVs	0.25	0.95	1.2

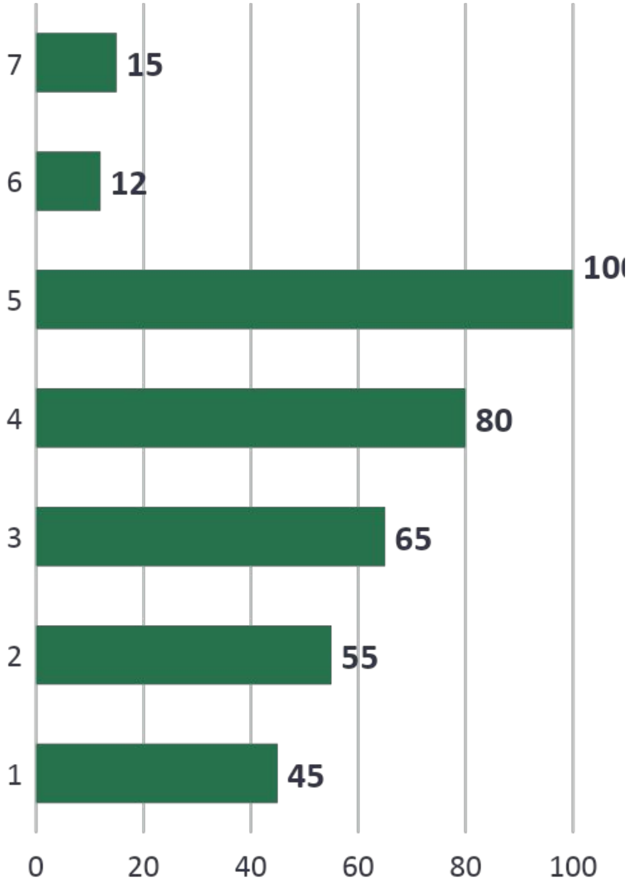


PNIEC | FF55
Million vehicles

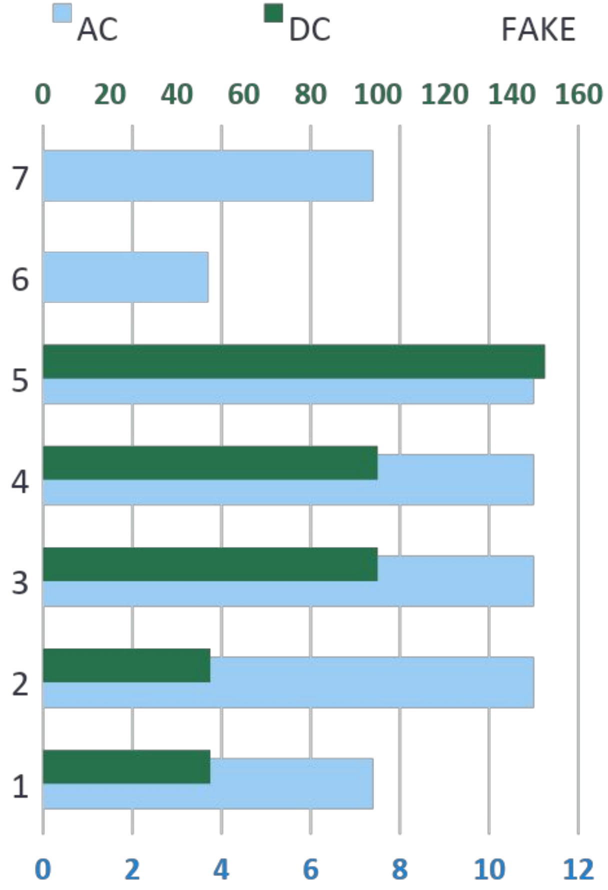
SEGMENTATION AND SPREAD OF ELECTRIC VEHICLES – VEHICLES BY 2030

Further hypotheses concern battery capacity, charging power and vehicle segmentation

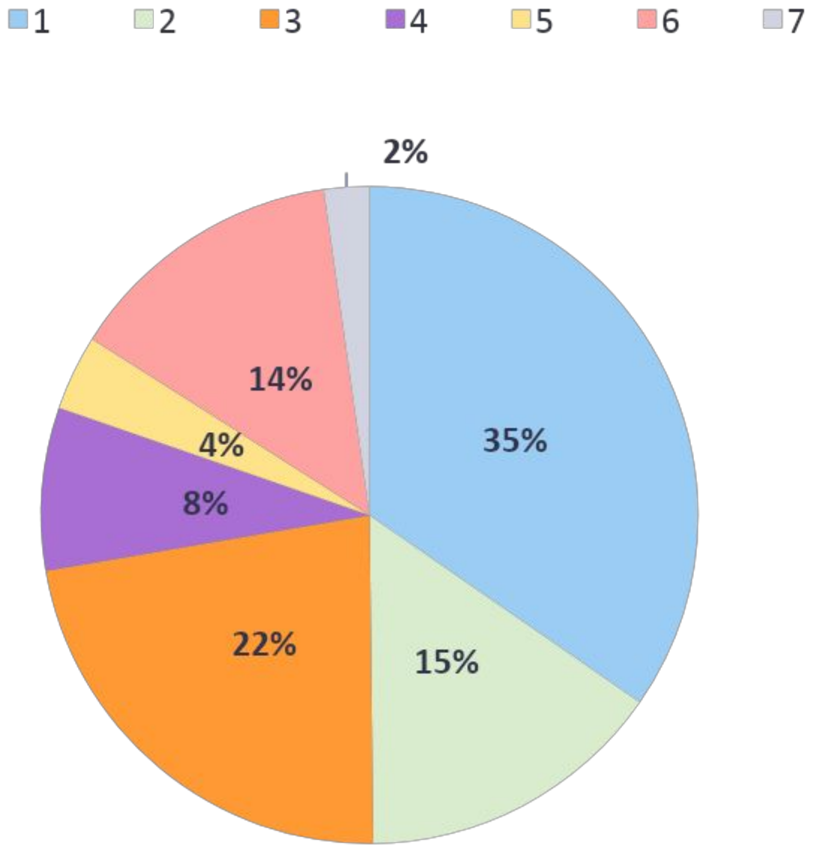
BATTERY CAPACITY [kWh]



CHARGING POWER [kW]



DISTRIBUTION



SEGMENTATION AND SPREAD OF ELECTRIC VEHICLES – FREIGHT TRANSPORT BY 2030

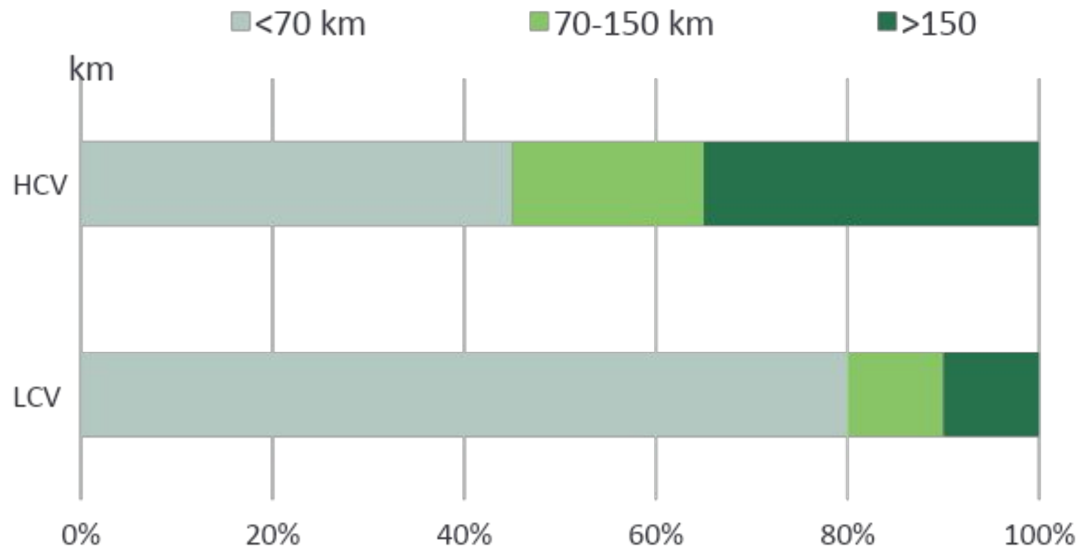
Freight transport was divided into LCVs and HCVs, defining their technical characteristics and conditions of use

[Million]	BASIC SCENARIO	ACCELERATED SCENARIO
LCVs	0.53	0.75
HCVs	0.03	0.05

DEFINITION OF THE FREIGHT VEHICLES IN CIRCULATION:

- definition of two uptake scenarios by 2030
- EV distribution across the country based on ANFIA data, with a census of electrical vehicles currently in circulation
- breakdown into *light commercial vehicles* (LCVs < 3.5 tonnes) and *heavy commercial vehicles* (HCVs), with usage classification

AVERAGE RANGE [km]



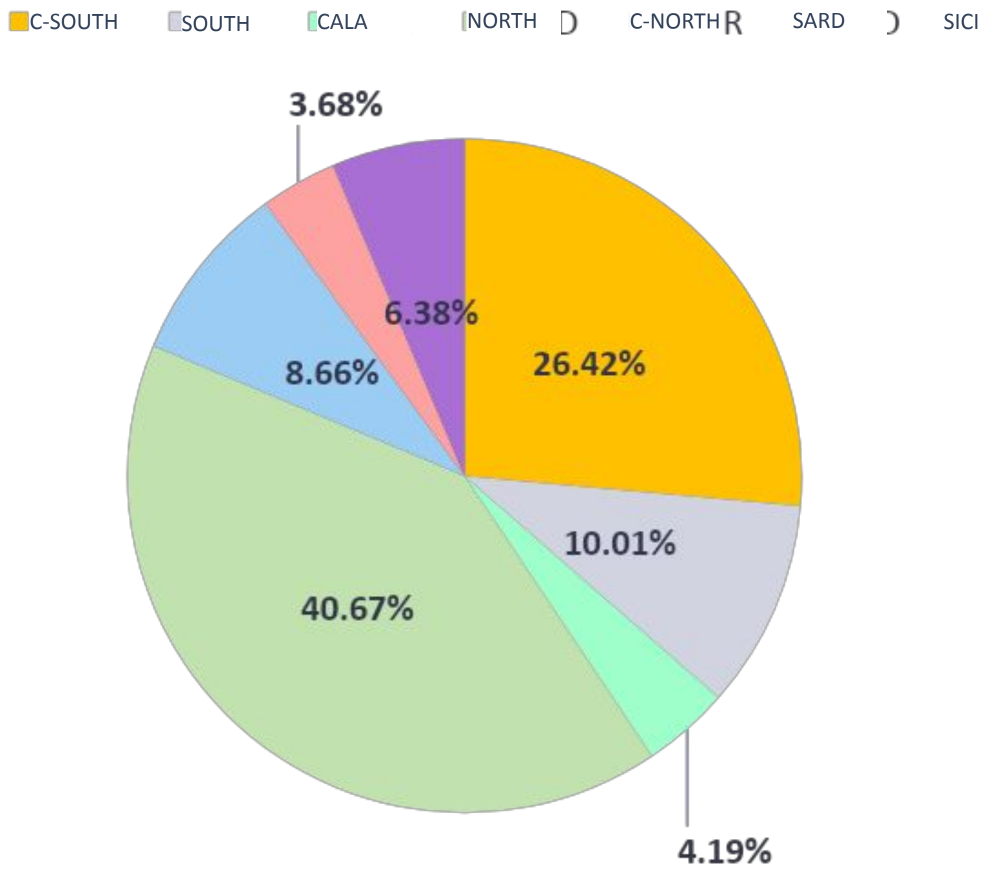
	CAPACITY [kWh]	AC CHARGING [kW]	DC CHARGING [kW]
LCVs	75	22	150
HCVs	400	22	350

	CONSUMPTION [kWh/km]	MILEAGE [km/year]
LCVs	0.35	20 000
HCVs	1.5	35 000

SEGMENTATION AND SPREAD OF ELECTRIC VEHICLES – LOCAL PUBLIC TRANSPORT BY 2030

We defined the main technical and utilisation hypotheses also for the local public transport (LPT) class

DISTRIBUTION



DEFINITION OF LPT VEHICLES IN CIRCULATION:

- definition of two uptake scenarios by 2030
- LPT distribution across the country based on ANFIA data, with a census of electrical vehicles currently in circulation
- definition of the main technical characteristics

[thousands]	BASIC SCENARIO	ACCELERATED SCENARIO
LPT	5	7

	CONSUMPTION [kWh/km]	MILEAGE [km/year]
LPT	1.5	45 000

	CAPACITY [kWh]	AC CHARGING [kW]	DC CHARGING [kW]
LPT	460	22	350

TOPICS EXAMINED

The system context and charging scenarios by 2030

- The Italian electricity system
- segmentation and characterisation of the vehicles in circulation
- **charging modes and expected flexibility profiles**

The impact of charging on the electrical system

Estimation of potential benefits derived from VGI solutions

VGI-driven business opportunities

Main findings of the study and policy proposals

USE CASES

Charging modes

Charging operations have been divided into:

- six modes typically applicable to motor vehicles,
- three modes typically applicable to large vehicles (LCVs, HCVs, LPT).

For each, we modelled a time profile:

- of charging consumption, useful for modelling a corresponding DAM aggregate,
- of charging flexibility, useful for modelling possible upward and downward offer configurations.

The charging profiles are the result of processing and analysis of data from the literature and discussions with industry stakeholders.

Available flexibility depends on the power ratings involved and the duration of the stopover: a longer stopover and/or higher power provides greater flexibility to the EV resource during charging.

V2G penetration is estimated based on interactions with stakeholders and insiders.

The time profiles presented below for each charging mode refer to a workday, in warm weather, in the NORTH market area and a non-urban context. The number and type of sub-cases examined for each charging mode are then detailed.

USE CASE NAME	AVERAGE STOPOVER TIME	CHARGING INFRASTRUCTURE POWER RANGE	
CHARGING IN RESIDENTIAL AREAS	Long (> 10 hours)	3 – 6 kW	CARS
CHARGING AT WORK	Employees: 8 hours Fleet: > 10 hours	7 – 22 kW	
URBAN PUBLIC CHARGING	Medium (3 hours)	22 – 50 kW	
HIGH-SPEED PUBLIC CHARGING	Short (<< 1 hour)	50 – 300 kW	
B2C CHARGING – COMMERCIAL AND LARGE-SCALE RETAIL OUTLETS	Short (1 hour)	22 – 50 kW	
B2C CHARGING – INTERCHANGE SITES	Long (6 hours)	7 – 22 kW	
LCV + HCV CHARGING IN LOGISTICS SETTINGS	LCV: 4 hours HCV: 6 hours	22 – 150 kW	OTHER
LPT VEHICLE CHARGING	Long (6 hours)	22 – 150 kW	

DEFINITION OF CHARGING PROFILES AND CALCULATION OF AVAILABLE FLEXIBILITY

Given the spread and segmentation of vehicles, charging and flexibility profiles have been calculated with a probabilistic

ASSUMPTIONS regarding the spread of vehicles, segmentation and charging modes enable us to define a set of input parameters. To each of these we can associate probability distributions: time of arrival/departure, incoming and target charge, battery capacity, AC and DC charging power.

FOR EACH CHARGING EVENT the value of each input parameter is sampled from its respective probability distribution, thus defining the specific charge profile of the simulated event.

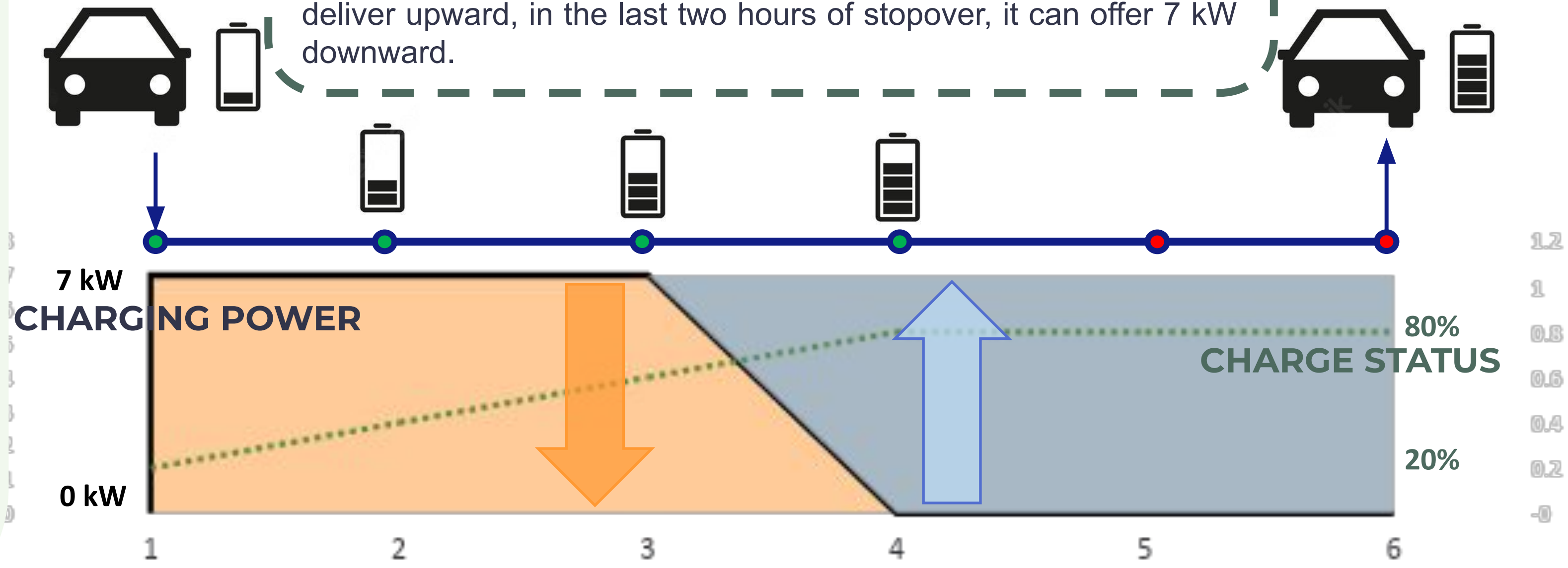
The CHARGING PROFILE AND STOPOVER DURATION can then be used to define the available flexibility for the specific charging event.

- **FLEXIBLE POWER:** equal to the charging power
- **DURATION OF SERVICE:** calculated so as to ensure no disruption to the user

REPEATED SIMULATION OF EACH CHARGING EVENT APPLYING THE MONTE CARLO METHOD

EXAMPLE

The vehicle remains parked for five hours, charging only in the first three, going from an SOC_{init} of 20% to a SOC_{target} of 80%. It can therefore offer 7 kW upward in the first three hours, with a maximum service duration of two hours. If it is not called upon to deliver upward, in the last two hours of stopover, it can offer 7 kW downward.



Upward available flexibility: an interruption of charging operations reduces the consumption from the grid, which is equivalent to an increase in hypothetical feed-in power.

Downward **available flexibility:** if charging is activated from a stand-by status, the service consists of an increase in consumption.

USE CASES – CHARGING AND FLEXIBILITY PROFILES

Residential contexts typically have peaks of consumption and flexibility during the evenings

CHARGING IN RESIDENTIAL AREAS

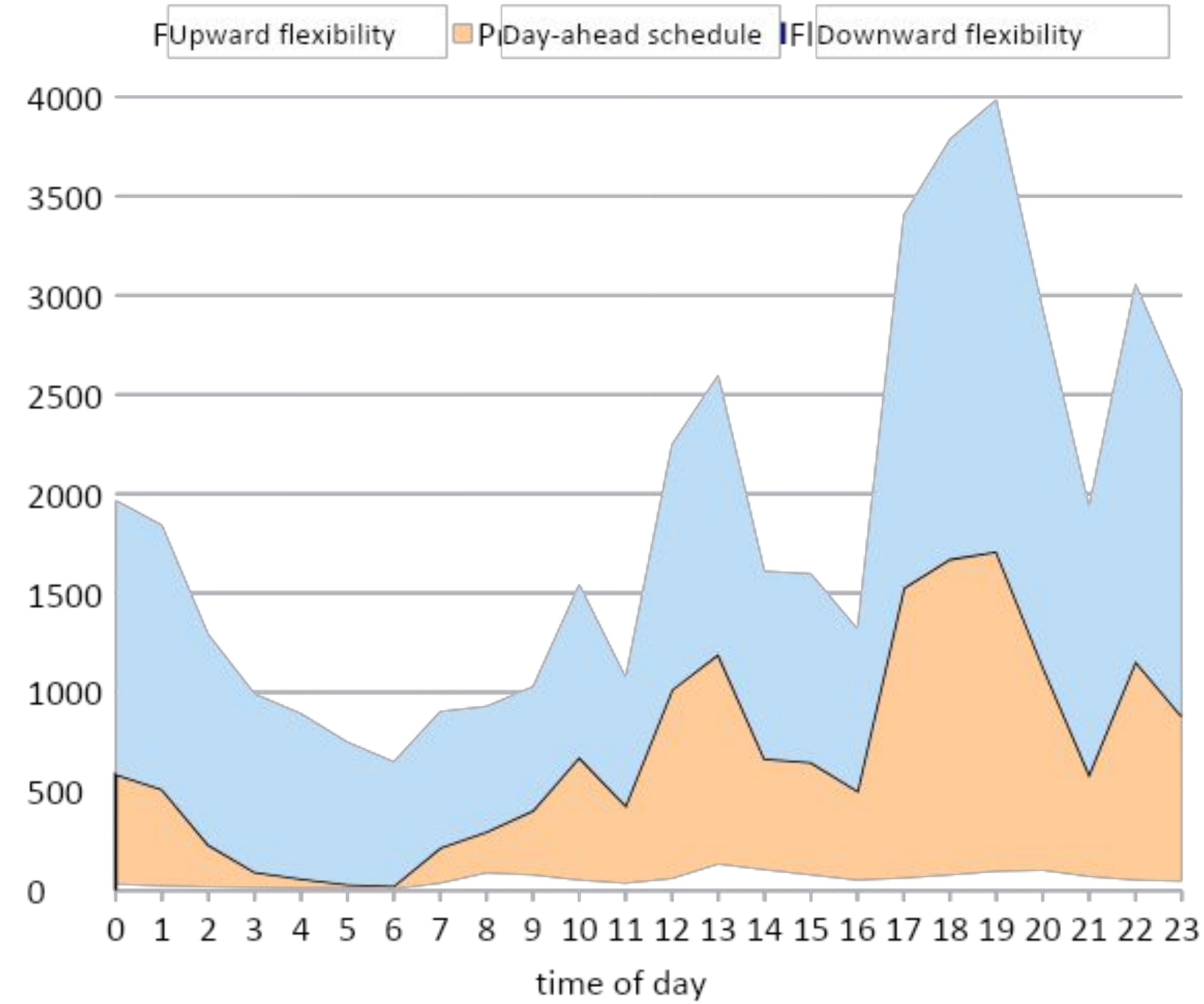
The use case refers to all contexts of residential charging with private access.
The following are therefore included:

- home charging,
- condominium charging,
- charging in distributed self-consumption configurations.

Charging mainly occurs at low voltage and low power, and the profile shows substantial differences between workdays and holidays (the figure shows a workday profile).

Power range	3 – 6 kW AC
Stopover duration	Long (> 10 hours)
Charge status (%) input/output	30 – 60/80 – 100
V2G Penetration	none/minimal

POWER (AGGREGATE LEVELS FOR ITALY) [MW]



USE CASES – CHARGING AND FLEXIBILITY PROFILES

Occupational contexts have daytime consumption and flexibility peaks

CHARGING AT WORKPLACES

The use case refers to all charging contexts at workplaces with limited access.

The following are therefore included:

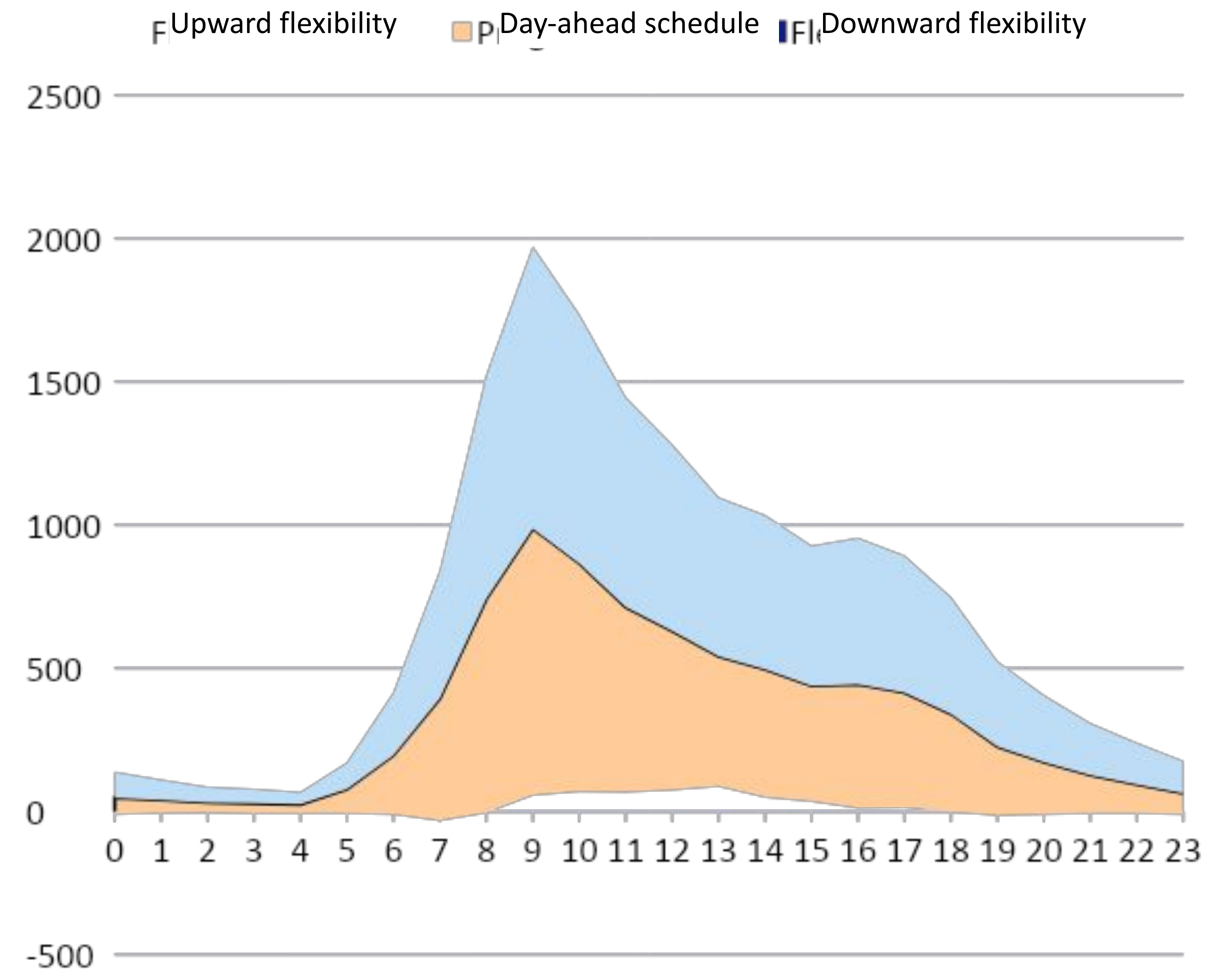
- charging of employee vehicles,
- charging of the company fleet.

The charging of employees' cars is prevalent (75%) and takes place during the working day. Fleets are also charged at night (25%).

Charging is mainly concentrated on weekdays.

Power range	7 – 22 kW AC
Stopover duration	Employees: 8 hours Fleet: > 10 hours
Charge status (%) input/output	30 – 70/80 – 100
V2G Penetration	Mean (30%)

POWER (AGGREGATE LEVELS FOR ITALY) [MW]



USE CASES – CHARGING PROFILES AND FLEXIBILITY

Public charging: medium-term stopovers and morning peak

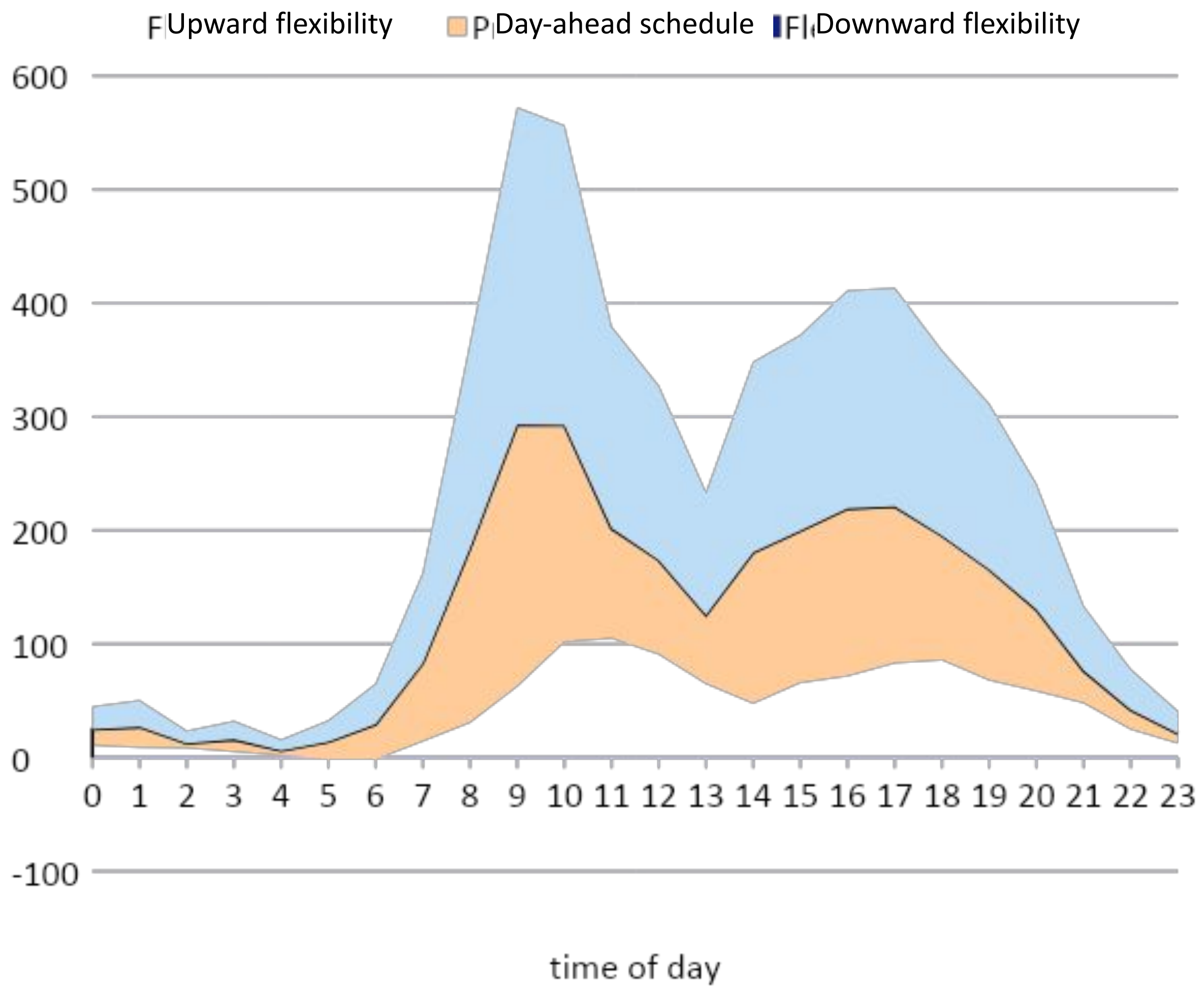
URBAN **PUBLIC CHARGING**

The use case refers to all publicly accessible charging areas, excluding charging on high-traffic/high-speed routes and charging at destinations (B2C).

Charging is concentrated in daylight hours and has an average duration depending on the driver's conditions of use.

Power range	7 – 22 kW AC (70%) 50 kW DC (30%)
Stopover duration	Medium (3 hours)
Charge status (%) input/output	10 – 40/50 – 80
V2G Penetration	Limited (20%)

POWER (AGGREGATE LEVELS FOR ITALY) [MW]



USE CASES – CHARGING PROFILES AND FLEXIBILITY

Charging on main thoroughfares: flexibility at mealtimes

PUBLIC CHARGING ON HIGH-SPEED/HIGH-TRAFFIC ROUTES

The use case refers to publicly accessible charging areas located on high-speed/high-traffic thoroughfares and characterised by short charging-dedicated stopovers.

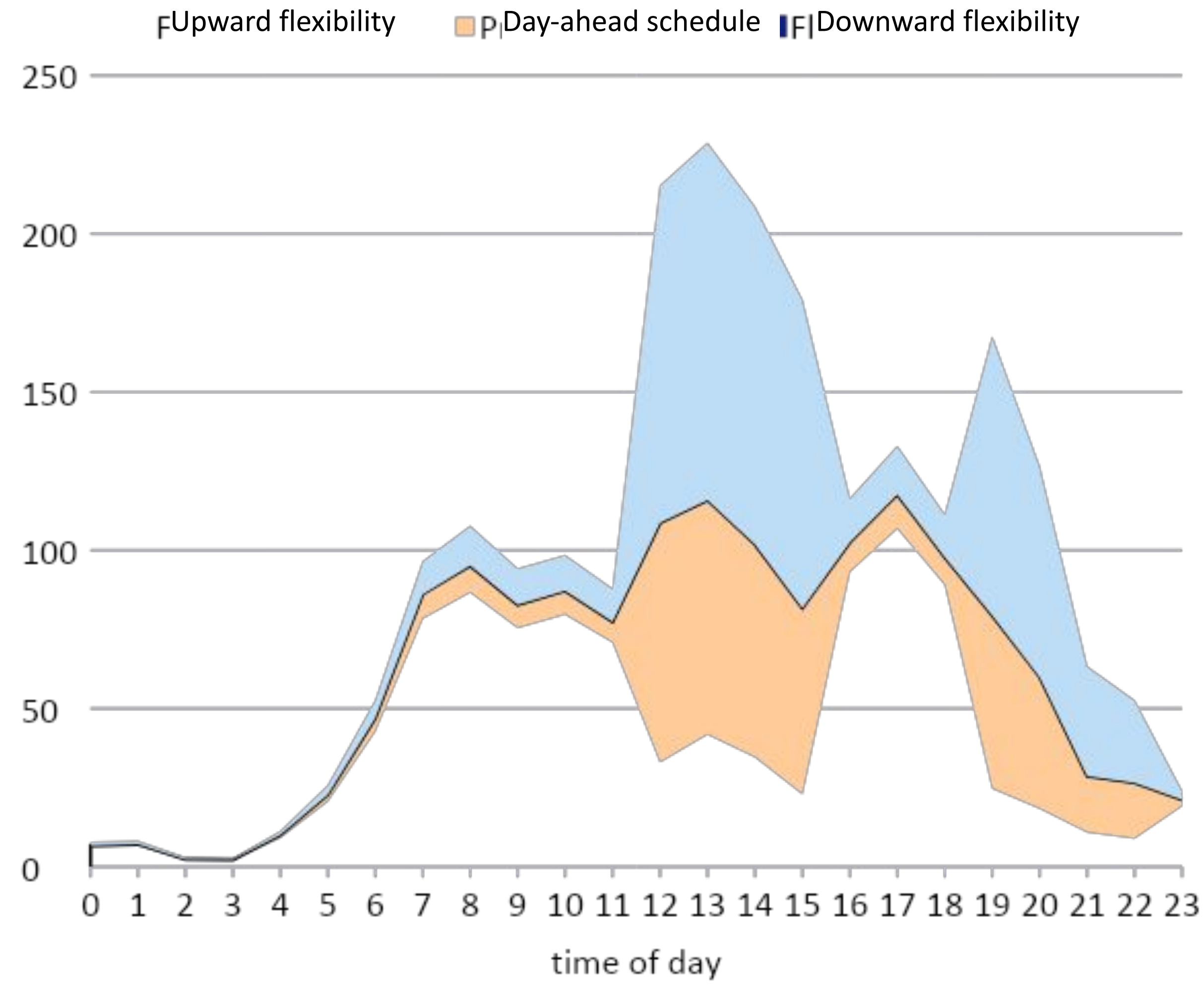
Such cases include:

- charging on motorways, dual carriageways and ring roads,
- charging on high-traffic urban routes.

Charging is concentrated during daylight hours and is usually very quick. Meal times are an exception: in these cases, longer stopovers are conducive to flexibility.

Power range	50 – 300 kW DC
Stopover duration	Short (<< 1 hour) Mealtimes: 1 hour
Charge status (%) input/output	20 – 50/50 – 80
V2G Penetration	None/minimal

POWER (AGGREGATE LEVELS FOR ITALY) [MW]



USE CASES – CHARGING PROFILES AND FLEXIBILITY

Charging at the destinations follows presence profiles

B2C CHARGING IN COMMERCIAL AND LARGE-SCALE RETAIL OUTLETS

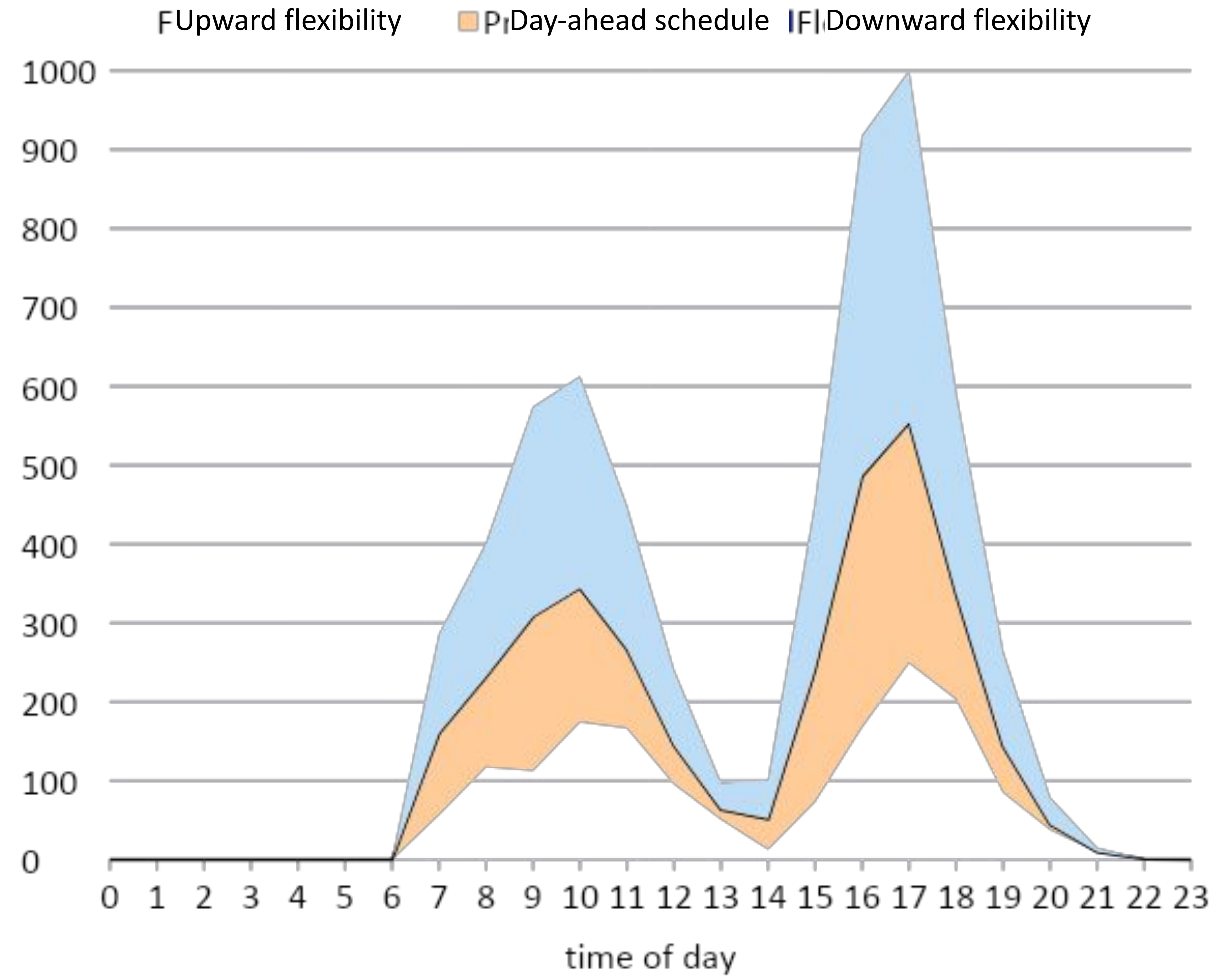
The use case refers to public-access charging contexts located at commercial and retail destinations, accessible to customers.
Such cases include:

- charging at shopping malls,
- charging at nearby shops.

Charging is concentrated during daylight hours, follows establishment attendance profiles and is generally of short duration, coinciding with a stopovers at the establishments themselves.

Power range	22 kW AC (50%) 50 kW DC (50%)
Stopover duration	Short (1 hour)
Charge status (%) input/output	30 – 70/40 – 100
V2G Penetration	Limited (20%)

POWER (AGGREGATE LEVELS FOR ITALY) [MW]



USE CASES – CHARGING PROFILES AND FLEXIBILITY

Intermodality offers opportunities, especially during morning hours

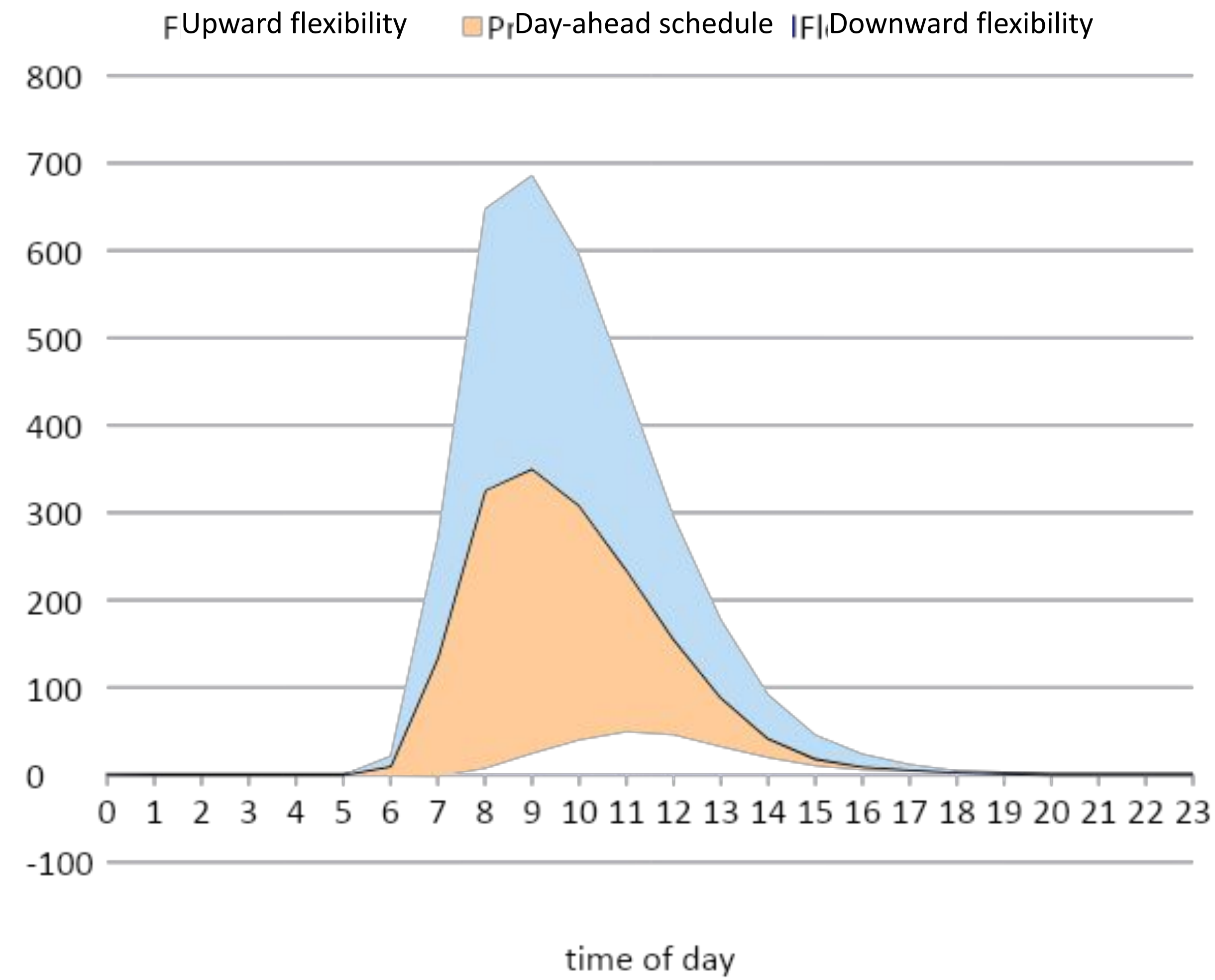
B2C CHARGING AT CAR PARKS AND OTHER INTERCHANGE SITES

The use case refers to publicly accessible charging areas located predominantly at LPT station car parks.

Charging is concentrated during daylight hours, following car park usage profiles, usually dominated by commuters.

Power range	7 – 22 kW AC
Stopover duration	Long (6 hours)
Charge status (%) input/output	30 – 70/90 – 100
V2G Penetration	Limited (20%)

POWER (AGGREGATE LEVELS FOR ITALY) [MW]



USE CASES – CHARGING AND FLEXIBILITY PROFILES

Logistics has a major influence on energy demand and flexibility

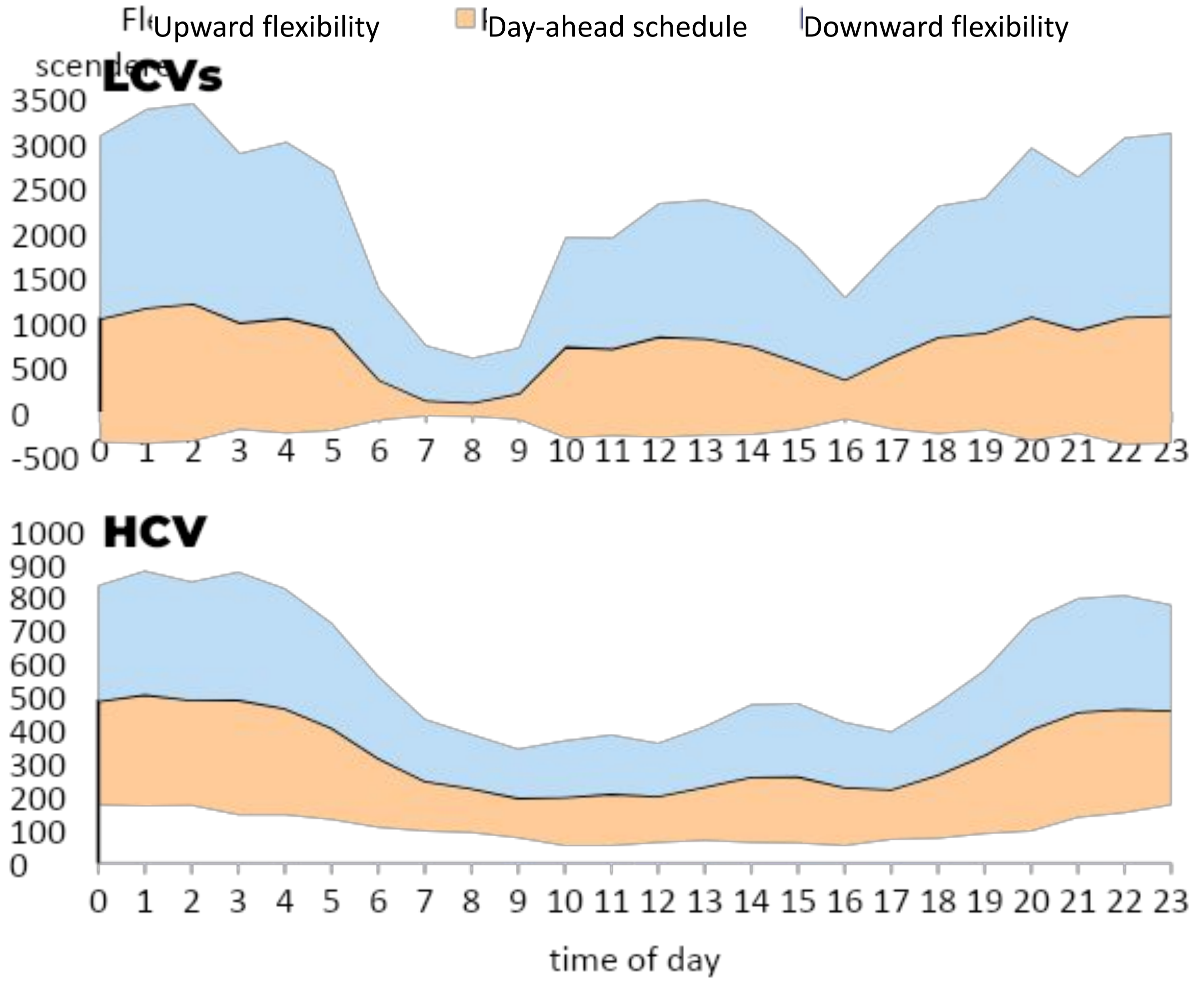
CHARGING LCVs AND HCVs

The use case refers to all charging activities involving heavy or light commercial vehicles (< 3.5 t). We adopted the model of logistics centres as they are representative of the hourly activity profiles of this vehicle category.

LCV charging tends to occur after the end of the working day or during lunch breaks.
HCV charging is concentrated during nighttime.

Power range	22 kW AC (50%) 50 – 150 kW DC (50%)
Stopover duration	LCV: 4 hours HCV: 6 hours
Charge status (%) input/output	LCVs: 40 – 70/60 – 100 HCVs: 10 – 40/80 – 100
V2G Penetration	High (50%)

POWER (AGGREGATE LEVELS FOR ITALY) [MW]



USE CASES – CHARGING AND FLEXIBILITY PROFILES

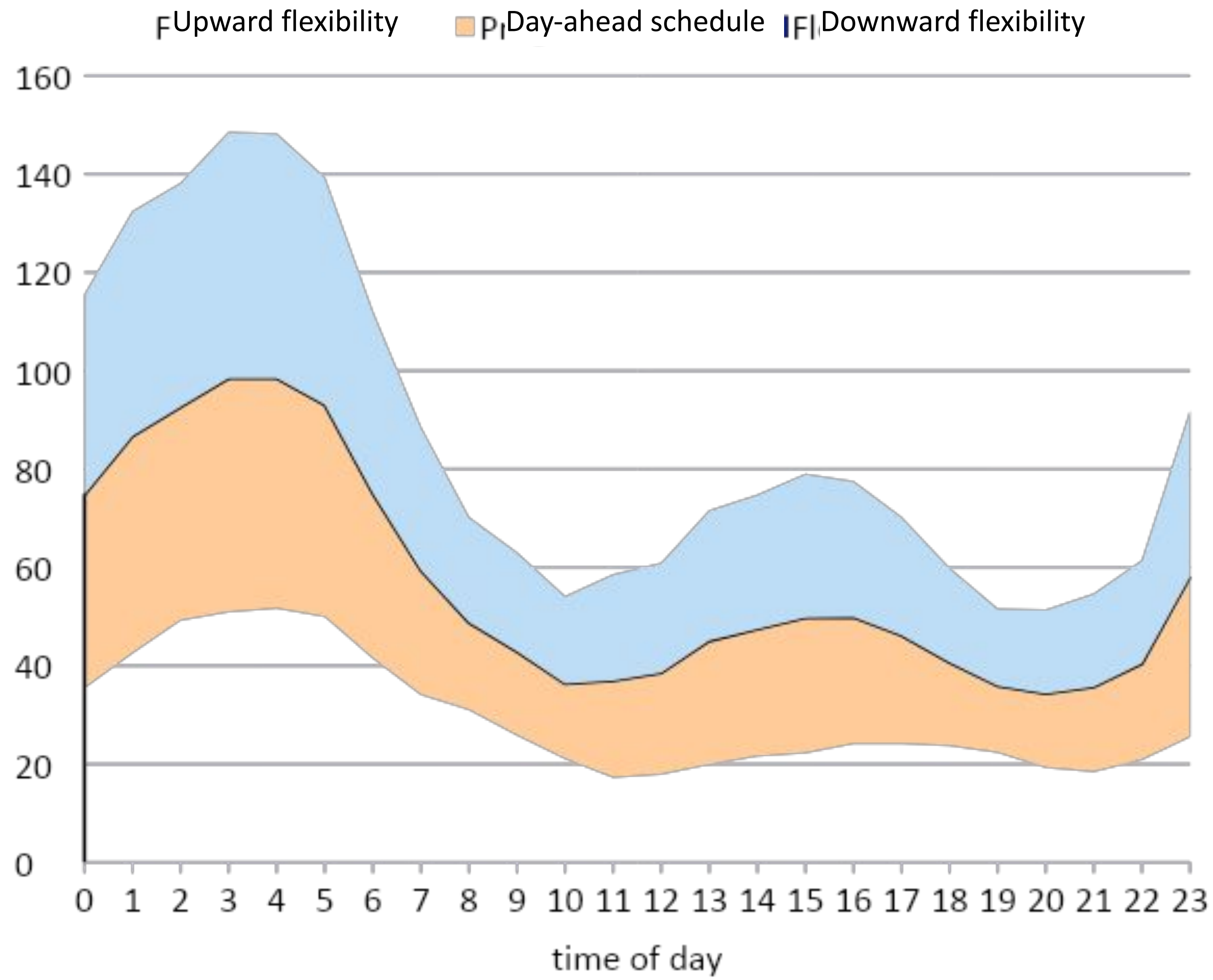
LPT: marginal and predominantly nighttime electricity demand

LPT VEHICLE CHARGING

The use case refers to all charging activities involving buses and other heavy public transport vehicles. Charging occurs at night only and mainly at the terminus.

Power range	22kW AC (40%) 50 – 150 kW DC (60%)
Stopover duration	Long (6 hours)
Charge status (%) input/output	10 – 20/90 – 100
V2G Penetration	High (50%)

POWER (AGGREGATE LEVELS FOR ITALY) [MW]



ACCELERATED SCENARIO

USE CASES – TYPICAL TOTAL CONSUMPTION PROFILE FOR ITALY

The expected consumption profile has daytime and evening peaks

Prior analysis of the charging profiles for each use case enabled us to estimate a global charging profile, with each charging mode weighted according to the degree of its penetration (see next slides).

It defines a trading schedule for the purchase and sale of energy on the Day-ahead Market that may be applied to electric charging by 2030 for each market zone.

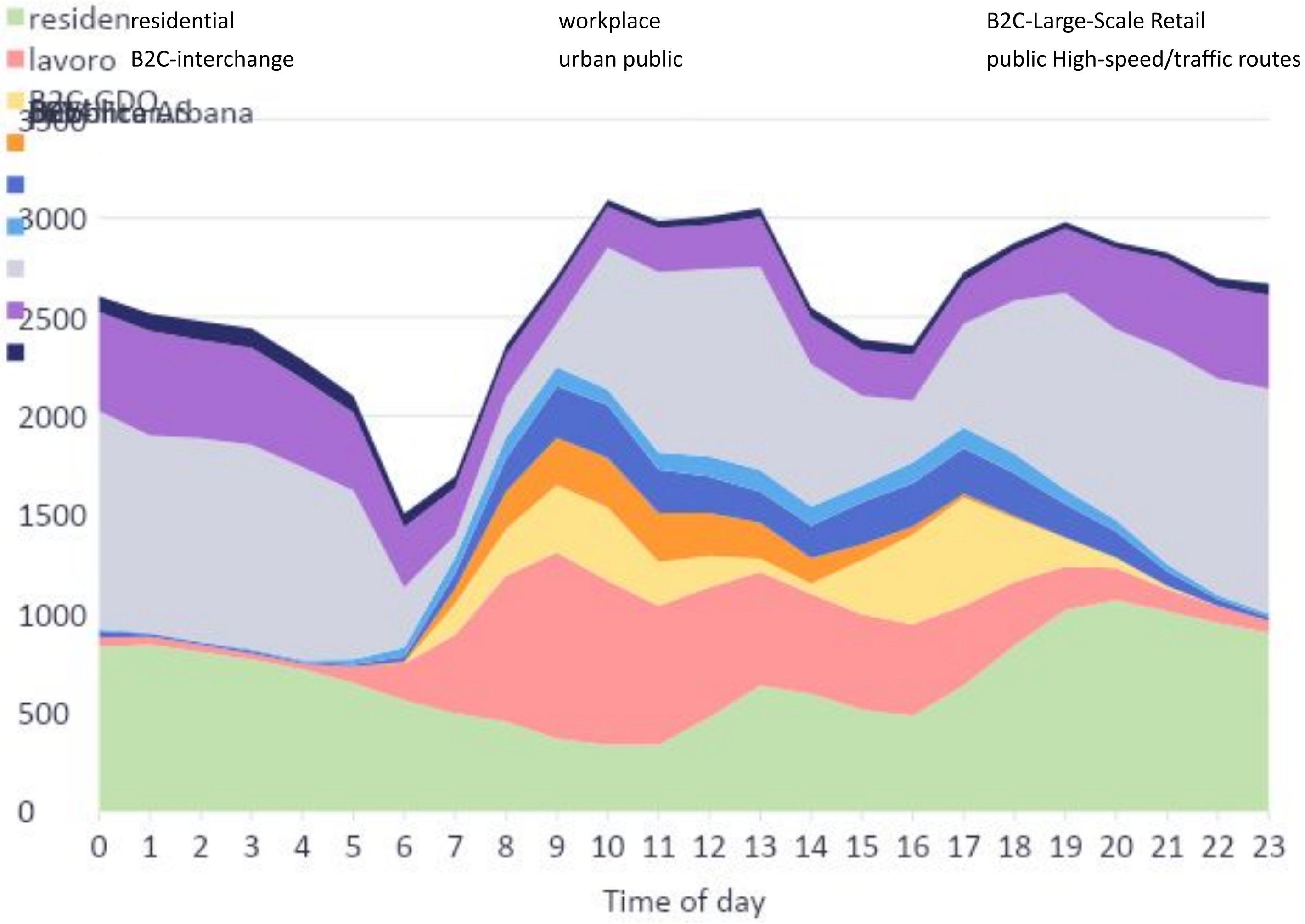
The total consumption profile for the Italian system, on a typical cold-season workday (shown in the figure), presents two 3 GW peaks (one around midday, the other in the evening) and two troughs, the first of around 1.5 GW in the early morning, the second of 2.4 GW in the early afternoon.

Finally, the nighttime consumption (10 pm to 5 am) presents a gradually decreasing trend, starting at 2.5 GW and reaching approximately 2.2 GW.

WEIGHTING FACTOR OF EV CHARGING ON TOTAL (2030):

ENERGY DEMAND:	CONSUMPTION PEAK:
15.5 TWh of the Italian system's 366 TWh (4.2%)	**3.1 GW** on the Italian system of approx 60 GW (5.2%)

DAY-AHEAD MARKET SCHEDULE (ITALY, WORKDAYS, WINTER) [MW]



USE CASES – SUB-CASES

We conducted further processing of charging profile data according to relevant geographical, temporal and seasonal parameters

GEOGRAPHIC

Charging methods in large urban centres differ with respect to outlying areas (LPT density, presence of private garages, average distance travelled).

Definition of two sub-cases:

- **urban** sub-case
- **rural** sub-case

TEMPORAL

Charging patterns differ between weekdays and holidays, partly due to a different weighting of the various use cases but also because of different expected charging profiles.

Definition of two sub-cases:

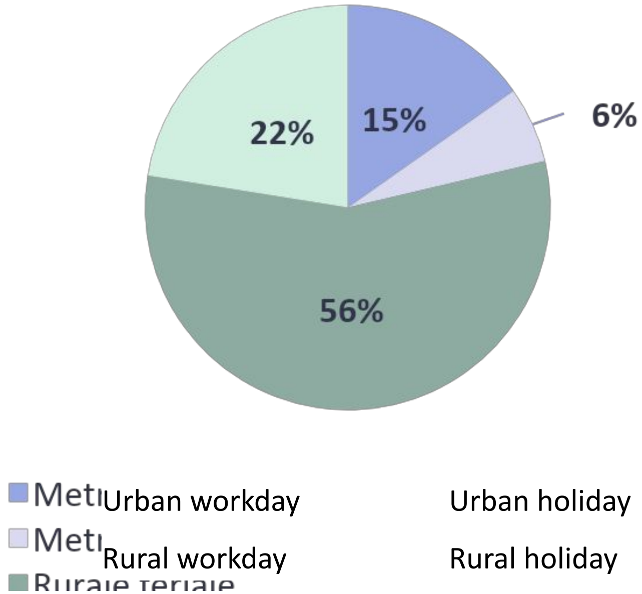
- **workday** sub-case
- **holiday** sub-case

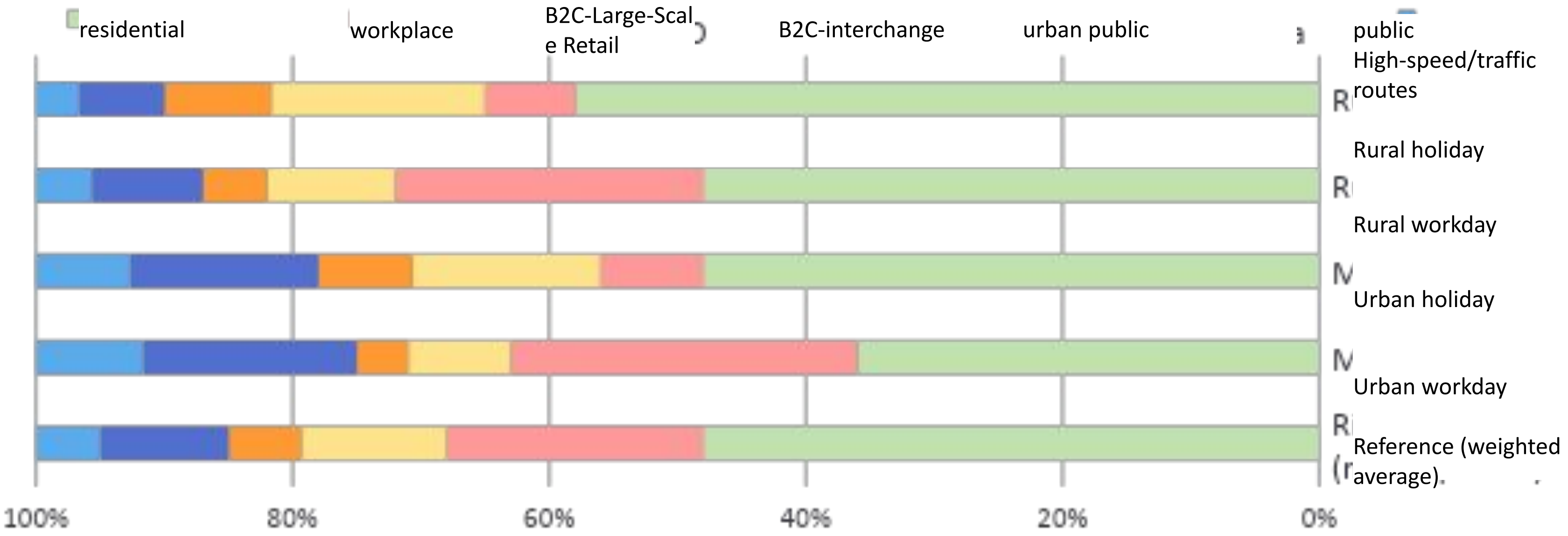
SEASONAL

Energy consumption is generally higher in the cold season due to the need to heat vehicles and their passenger compartments.

Definition of two sub-cases:

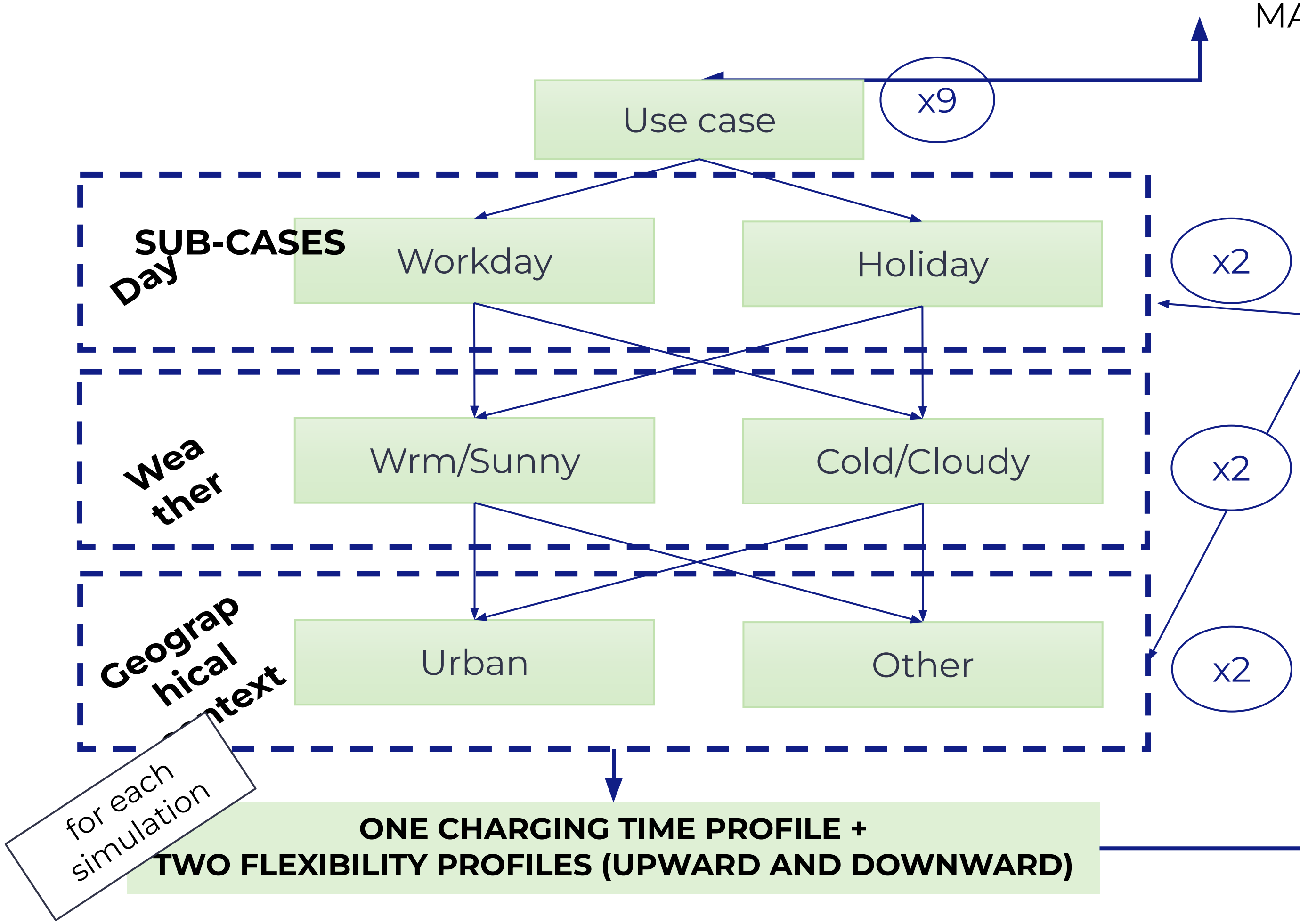
- **warm season** subcase
- **cold season** subcase





USE CASES – SUB-CASES

A consumption profile and a flexibility profile were defined for each sub-case, market area and penetration scenario



MARKET ZONES

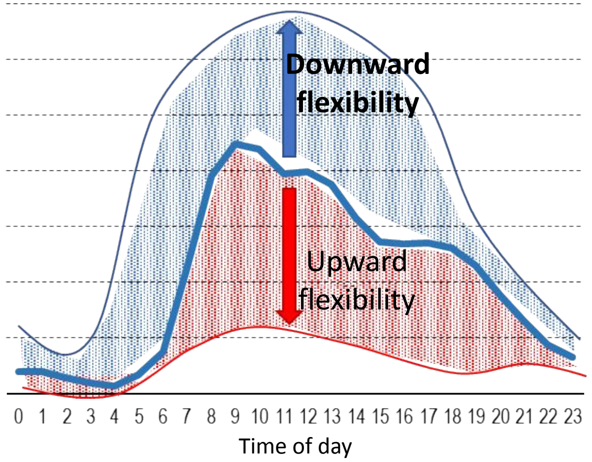
x7

Density of vehicles per zone according to two scenarios (**Basic and Accelerated**)

x2

Different profiles or different penetrations of each mode

ONE CHARGING TIME PROFILE + TWO FLEXIBILITY PROFILES (UPWARD AND DOWNWARD)



1003 x 3 daily profiles (24h) fed as inputs to network and market models

USE CASES – SUB-CASES

As an example of the procedure, we can observe the distinction made between sub-cases in the residential charging mode

GEOGRAPHIC

Urban areas (cities with populations exceeding 100,000) are weighted less than rural areas.

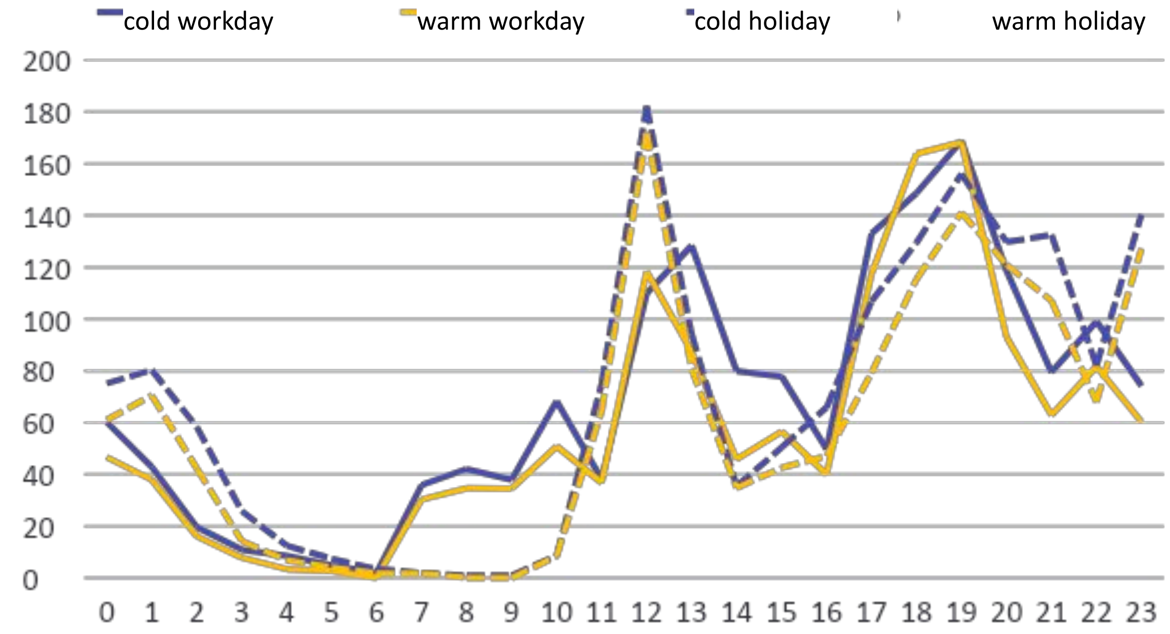
TEMPORAL

Workdays have more pronounced evening peaks, while holidays present a peak at noon.

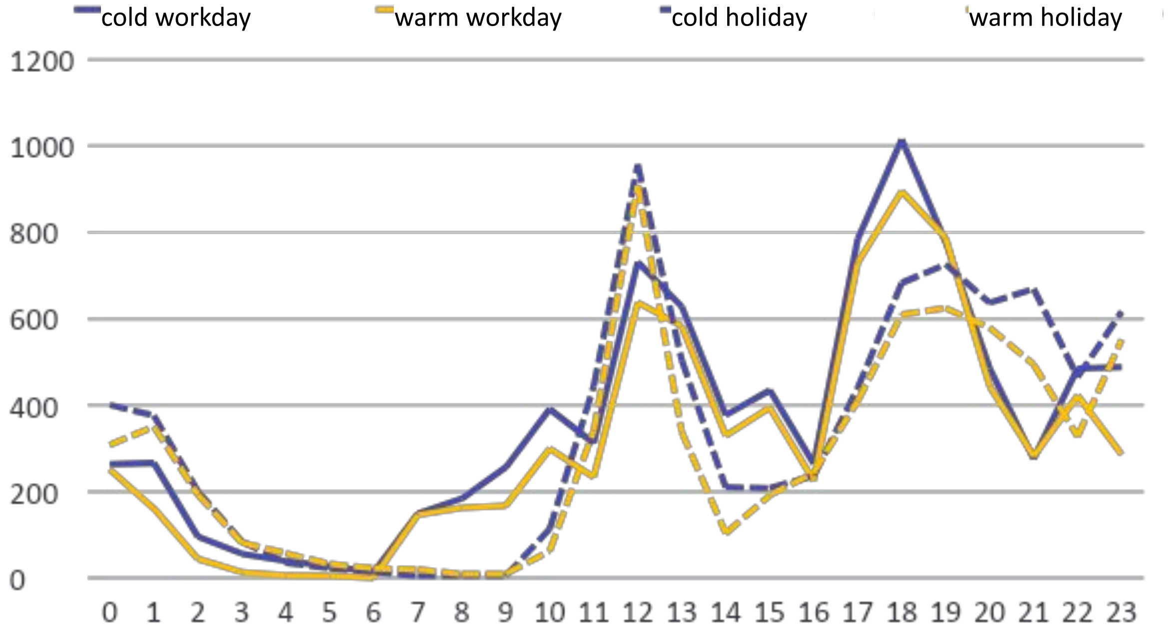
SEASONAL

The cold-season profile indicates power consumption slightly higher than that of the warm season.

DAY-AHEAD MARKET SCHEDULE (URBAN) [MW]



DAY-AHEAD MARKET SCHEDULE (RURAL) [MW]



TOPICS EXAMINED

The system context and charging scenarios by 2030

The impact of charging on the electrical system:

- **contribution to the need to strengthen electricity grids**
- analysis of costs related to electrical dispatching

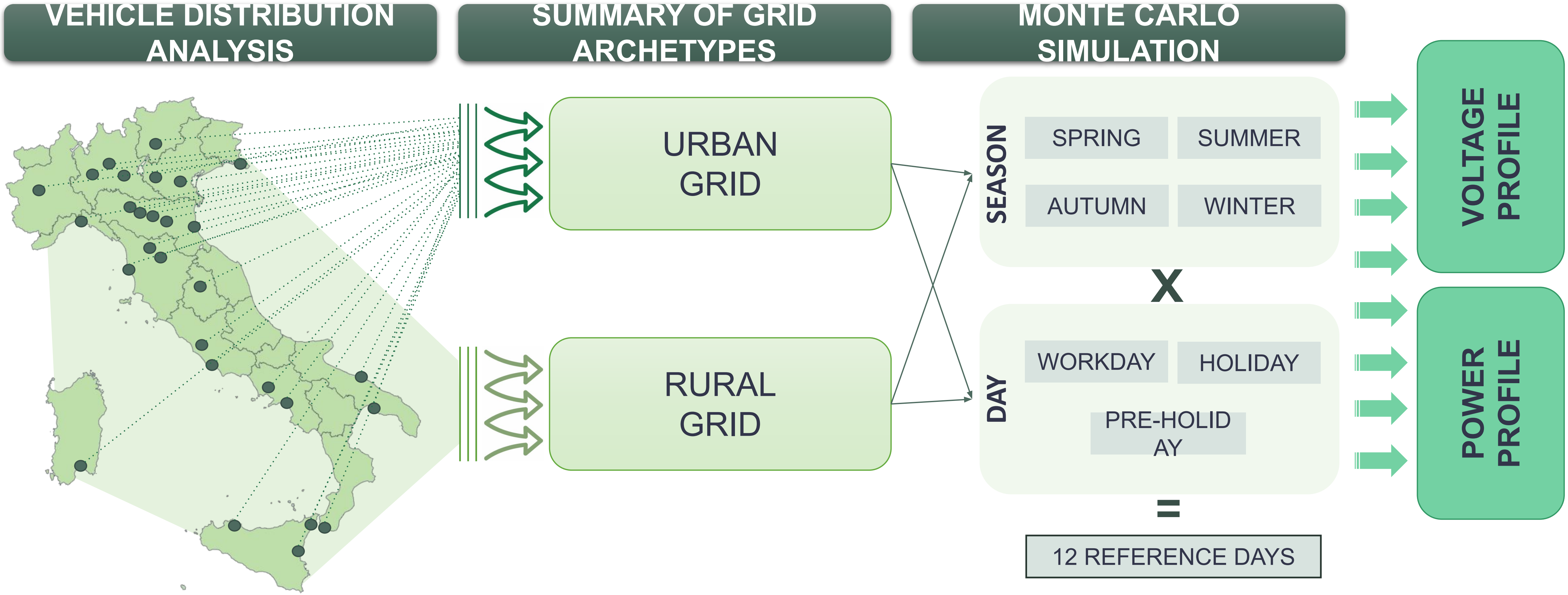
Estimation of potential benefits derived from VGI solutions

VGI-driven business opportunities

Main findings of the study and policy proposals

MV/LV NETWORK DEVELOPMENT – SIMULATION PROCEDURE

We modelled two grid archetypes by randomly positioning charging points according to the type and volume of users to be served



VEHICLE DISTRIBUTION ANALYSIS

SUMMARY OF GRID ARCHETYPES

MONTE CARLO SIMULATION

URBAN GRID

RURAL GRID

SEASON: SPRING, SUMMER, AUTUMN, WINTER

X

DAY: WORKDAY, HOLIDAY, PRE-HOLIDAY

=

12 REFERENCE DAYS

VOLTAGE PROFILE

POWER PROFILE

MV/LV GRID DEVELOPMENT – EVOLUTION OF URBAN GRIDS

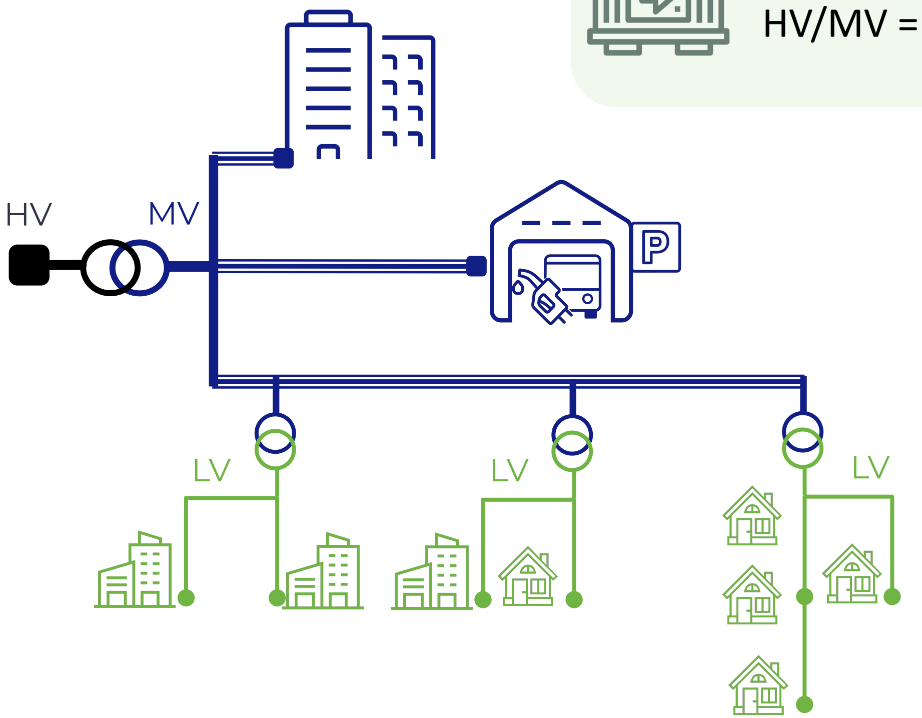
Urban grids are characterised by short sections and high load density, with high power transformation factors (HV/MV 63 MVA)

TODAY'S URBAN GRID

2022 – REF

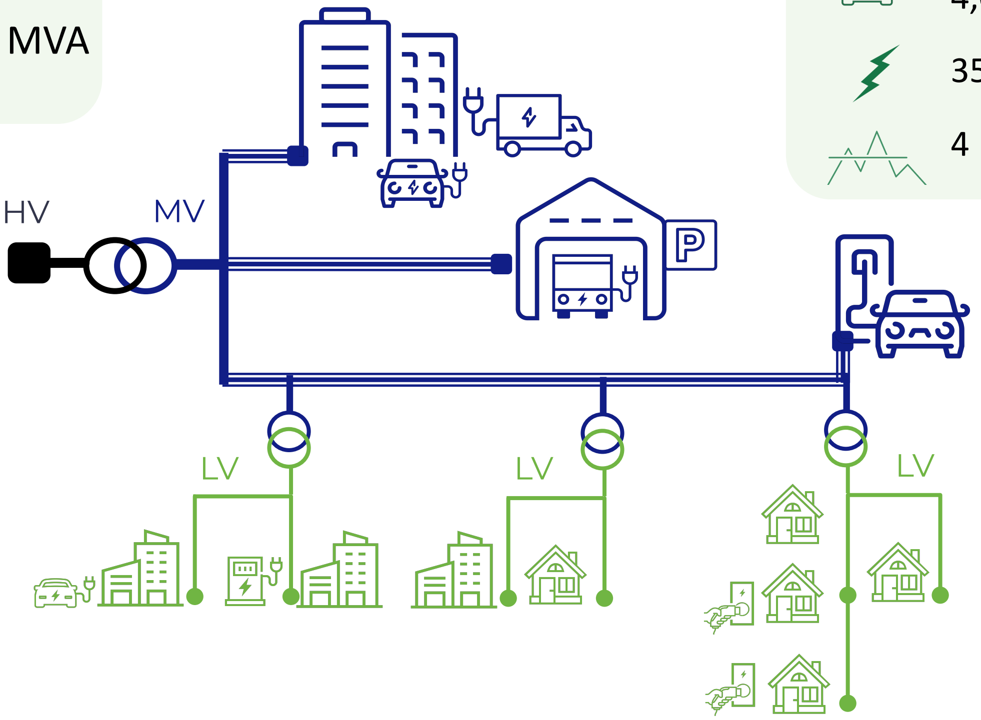
MV/LV ≥ 400 kVA

HV/MV = 63 MVA



SPREAD OF EV CHARGING POINTS

2030 – EV



EV IMPACT ON URBAN GRIDS

- 4,000 electric vehicles
- 35 MWh/day absorbed
- 4 MW peak

2,000 CPs:

SLOW □ 85%

QUICK □ 12%

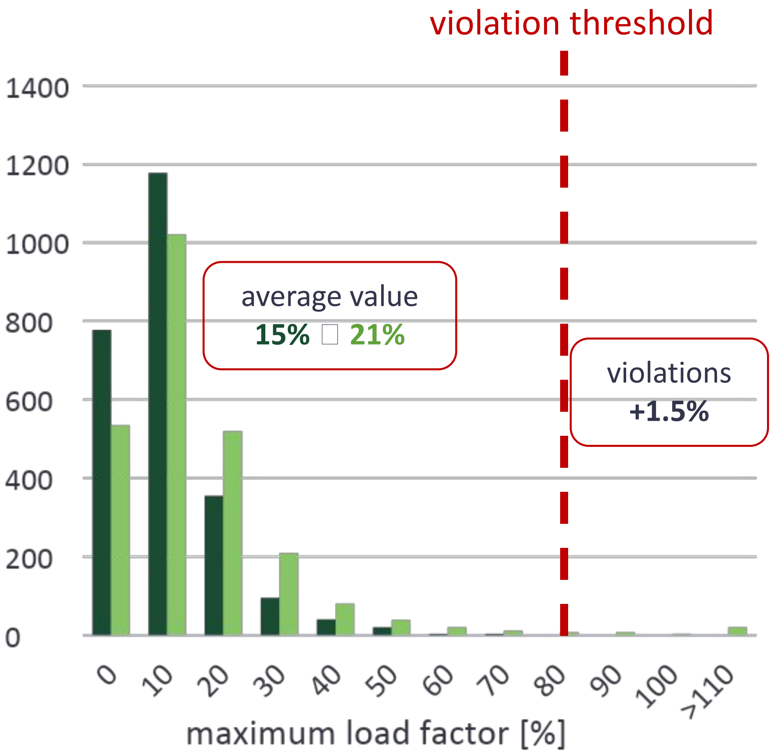
FAST □ 3%

MV/LV GRID DEVELOPMENT – IMPACT OF CHARGING ON URBAN GRIDS

Charging electric vehicles generally increases load factors, increasing the number of load-violating elements

🟩 2022 – REF 🟩 2030 – EV

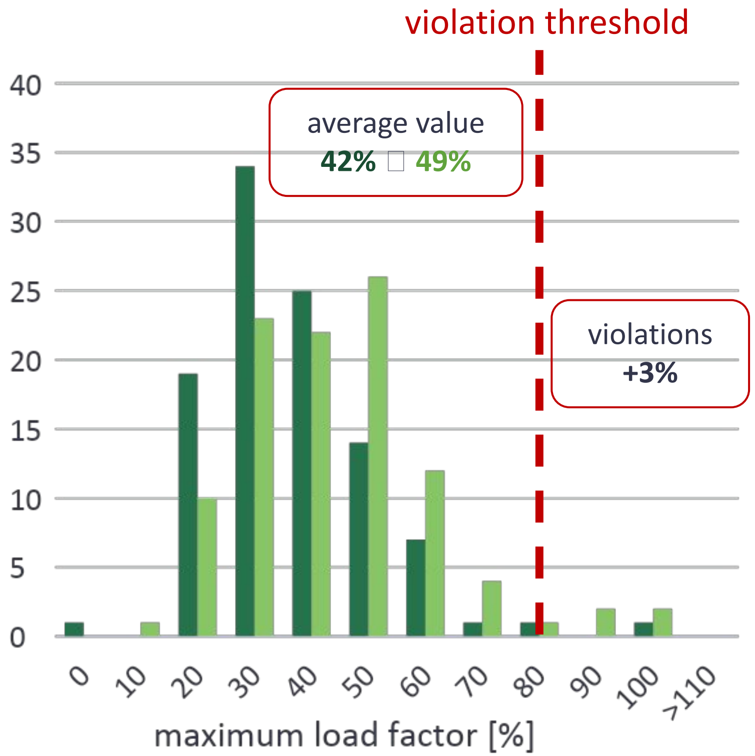
LOW VOLTAGE LINES



average value
15% □ 21%

violations
+1.5%

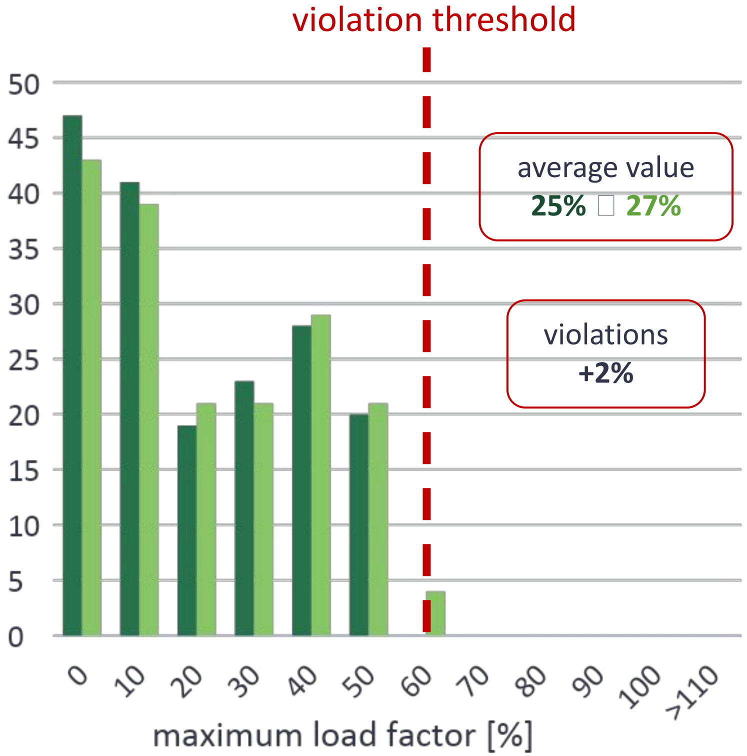
MV/LV TRANSFORMERS



average value
42% □ 49%

violations
+3%

MEDIUM VOLTAGE LINES



average value
25% □ 27%

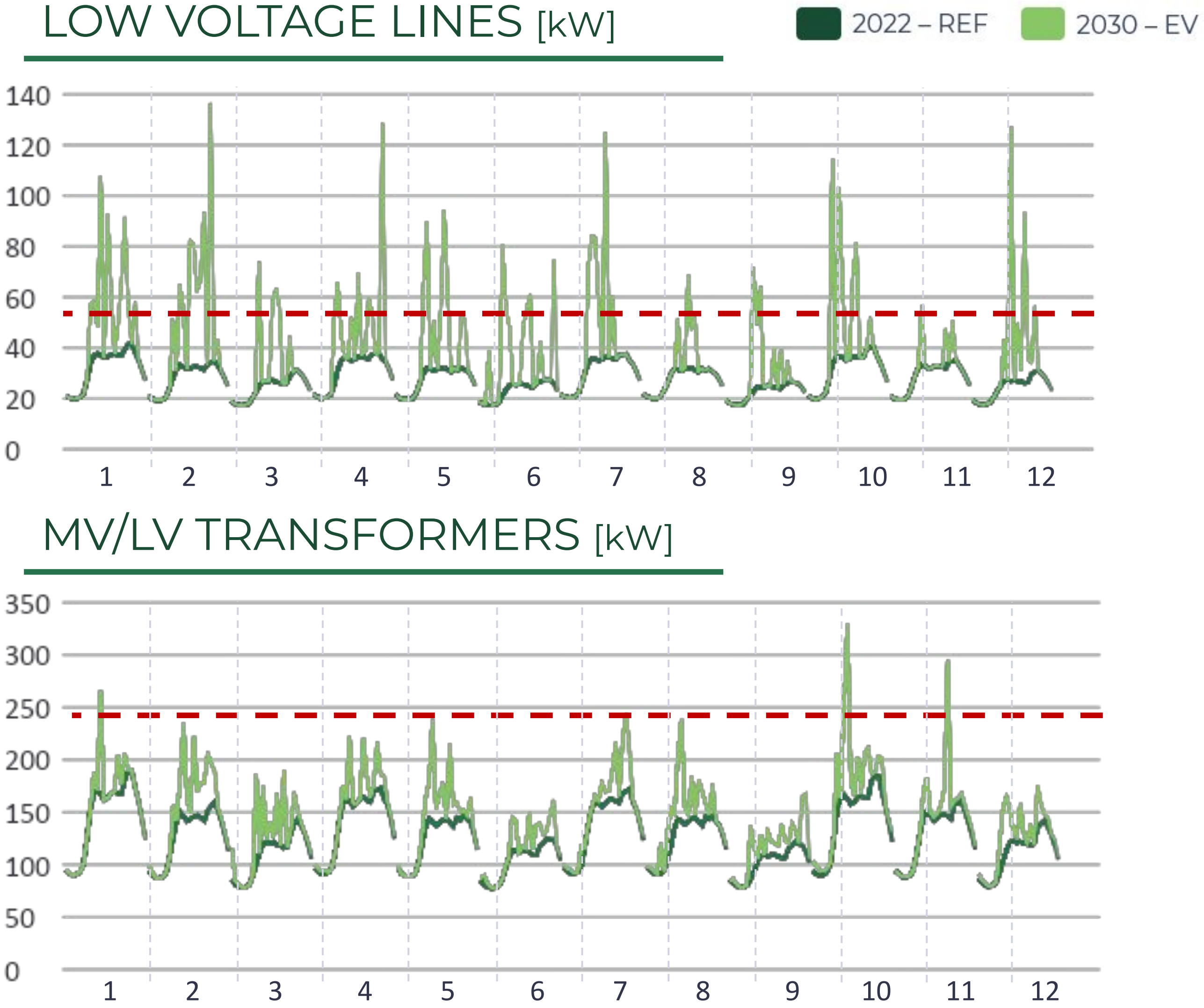
violations
+2%

MV/LV GRID DEVELOPMENT – IMPACT OF CHARGING ON URBAN GRIDS

Low-voltage grid sections suffer from overloads of short duration but high intensity compared to violation thresholds

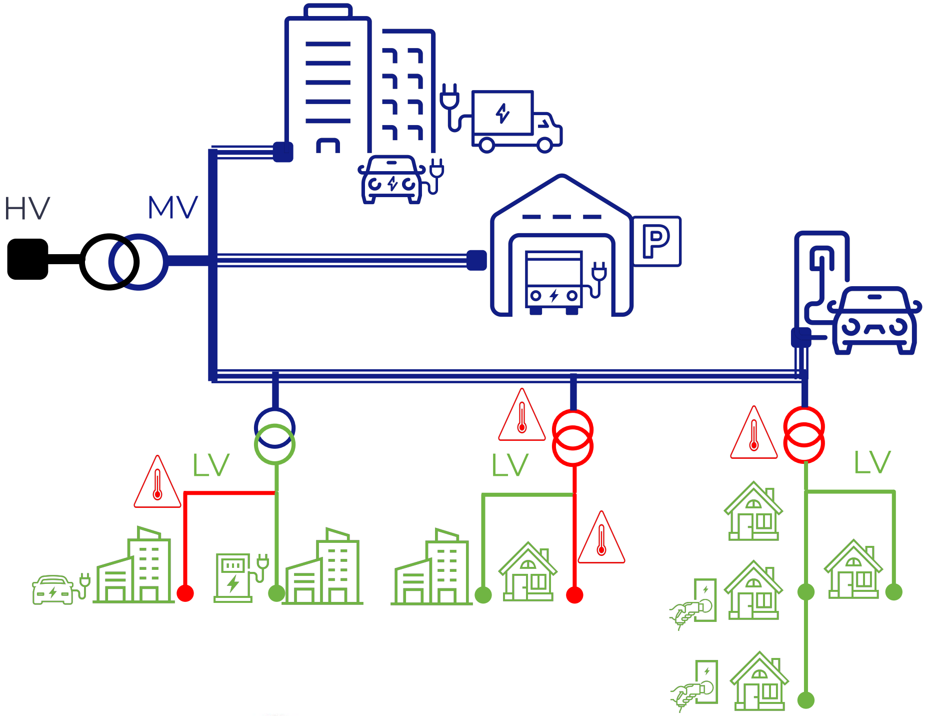
LOW VOLTAGE LINES [kW]

MV/LV TRANSFORMERS [kW]



! Grids must be further developed!

- installation of new LV lines for charging PODs
- grid enhancement to improve Charging Infrastructure based on existing PODs

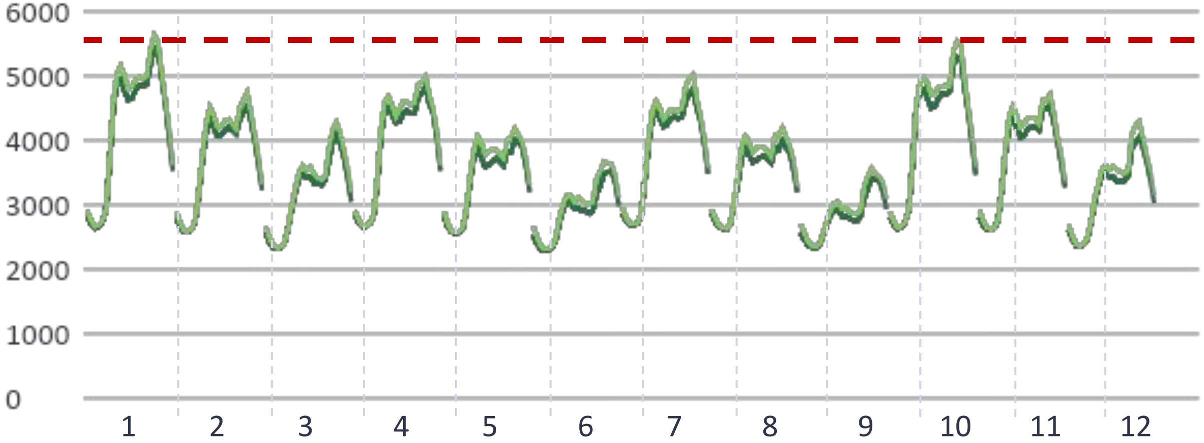


MV/LV GRID DEVELOPMENT – IMPACT OF CHARGING ON URBAN GRIDS

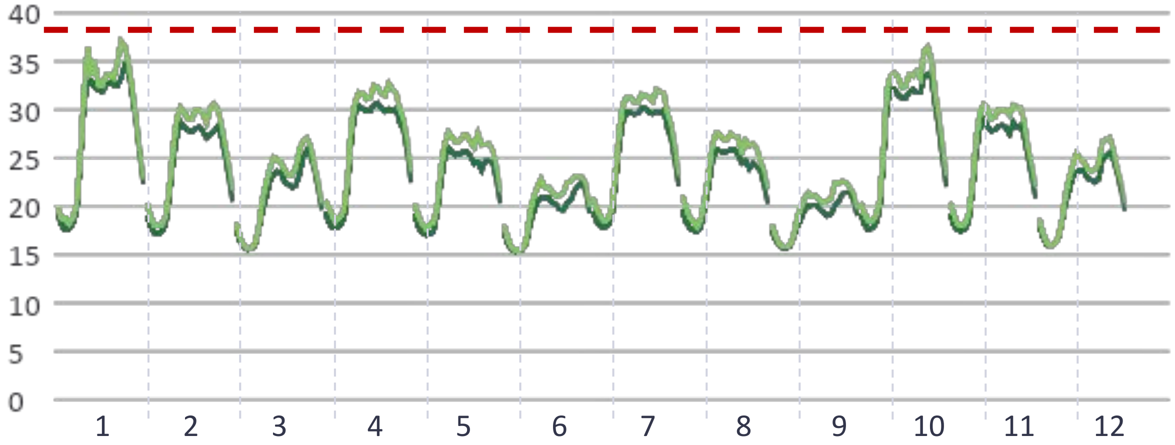
Medium voltage grid sections suffer from extended overloads due to EV charging requirements superimposed on base loads that are already high

MEDIUM VOLTAGE LINES [kW]

■ 2022 – REF ■ 2030 – EV

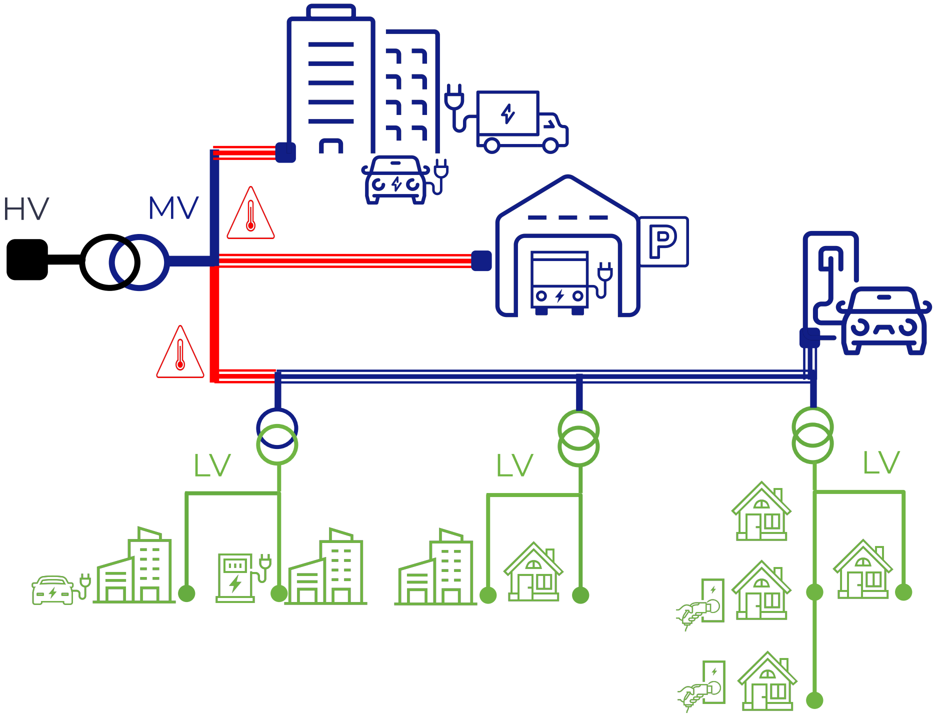


HV/MV TRANSFORMERS [MW]



! Grids must be further developed!

- grid enhancement using high-density clusters



MV/LV GRID DEVELOPMENT – EVOLUTION OF RURAL GRIDS

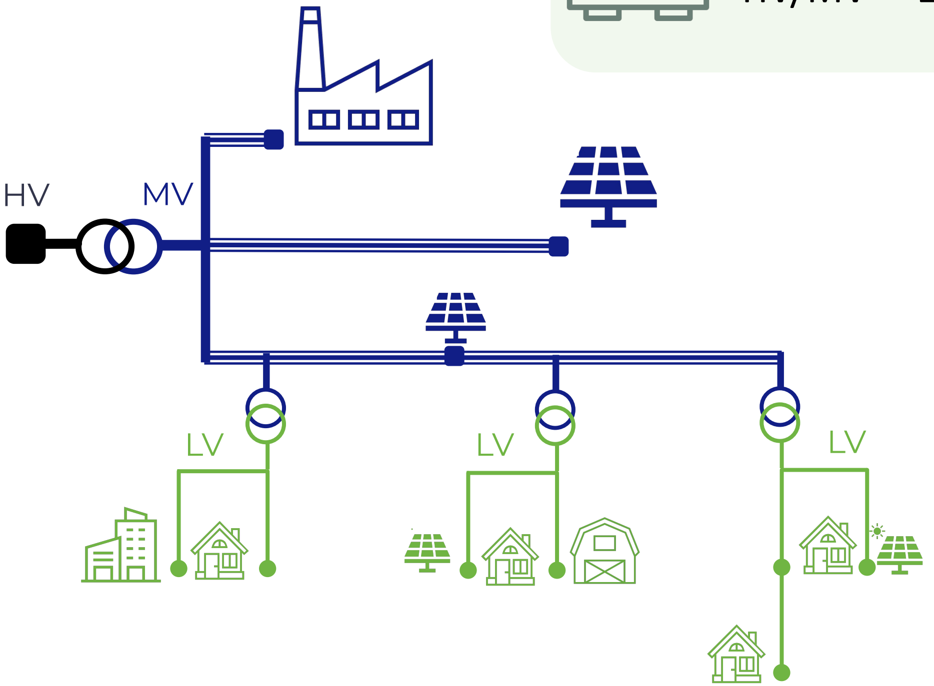
Rural grids are characterised by long sections with low load density and high penetration of NPRES distributed generation

TODAY'S RURAL GRID

2022 – REF

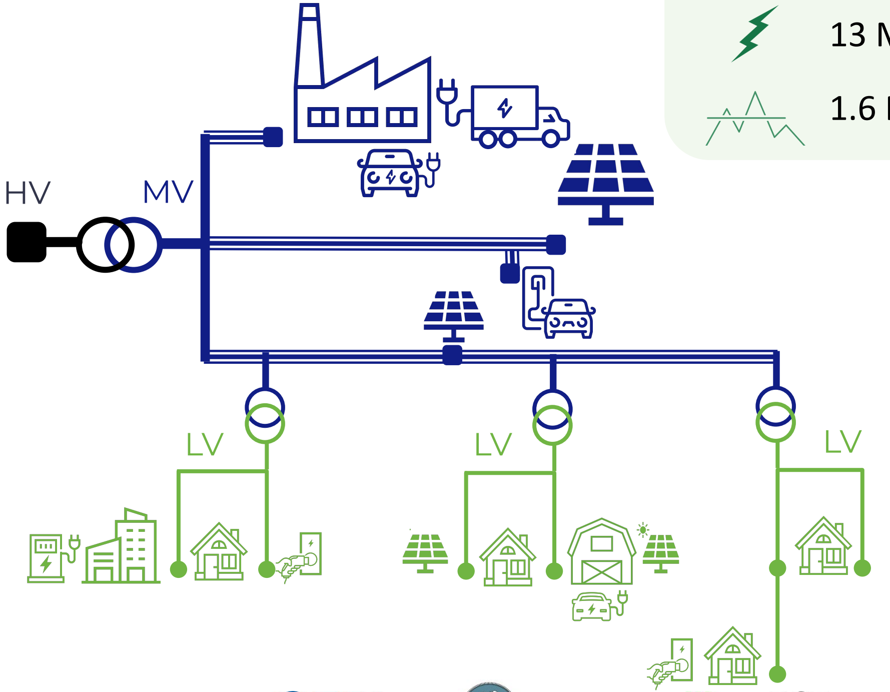
MV/LV ≤ 250 kVA

HV/MV = 25 MVA



SPREAD OF EV CHARGING POINTS

2030 – EV



IMPACT ON RURAL GRIDS

- 1,500 electric vehicles
- 13 MWh/day absorbed
- 1.6 MW peak

800 CPs:

SLOW □ 87%

QUICK □ 10%

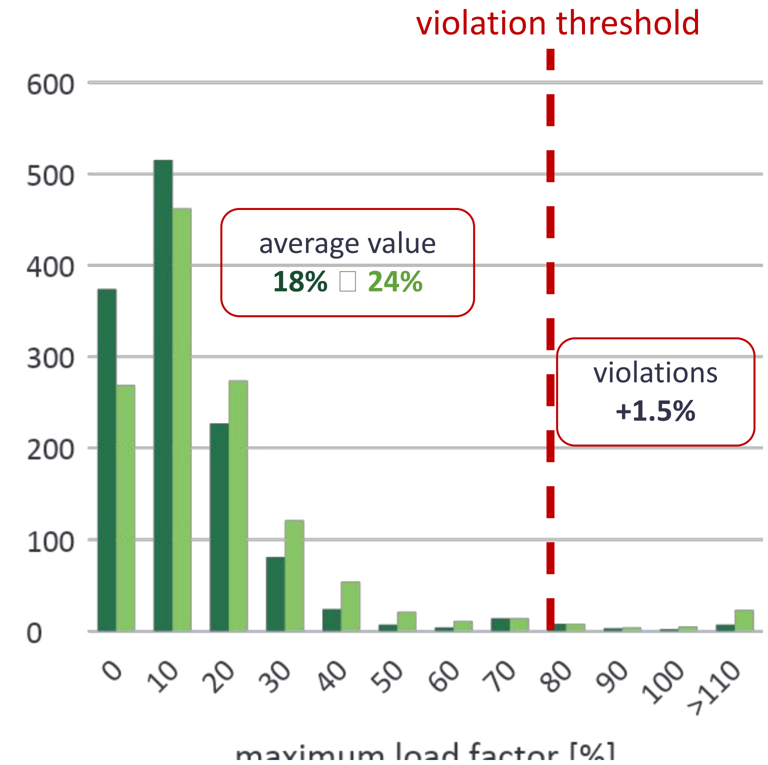
FAST □ 3%

MV/LV GRID DEVELOPMENT – IMPACT OF CHARGING ON RURAL GRIDS

EV charging increases load violations on elements that are already critical only when local generation fails to compensate

🟩 2022 – REF   🟩 2030 – EV

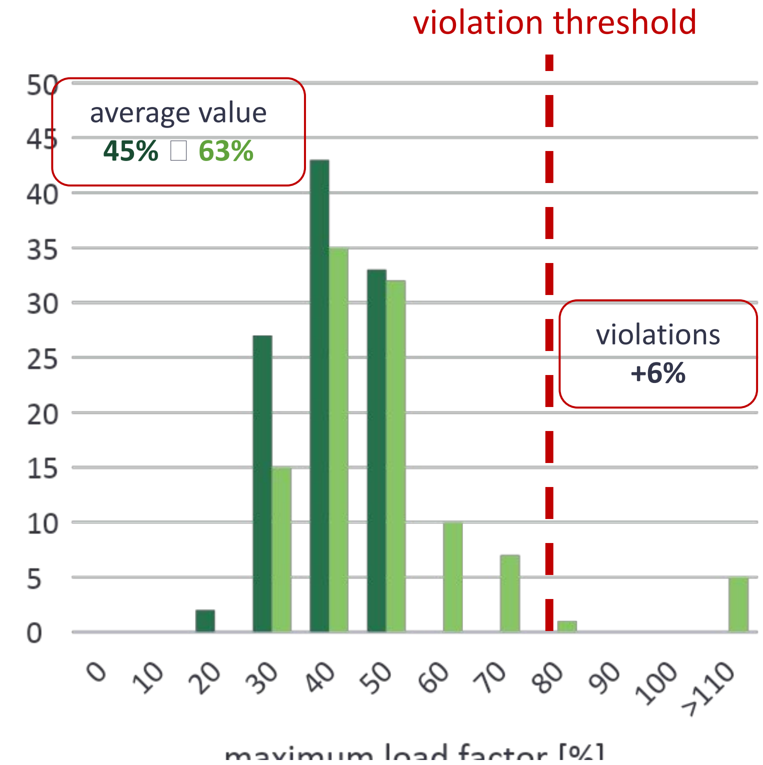
LOW VOLTAGE LINES



average value
18% □ 24%

violations
+1.5%

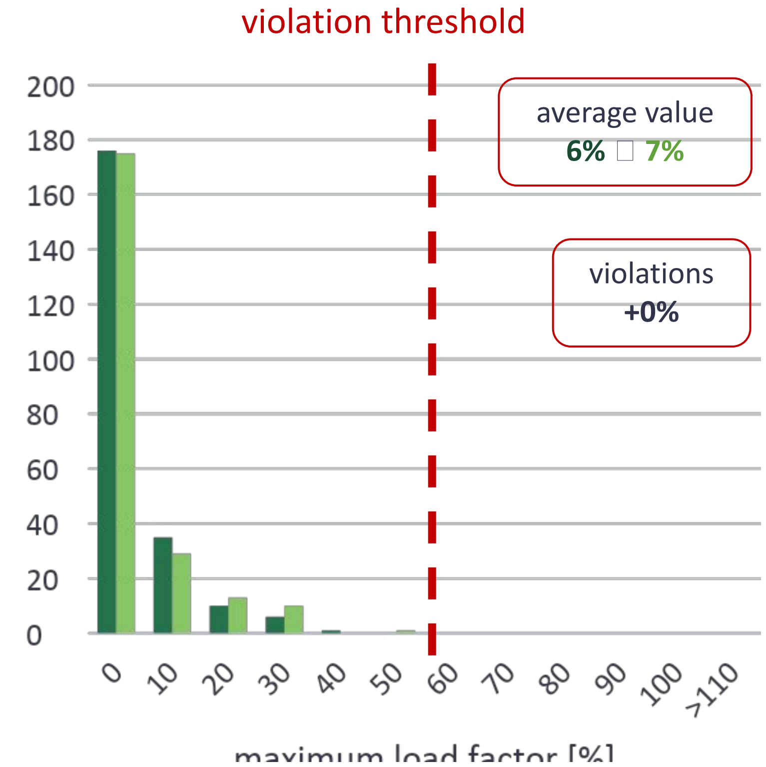
MV/LV TRANSFORMERS



average value
45% □ 63%

violations
+6%

MEDIUM VOLTAGE LINES



average value
6% □ 7%

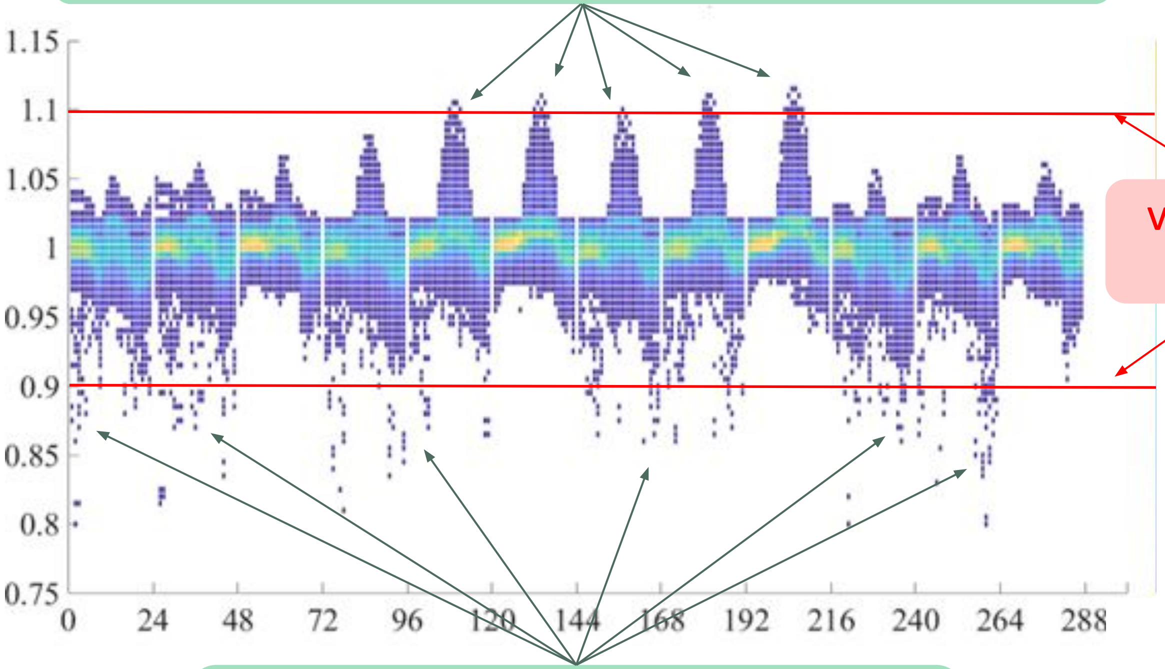
violations
+0%

MV/LV GRID DEVELOPMENT – IMPACT OF CHARGING ON RURAL GRIDS

Rural grids exhibit voltage profile problems that can be solved by synchronising NPRES generation and consumption

HOURLY VOLTAGE PROFILE [p.u. of V_n]

over-voltage due to PV overproduction

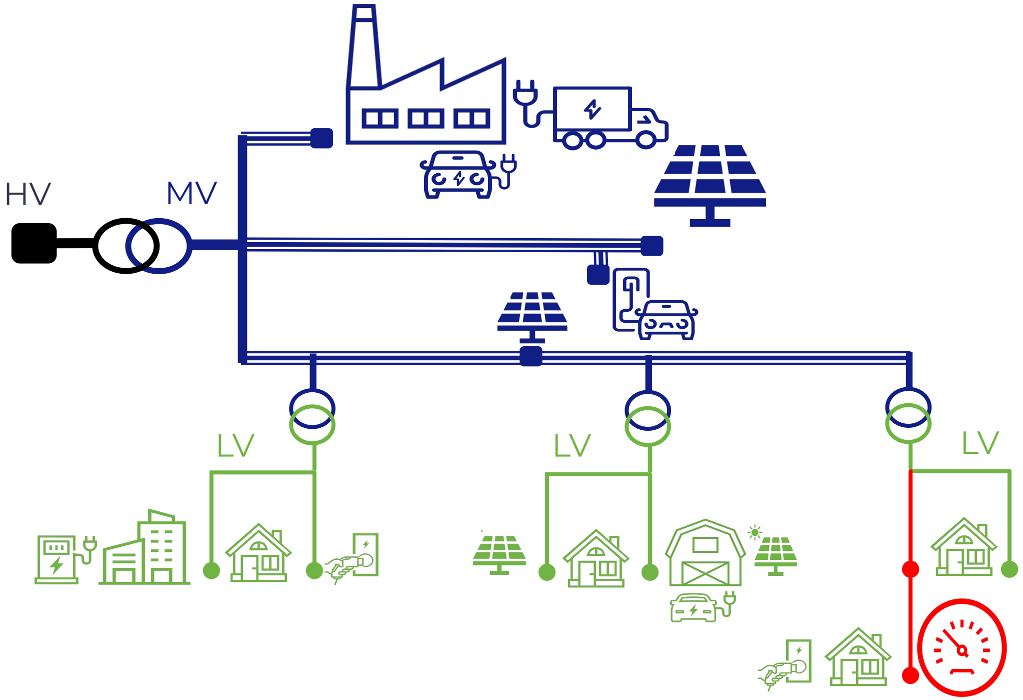


voltage limits

under-voltages caused by peripheral consumption peaks

! Grids must be further developed!

- installation of compensation banks in primary and secondary substations



TOPICS EXAMINED

The system context and charging scenarios by 2030

The impact of charging on the electrical system:

- contribution to the need to strengthen electricity grids
- **analysis of costs related to electrical dispatching**

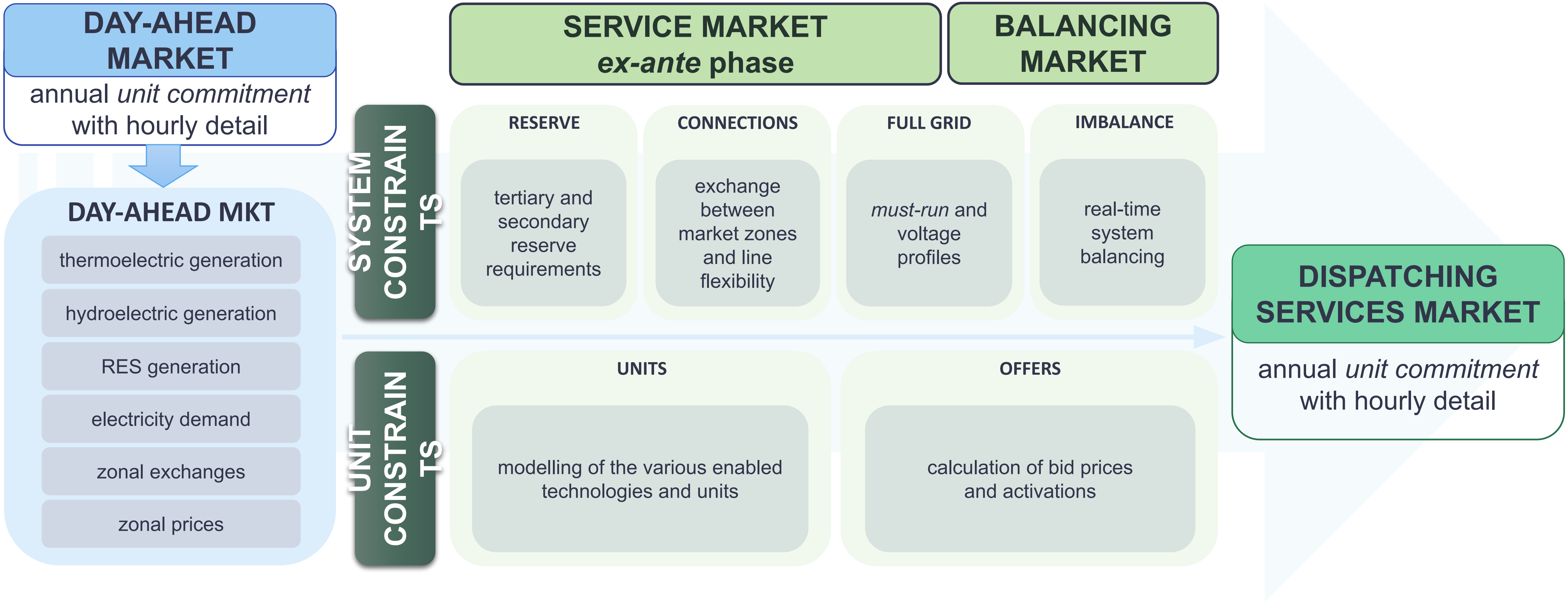
Estimation of potential benefits derived from VGI solutions

VGI-driven business opportunities

Main findings of the study and policy proposals

DISPATCHING COSTS – SIMULATION PROCEDURE

The simulation includes the *ex-ante* and *real-time* DSM constraints, plus the unit technical and economic constraints



DAY-AHEAD MARKET

annual *unit commitment* with hourly detail

DAY-AHEAD MKT

- thermoelectric generation
- hydroelectric generation
- RES generation
- electricity demand
- zonal exchanges
- zonal prices

SERVICE MARKET *ex-ante* phase

BALANCING MARKET

SYSTEM CONSTRAINTS

- **RESERVE**: tertiary and secondary reserve requirements
- **CONNECTIONS**: exchange between market zones and line flexibility
- **FULL GRID**: *must-run* and voltage profiles
- **IMBALANCE**: real-time system balancing

UNIT CONSTRAINTS

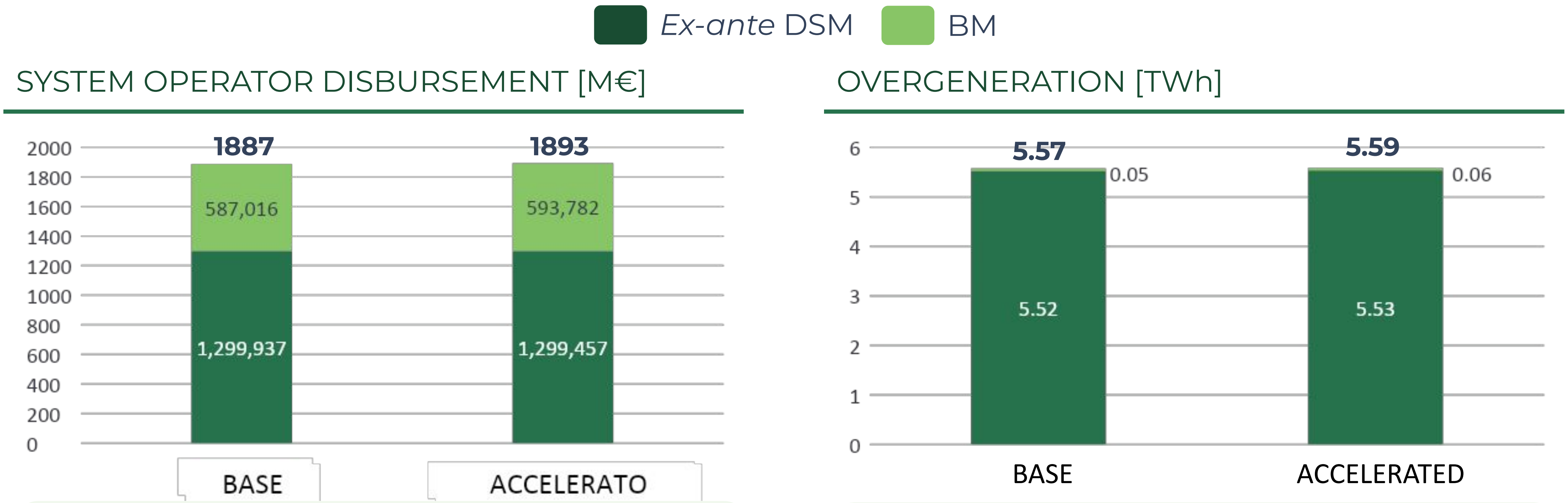
- **UNITS**: modelling of the various enabled technologies and units
- **OFFERS**: calculation of bid prices and activations

DISPATCHING SERVICES MARKET

annual *unit commitment* with hourly detail

DISPATCHING COSTS – TOTAL COST AND INDUCED OVERGENERATION

The DSM cost estimate is €1.9 BILLION, with *overgeneration* at 5.5 TWh The results are the same for the basic and the accelerated scenarios



SYSTEM OPERATOR DISBURSEMENT [M€]

OVERGENERATION [TWh]

DSM ***ex-ante***	In the *scheduling* phase, the system must be prepared for operation in accordance with the safety and reliability criteria established in the Italian and European network codes
BM	In the operational phase, real-time system reliability and balancing must be ensured.

Grid operations required during the *scheduling* phase to ensure system reliability (reserve margins and Full Grid Constraints) may involve activating thermoelectric units to replace a share of generation from NPRES (*overgeneration*), which would thus remain unused.

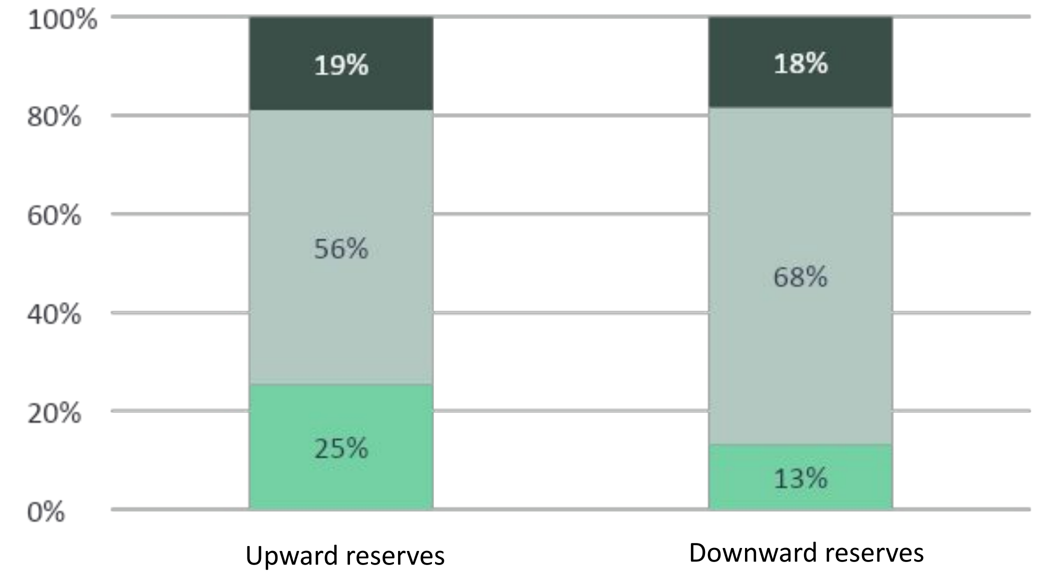
DISPATCHING COSTS – ALLOCATION OF RESERVES AND *EX-ANTE* GRID OPERATIONS

In order to provide the necessary reserve margins for the system, a high degree of thermoelectric generation must be activated in the *ex-ante* DSM phase

🟩 Flexible Demand (upward) and RES (downward)   ▨ Storage   ■ Thermoelectric

ACCELERATED SCENARIO
similar results per base

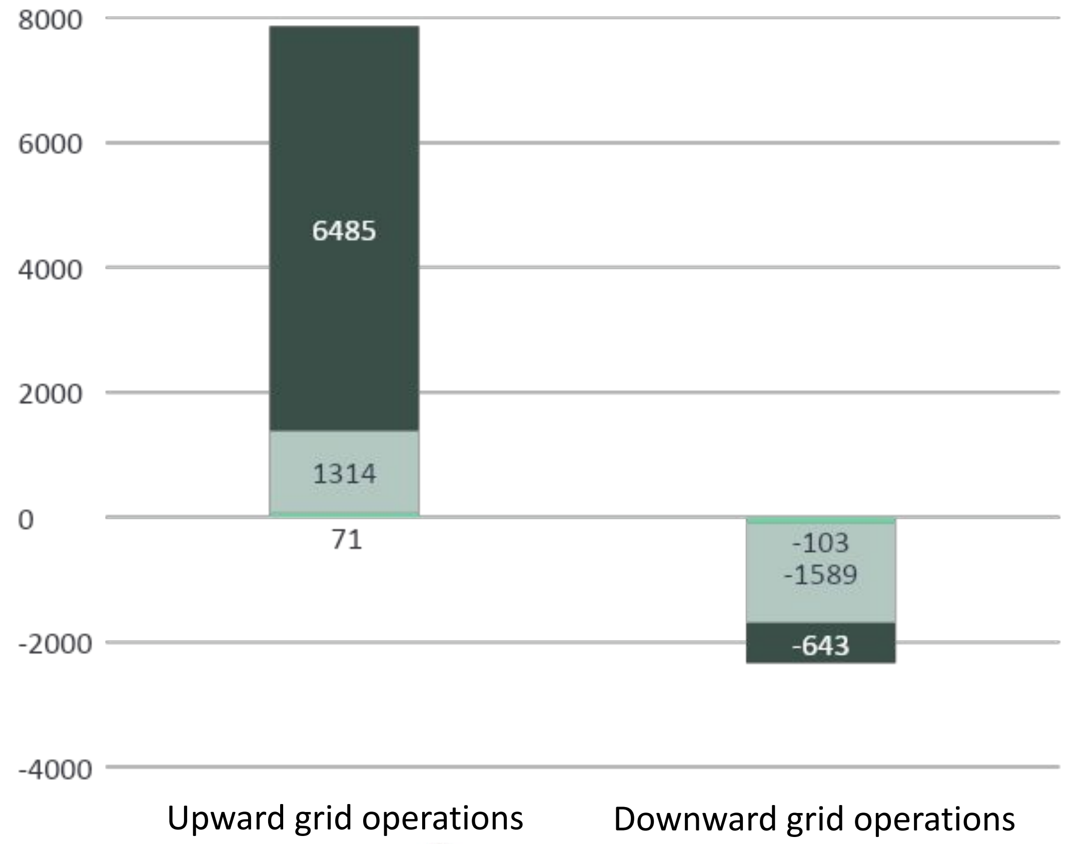
ALLOCATION OF RESERVES



During the DSM *scheduling* phase, it is also necessary to procure the appropriate reserve margins by activating certain generation plant facilities and changing their constraint schedules.

Storage facilities, flexible demand and RES have greater flexibility and thus provide reserves without requiring extensive *ex-ante* operations.

Ex-ante DSM GRID OPERATIONS [GWh]

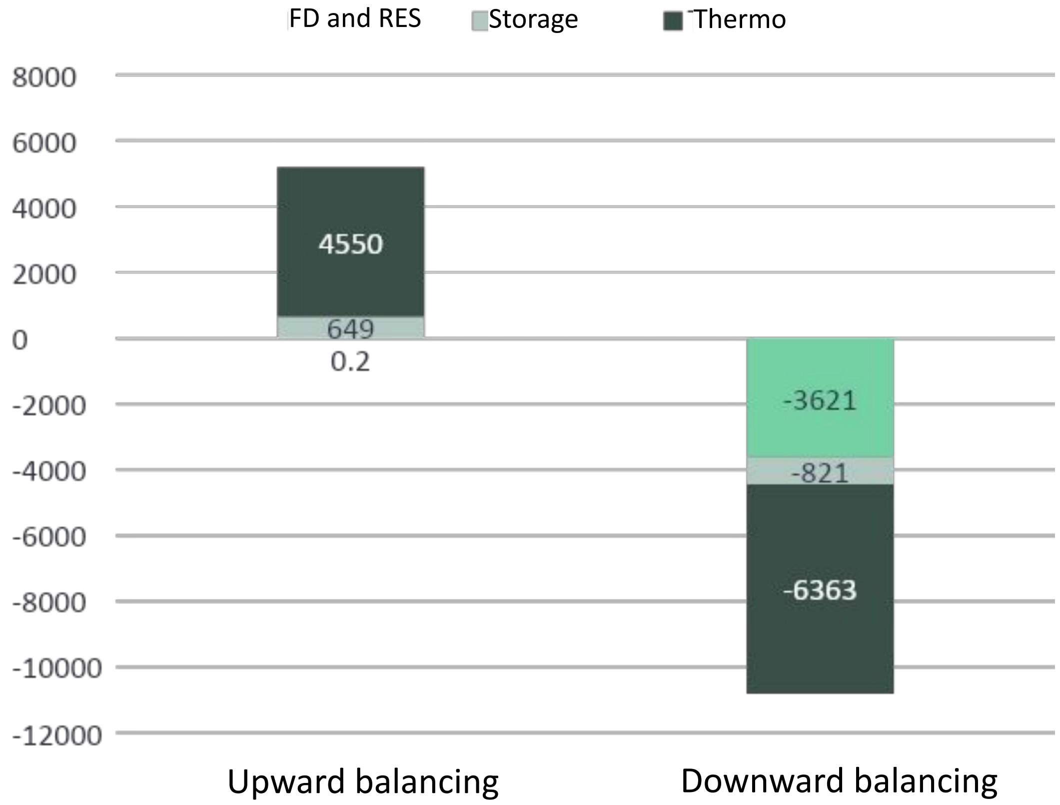


DISPATCHING COSTS – VOLUMES AND PRICING IN THE BALANCING MARKET

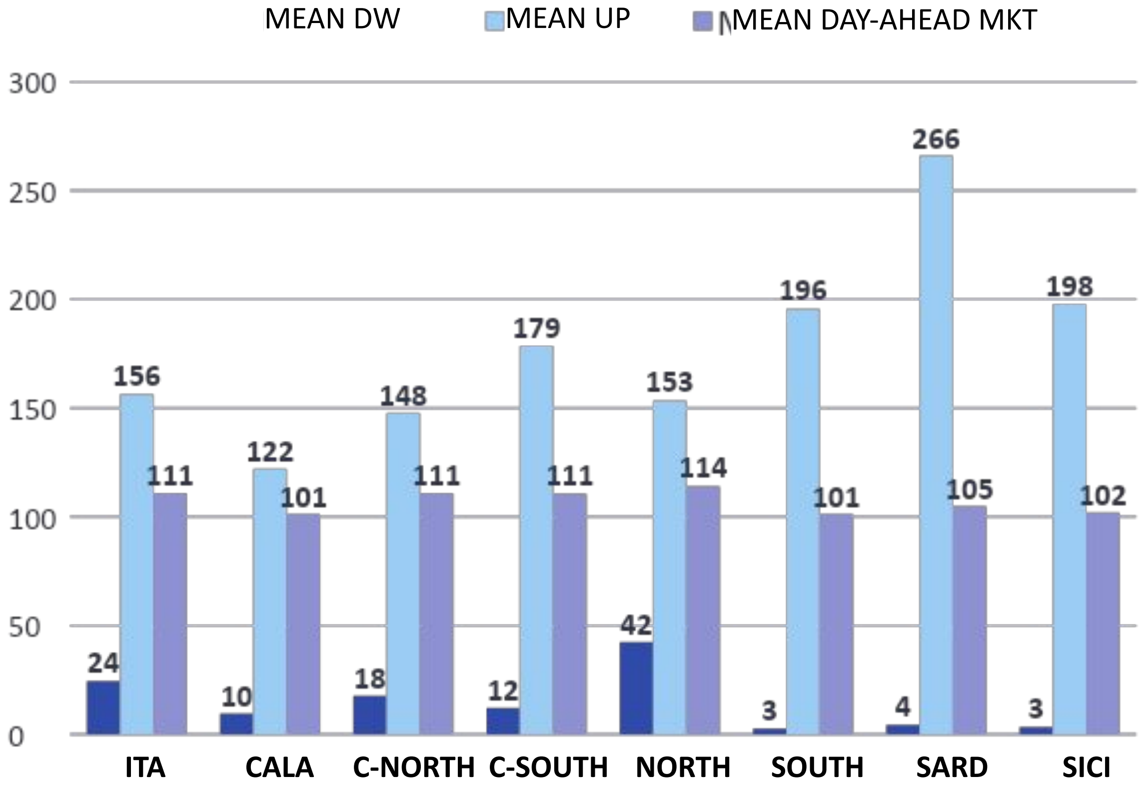
Real-time system imbalance is compensated, and average prices reflect the marginal costs of called-up units

ACCELERATED SCENARIO
similar results per base

BM GRID OPERATIONS [GWh]



ZONAL PRICING [€/MWh]



TOPICS EXAMINED

The system context and charging scenarios by 2030

The impact of charging on the electrical system

Estimation of potential benefits derived from VGI solutions:
- **VGI solutions to reduce the impact of charging on distribution networks**
- the Benefits of VGI on electrical dispatching costs

VGI-driven business opportunities

Main findings of the study and policy proposals

VGI SOLUTIONS FOR MV/LV GRIDS

Possible VGI solutions encompass *smart charging* practices and appropriate synchronism between generation, storage and charging

SMART CHARGING

LOCAL ENERGY SHARING

CHARGING CONTROL

Charging a vehicle at reduced power, especially during long stopovers, reduces the impact on the electricity grid for a given amount of total energy recharged, thus avoiding negative end-user impact.
Residential, interchange and workplace charging modes are of particular interest due to the high ratio of dwell time to recharged energy.

USE OF ELECTRICAL STORAGE

The use of energy storage systems associated with high-power (>50 kW) charging points makes it possible to reduce peak demand on the grid and thus also the number of elements potentially subject to violation of operational reliability thresholds.
The use of storage facilities reduces violations due to phenomena of short duration but high intensity.

LOCAL ENERGY SHARING

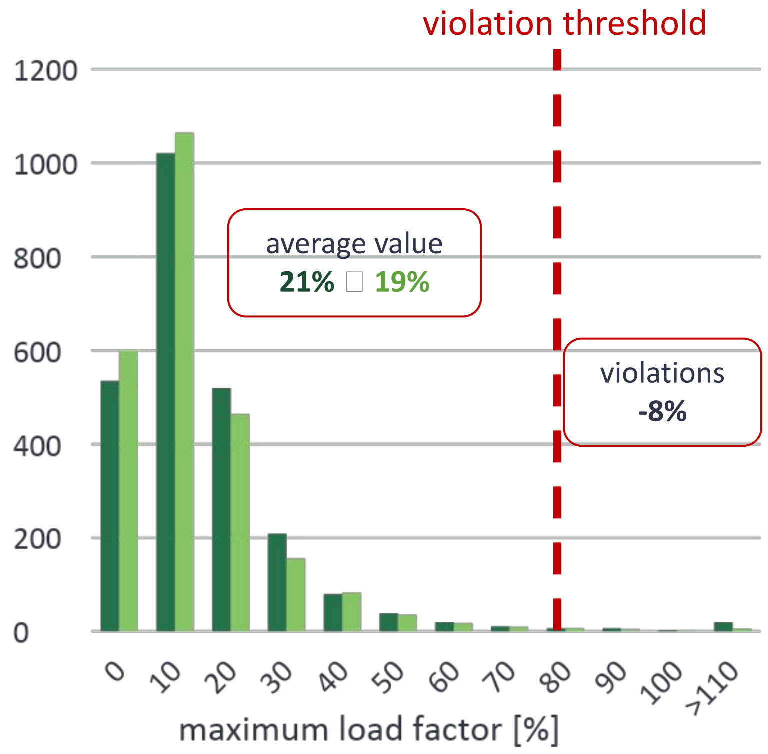
The sharing of energy produced locally by NPRES requires spatial proximity and synchronisation of energy fed to and consumed from the electricity grid.
For this reason, charging electric vehicles near distributed NPRES generation plant when such facilities are actively generating results in a lightening of the grid load.

VGI SOLUTIONS FOR MV/LV GRIDS – URBAN SMART CHARGING

Smart charging reduces critical issues observed on low-voltage sections of urban grids

UNCONTROLLED SMART

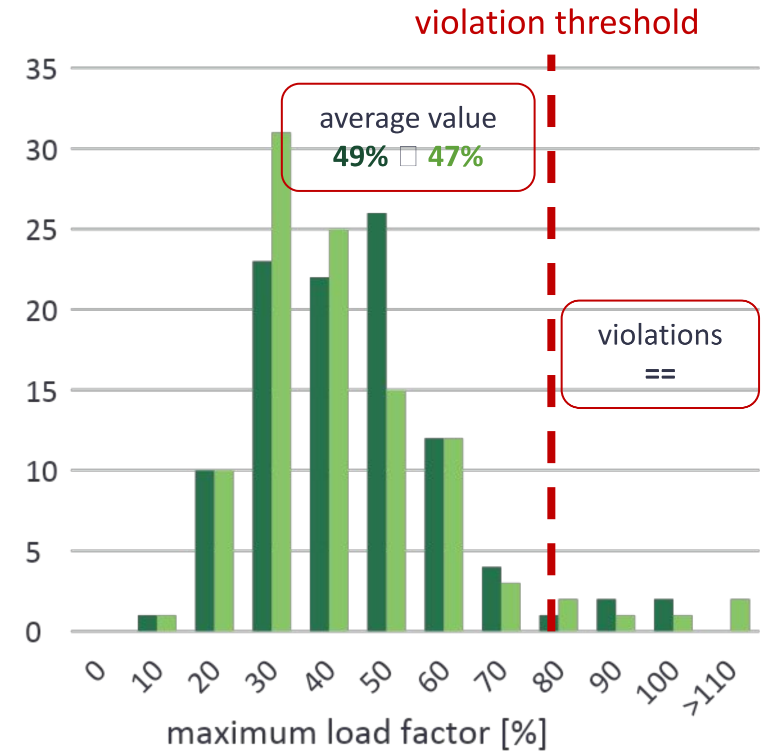
LOW VOLTAGE LINES



average value
21% □ **19%**

violations
-8%

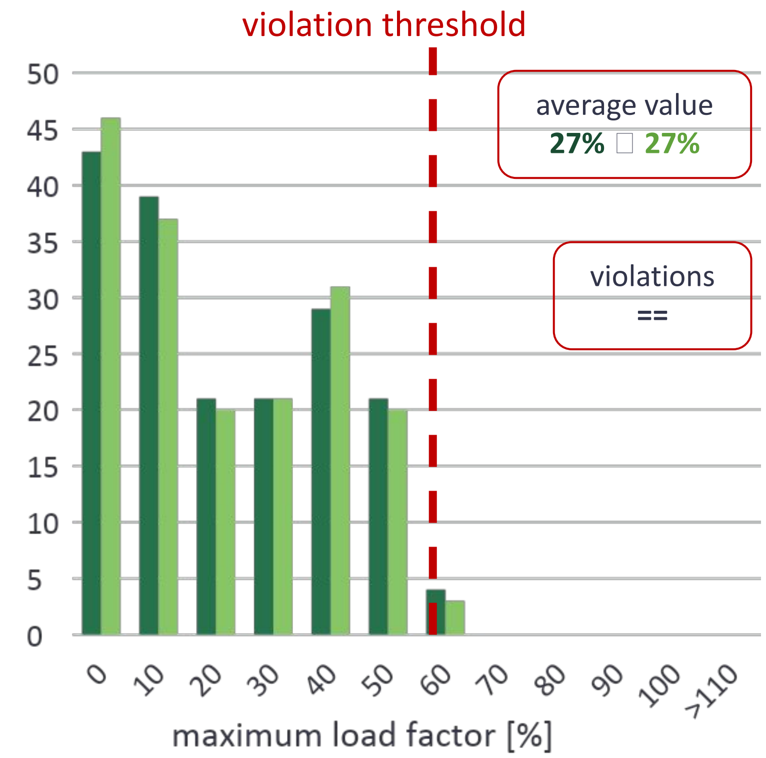
MV/LV TRANSFORMERS



average value
49% □ **47%**

violations
==

MEDIUM VOLTAGE LINES

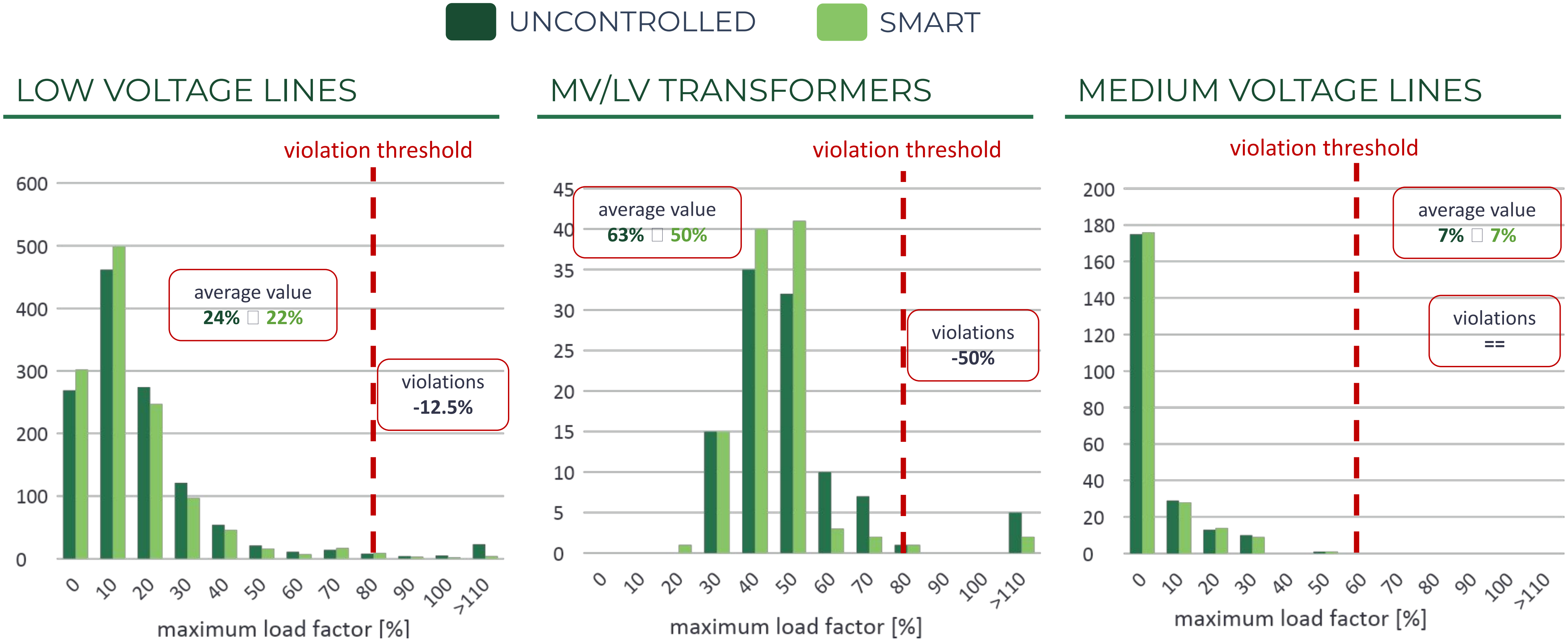


average value
27% □ **27%**

violations
==

VGI SOLUTIONS FOR MV/LV GRIDS – RURAL SMART CHARGING

Smart charging reduces critical issues observed on low-voltage sections of rural grids



LOW VOLTAGE LINES

average value
24% □ 22%

violations
-12.5%

MV/LV TRANSFORMERS

average value
63% □ 50%

violations
-50%

MEDIUM VOLTAGE LINES

average value
7% □ 7%

violations
==

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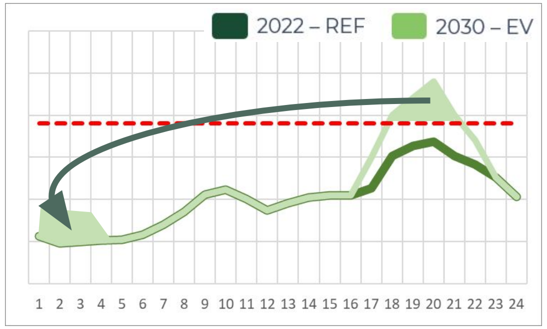
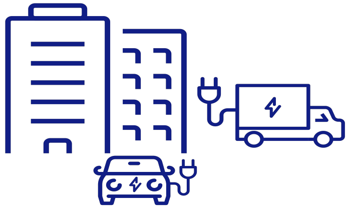
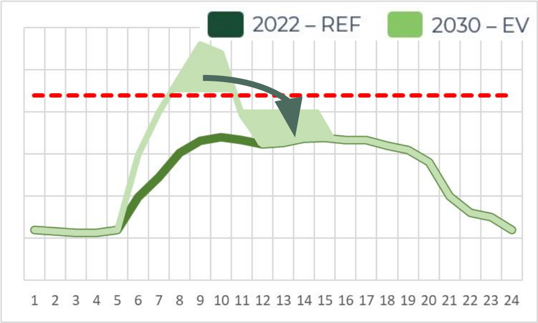
VGI SOLUTIONS FOR MV/LV GRIDS – SMART CHARGING SUMMARY

Smart charging reduces average power profiles of grid elements

URBAN GRIDS
similar results as for rural







SMART CHARGING

	LOAD FACTOR	ENERGY IN VIOLATION CONDITIONS [MWh]
LV LINES	20.6% → 19%	205 → 107
MV/LV Transformer	49.4% → 47%	169 → 95
MV LINES	26.8% → 26.5%	16 → 16

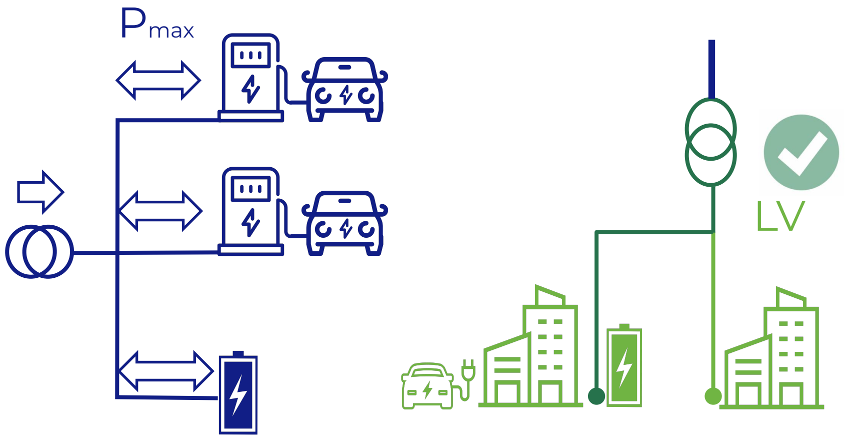
Smart charging reduces the evening consumption peak in residential areas and the morning/afternoon peak in business and industrial areas.

Smoothing out the absorption profile is generally beneficial to the system, especially with regard to load factors and violation energy levels.

VGI SOLUTIONS FOR MV/LV NETWORKS – USE OF STORAGE SYSTEMS

The use of storage systems reduces the number of violations due to brief but high-power dwell times

URBAN GRIDS
similar results as for rural



The use of a storage system combined with charging infrastructure is particularly useful when the charging power cannot be modulated (short dwell time) or in cases where violations are caused by short-duration but high-intensity peaks, such as on low-voltage grid sections.

By combining a storage system with high-power charging infrastructure, costs and connection times can be reduced by switching from medium (>100 kW) to low voltage (<100kW).

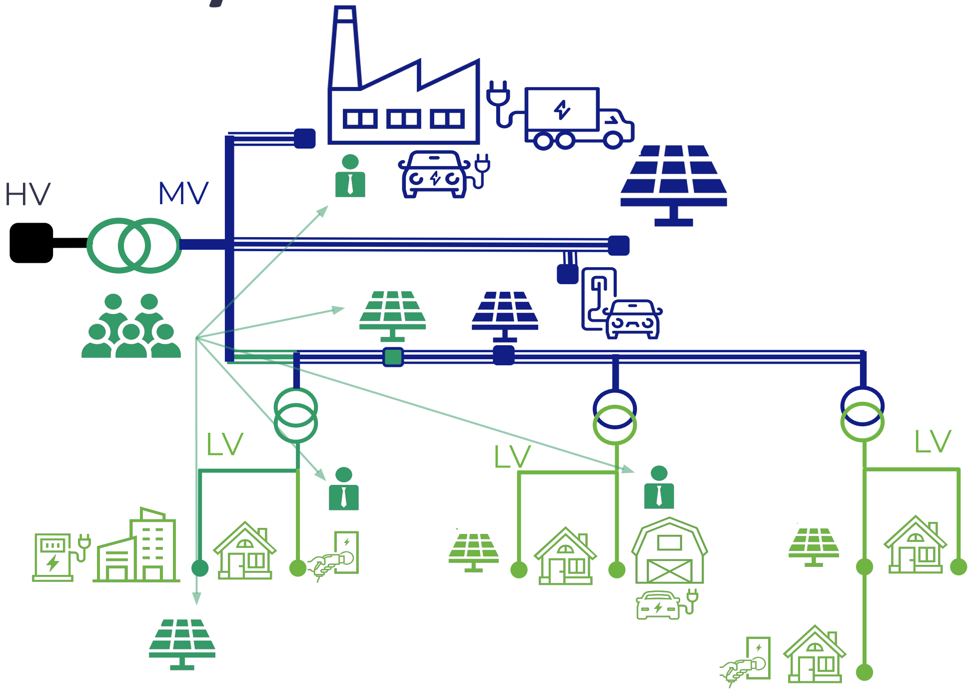
USE OF A STORAGE SYSTEM

	LOAD FACTOR	GRID ELEMENTS IN VIOLATION CONDITIONS
LV LINES	20.6% → 20%	1.5% → 1%
MV/LV Transformer	49.4% → 48.5%	2.9% → 1.9%
MV LINES	26.8% → 26.7%	2.3% → 2.2%

VGI SOLUTIONS FOR MV/LV GRIDS – LOCAL ENERGY SHARING

The sharing of local RES-generation reduces the frequency and intensity of violations

URBAN GRIDS



The local use of RES generation while feeding the distribution grid reduces energy exchanged during reliability threshold violation events by up to 70% due to their lower frequency and intensity. The benefits are particularly significant on urban grids, while less so in rural areas.

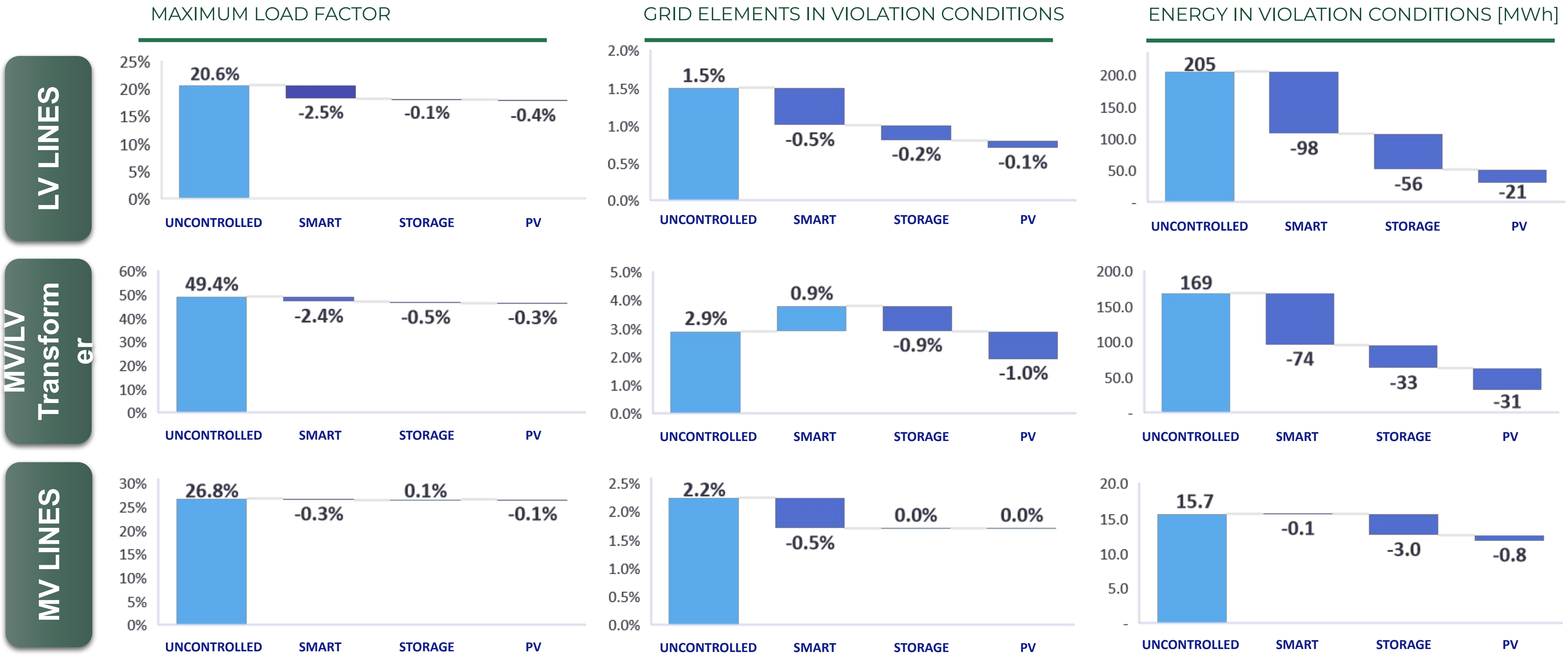
LOCAL ENERGY SHARING

	LOAD FACTOR	ENERGY IN VIOLATION CONDITIONS [MWh]
LV LINES	20.6% → 20.1%	205 → 132
MV/LV Transformer	49.4% → 48.9%	169 → 48
MV LINES	26.8% → 26.7%	16 → 5

VGI SOLUTIONS FOR MV/LV NETWORKS – GLOBAL IMPACT OF VGI SOLUTIONS

Combining the use of VGI solutions shows a particularly strong overall benefit for low-voltage sections

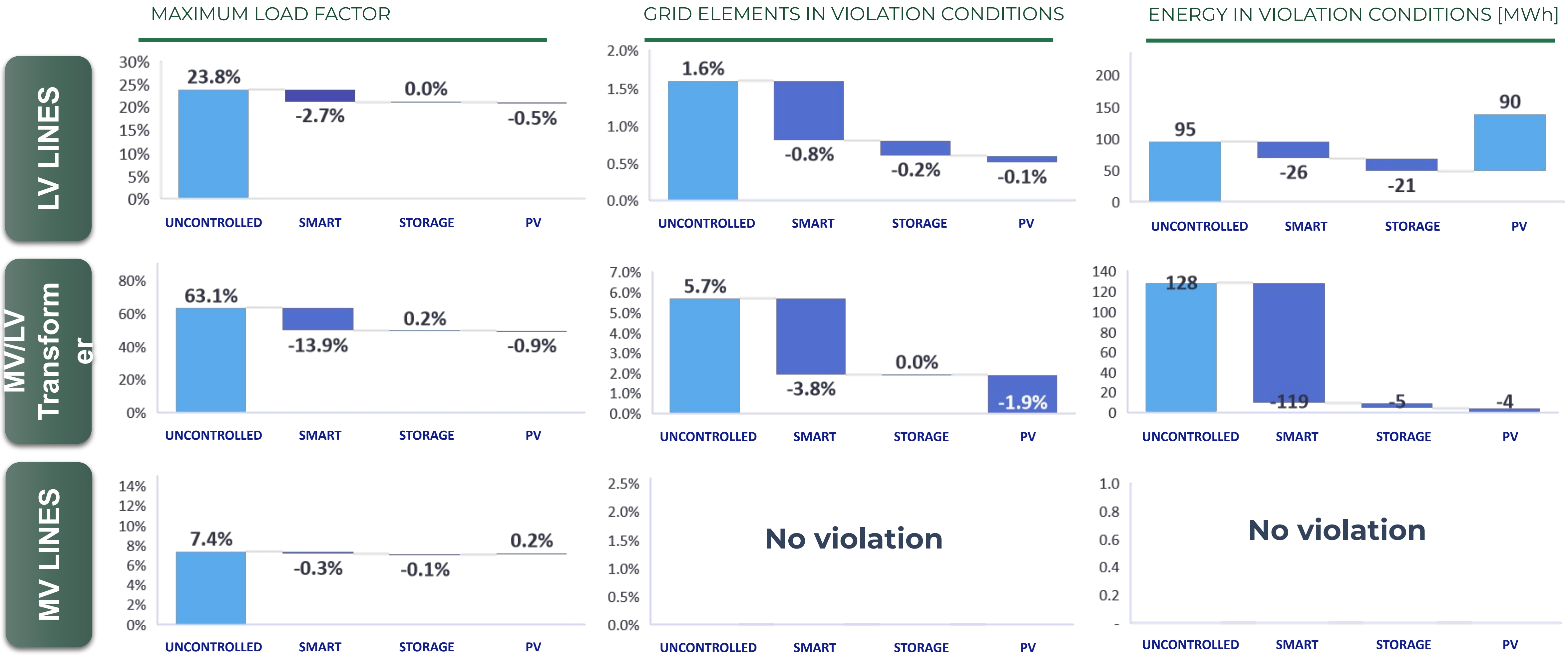
URBAN GRIDS



VGI SOLUTIONS FOR MV/LV NETWORKS – GLOBAL IMPACT OF VGI SOLUTIONS

Combining the use of VGI solutions shows a particularly strong overall benefit for low-voltage sections

RURAL GRIDS



TOPICS EXAMINED

The system context and charging scenarios by 2030

The impact of charging on the electrical system

Estimation of potential benefits derived from VGI solutions:

- VGI solutions to reduce the impact of charging on distribution networks
- **the Benefits of VGI on electrical dispatching costs**

VGI-driven business opportunities

Main findings of the study and policy proposals

VGI DISPATCHING SOLUTIONS

To simulate the enabling of electric vehicles on the DSM, it is necessary to make some assumptions about their mode of participation

MAIN ASSUMPTIONS FOR SIMULATING THE PARTICIPATION OF ELECTRIC VEHICLES IN THE DSM

CHARGING PROFILES

The charging profile is used as the Day-ahead result, together with the flexibility profile, enabling SOC and available power to be estimated for each vehicle.

AGGREGATION PERIMETER

A total of 63 aggregates are considered for participation in the DSM, one for each market area and charging mode.

OFFER PRICES

In the reference simulation, the offer is set at €115/MWh upward and €55/MWh downward; this is competitive in relation to Day-ahead pricing.

TECHNICAL PARAMETERS

For vehicles charging and discharging phases, a *round-trip* efficiency of 80% is considered, with partial efficiencies (charging or discharging) of the same value.

DURATION CONSTRAINTS

A minimum required duration constraint of one hour is considered for all storage technologies and reserve types.

UNAVAILABILITY

Conservative unavailability presumption with a 1.5% correction factor. In addition, a maximum band is set for secondary adjustment (for EV = 15%).

NB: flexibility is estimated considering no detriment to the user compared to the situation without provision of the service. See also slide 27

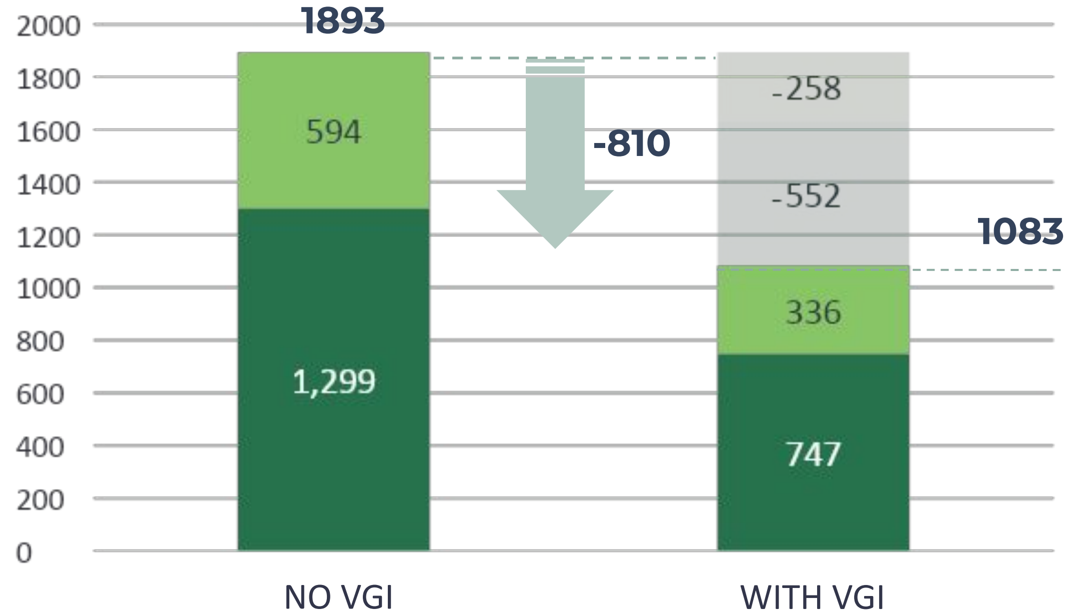
VGI DISPATCHING SOLUTIONS – OVERALL BENEFITS ON DISPATCHING

Enabling electric vehicles in the accelerated scenario reduces DSM costs by 40% and overgeneration by 50%

Ex-ante DSM BM *Ex-ante* DSM BM

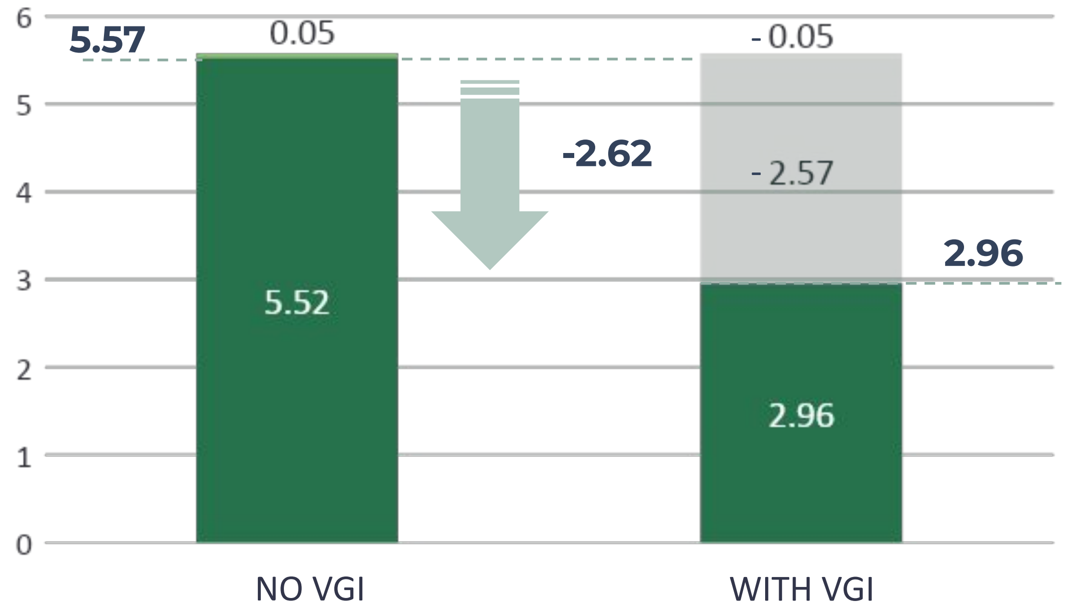
ACCELERATED SCENARIO
similar results per base

DSM COST REDUCTION [M€]



Envisaged total savings on electricity dispatching costs resulting from the enabling of EVs amount to €800 million. These savings come from the combined effect of avoided *ex-ante* grid operations (free reserve) and reduced balancing costs.

OVERGENERATION BENEFITS [TWh]



By enabling electric vehicles to the DSM, use can be made of their available reserve margins, avoiding the activation of thermoelectric and cuts in RES generation, with consequent economic and environmental benefits.

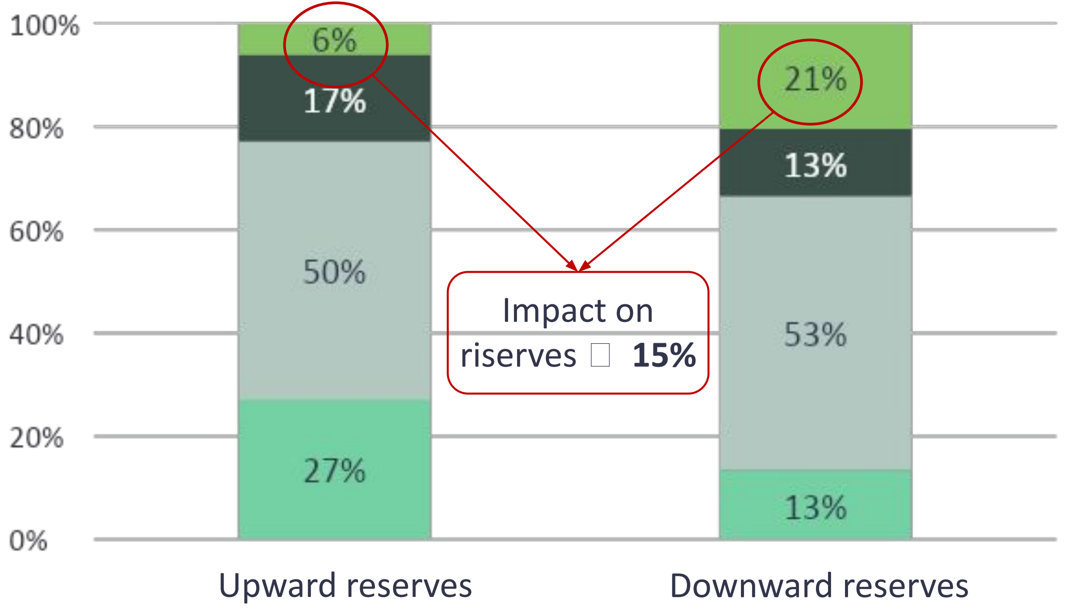
VGI DISPATCHING SOLUTIONS – CONTRIBUTING TO THE RESERVE POOL

EVs contribute to 15% of the reserve pool, do not require many *ex-ante* grid operations and reduce fossil generation

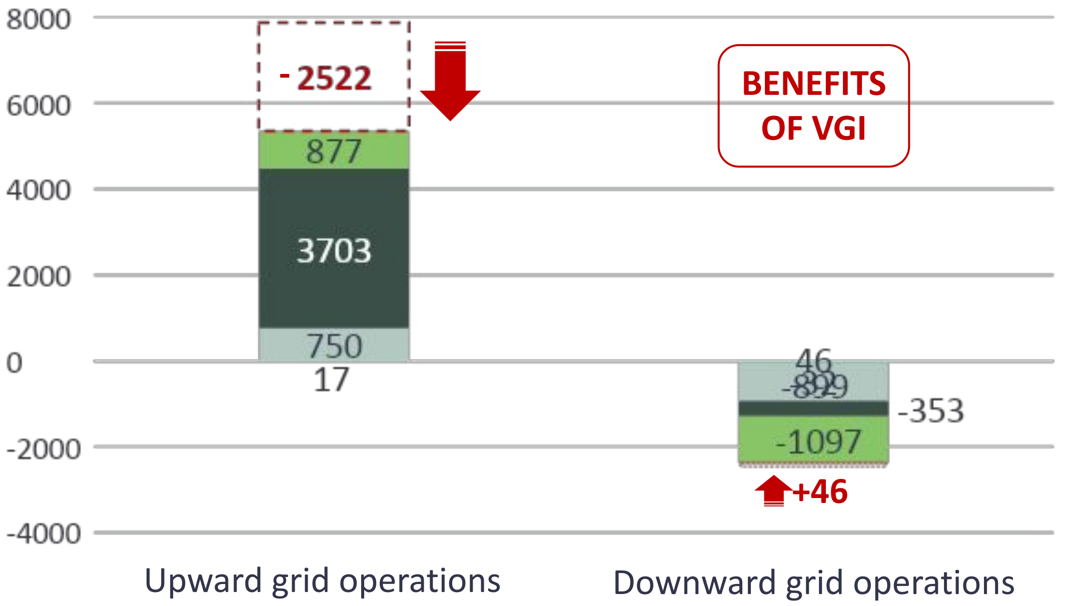
🟩 Electric Vehicles 🟩 FD (upward) and RES (downward) ▨ Storage ■ Thermoelectric

ACCELERATED SCENARIO
similar results per base

PROCURED RESERVES



Ex-ante DSM GRID OPERATIONS [GWh]



Electric vehicles significantly contribute to reserve requirements, displacing thermoelectric units and, to some extent, other forms of storage, due to their greater convenience.

Enabling electric vehicles reduces overall *ex-ante* grid operations by 2.5 TWh. It also reduces upward thermoelectric unit operations by almost 3 TWh, also halving downward grid operations in both thermoelectric and storage modes.

NB: please refer to slide 14 for the VGI solutions considered and slide 27 for the definition of the upward and downward services.

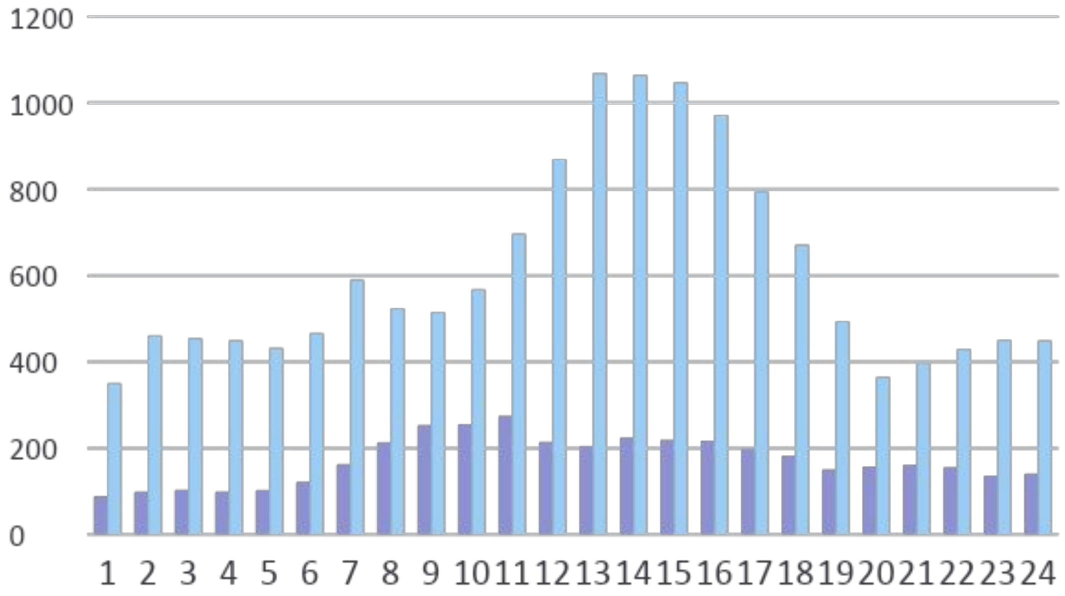
VGI DISPATCHING SOLUTIONS – THE HOURLY RESERVE PROFILE

Ex-ante EV-related grid operations mainly occur during the day, as does peak reserve allocation

🟦 Downward 🟪 Upward

ACCELERATED SCENARIO
similar results per base

HOURLY RESERVE PROFILE [GWh total]



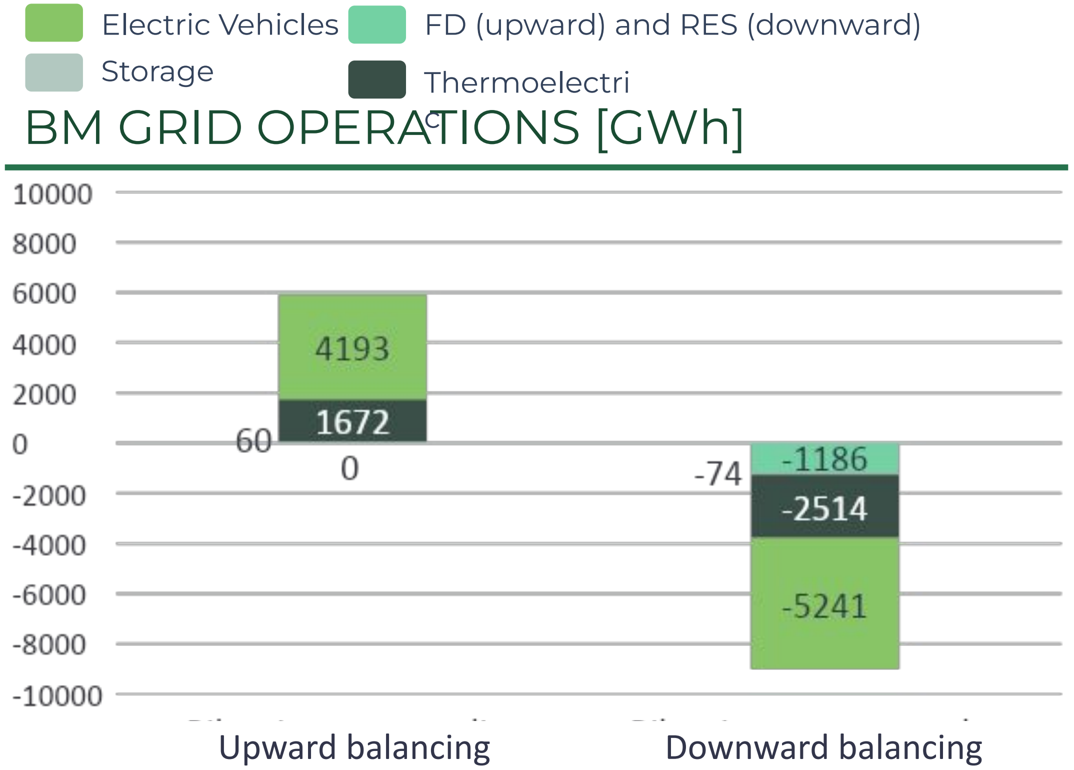
The total annual hourly profile for the upward EV allocated reserve peaks in the early morning, while that for the downward reserve peaks in the early afternoon, following the typical PV generation trend.

Ex-ante GRID OPERATION PROFILE [total GWh]

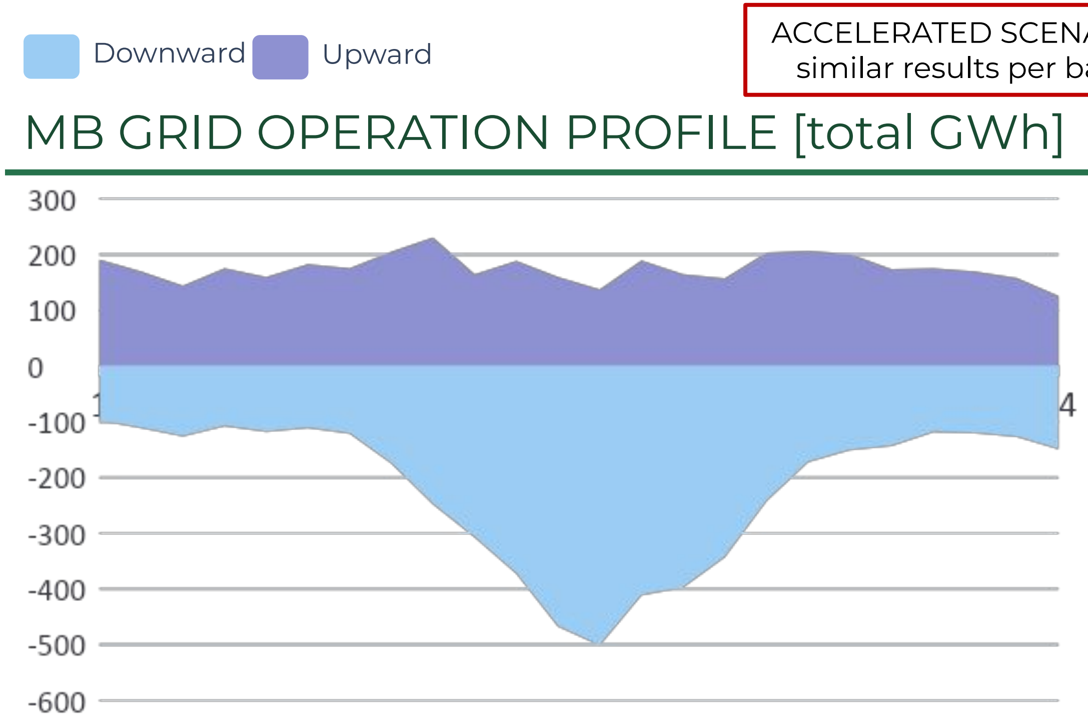
Total annual *ex-ante* upward and downward EV-related grid operations are almost symmetrical, with a higher average value during daytime hours and a greater need for downward operations at night.

VGI DISPATCHING SOLUTIONS – BALANCING THE ELECTRICITY SYSTEM

EVs contribute 63% of the electrical balance, with a large volume of afternoon downward regulation



ACCELERATED SCENARIO
similar results per base



Electric vehicles contribute to electrical system balancing by providing 4 TWh of upward regulation and 5 TWh of downward regulation.

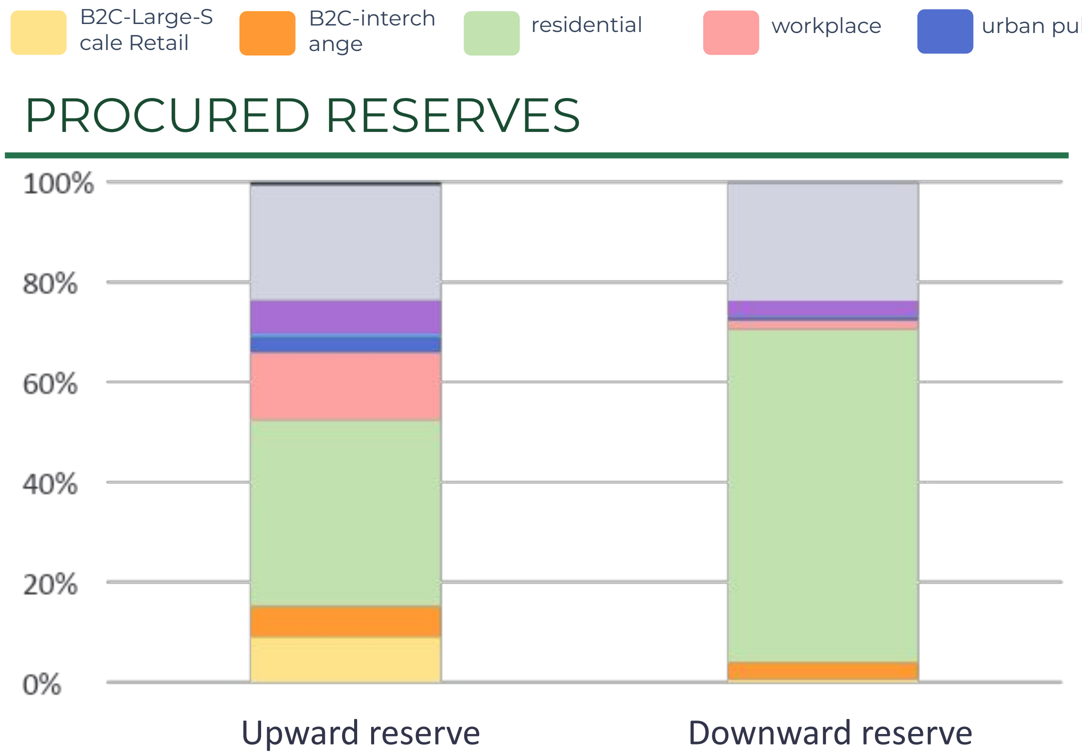
Observing the total number of system balancing requests over the year, we notice a concentration of downward balancing in the early afternoon, when EVs absorb the excess power from photovoltaic sources.

VGI DISPATCHING SOLUTIONS – CONTRIBUTION OF THE VARIOUS CHARGING MODES

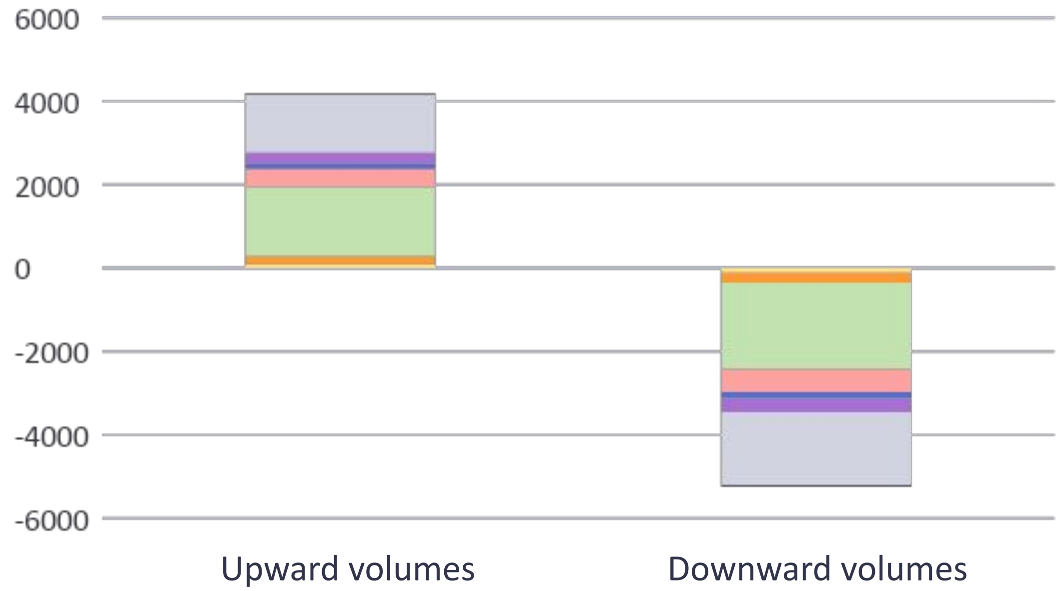
The greatest contribution to dispatching comes from long cycles that constitute the prevalent charging mode

ACCELERATED SCENARIO
similar results per base

PROCURED RESERVES



BM GRID OPERATIONS [GWh]



The contribution to the reserve pool is dominated by the modes in which most energy is charged (residential and LCV), which also have long dwell times (workplace, B2C-Interchange and HCV charging).

Residential charging of *Light Commercial Vehicle* plays a major role in the provision of balancing regulation.

VGI DISPATCHING SOLUTIONS – IMPACT OF DISPATCHING ON ELECTRIC VEHICLES

The possibility of aggregating several charging stations reduces the contribution required from individual vehicles for service provision purposes

ACCELERATED SCENARIO
similar results per base

Ratio of maximum power to number of vehicles

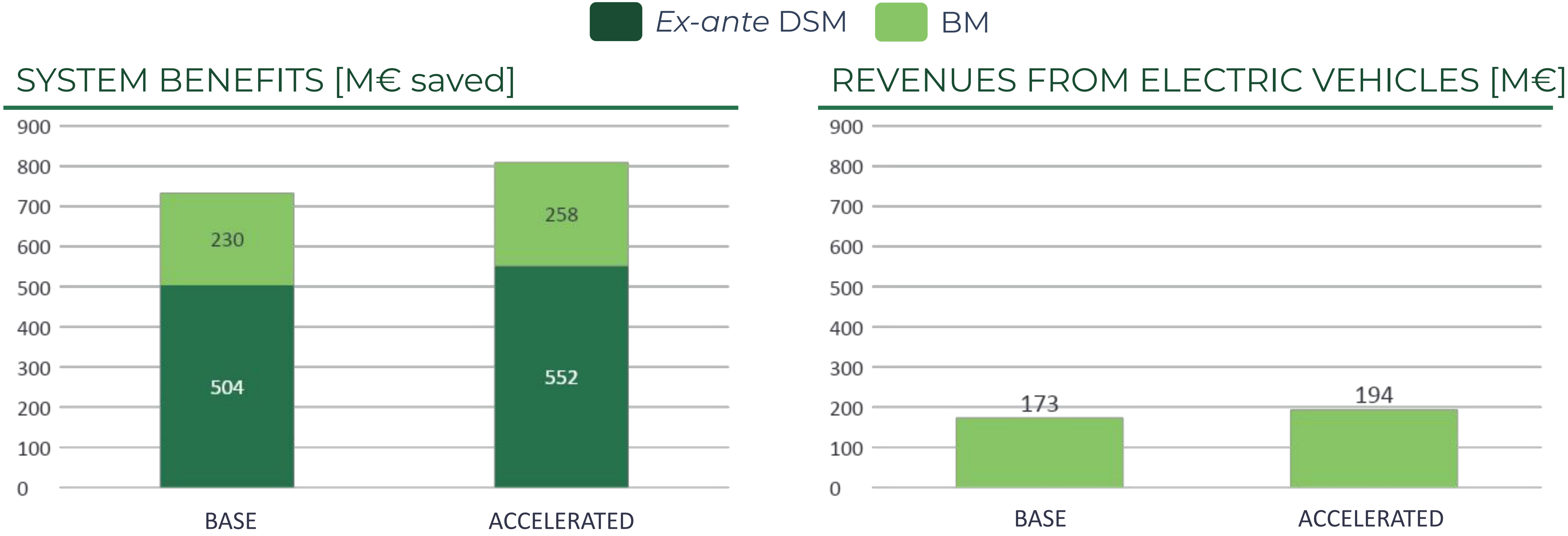
Motor vehicles	Battery [kWh/EV]	#No. of vehicles	Upward reserve [kW peak/EV]	Downward reserve [kW peak/EV]	DSM grid operations [kW peak/EV]	BM volumes [kW peak/EV]
BEVs+PHEVs	53	7 500 000	0.36	0.74	0.67	0.80
LCVs	75	750 000	1.95	3.70	4.27	4.46
HCVs	400	50 000	3.96	3.32	5.76	6.81
LPT	460	7 000	3.47	3.13	4.18	5.02

Ratio of required energy to number of vehicles

Motor vehicles	Battery [kWh/EV]	#No. of vehicles	Upward reserve [kWh/EV day]	Downward reserve [kWh/EV day]	DSM grid operations [kWh/EV day]	BM volumes [kWh/EV day]
BEVs+PHEVs	53	7 500 000	1.05	3.89	0.44	2.06
LCVs	75	750 000	3.46	12.58	2.45	11.54
HCVs	400	50 000	15.08	24.42	5.04	32.53
LPT	460	7 000	10.96	11.78	2.90	21.76

VGI DISPATCHING SOLUTIONS – POTENTIAL REVENUES FOR ELECTRIC VEHICLES

The economic benefits to the system far outweigh the revenues accruing to electric vehicles



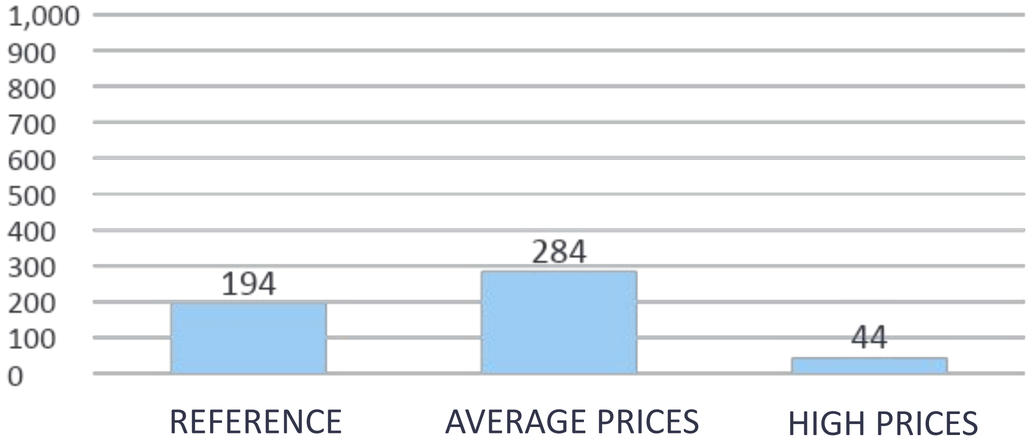
With an overall economic benefit for the system of between €700 and €800 million, depending on the electric vehicle penetration scenario considered, the revenues for service providers are between €170 and €195 million. It is therefore conceivable to transfer part of the benefits to electric vehicles on account of their willingness to provide reserve from the scheduling phase without requiring operational activation (payment in €/MW). The ratio of electric vehicle revenues to system economic benefits would still remain low.

VGI DISPATCHING SOLUTIONS – SENSITIVITY TO ELECTRIC VEHICLE OFFER PRICES

A sensitivity analysis on offer prices reveals how revenues can be maximised at the expense of system benefits

ACCELERATED SCENARIO
similar results per base

REVENUES FROM ELECTRIC VEHICLES [M€]



SYSTEM BENEFITS [M€]

PRICING SENSITIVITY ANALYSIS

REFERENCE PRICES

In the reference scenario, the offer prices are competitive with the prices recorded on the Day-ahead Market and are set at €115/MWh upwards and €55/MWh downwards.

AVERAGE PRICES

An initial sensitivity test pegs prices near the mean accepted DSM and BM offers at €155/MWh upwards and €30/MWh downwards.

HIGH PRICES

A third scenario sets offer prices at an uncompetitive level compared to market pricing, i.e. €270/MWh upwards and €15/MWh downwards.

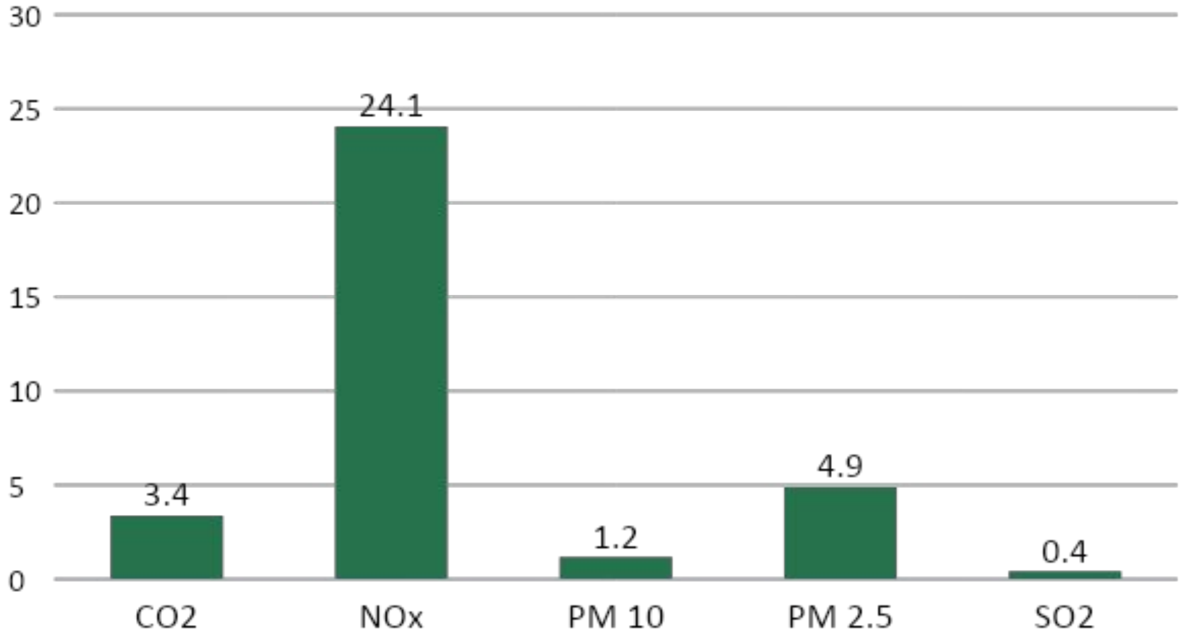
VGI DISPATCHING SOLUTIONS – SYSTEM ENVIRONMENTAL BENEFITS

Enabling electric vehicles reduces CO2 and other polluting gases emissions by 41%, thanks to avoidance of fossil production

CO_2 AND OTHER GHG EMISSIONS

Emissions	NO VGI	WITH VGI
CO2 [kton]	1633	958
NOx [ton]	1473	864
SO2 [ton]	75	44
PM 2.5 [ton]	118	69
PM 10 [ton]	41	24

SOCIAL COSTS AVOIDED BY THE DSM [M€]



Emissions avoided thanks to electric vehicles are monetised by evaluating the reduction in social costs of system externalities. The social cost, expressed in €/tonne, represents the total net damage to the company of an extra tonne of emissions of the gas in question. The social cost thus defined is subtracted from the cost of CO_2 explicitly paid by the generation plants within the ETS mechanism, thus avoiding forms of *double counting*.

TOPICS EXAMINED

The system context and charging scenarios by 2030

The impact of charging on the electrical system

Estimation of potential benefits derived from VGI solutions

VGI-driven business opportunities:

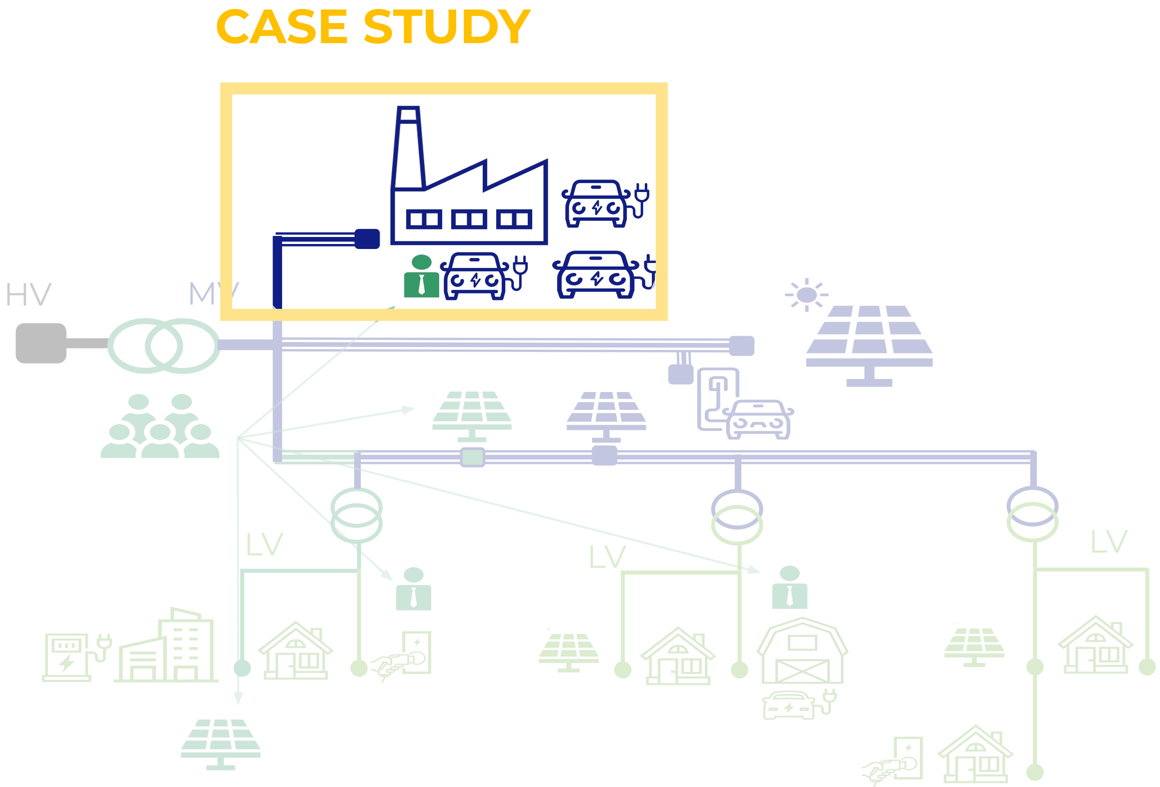
- **assessment of the economic potential, technical enabling features and potential criticalities of a VGI solution for a case study**

Main findings of the study and policy proposals

CASE STUDY

Case study: employee users with a prevalence of their own cars

- The case study considered supplements the global analyses made on the zonal aggregates to verify the compatibility of the proposed analyses with the particular features of a specific EV charging infrastructure.
- This analysis also offers a business model perspective, identifying the economic supply/demand flows for the implementation of a workplace VGI solution.
- **We emphasise that the results obtained here relate to the enablement of V1G only, thus without need for V2G infrastructure.**

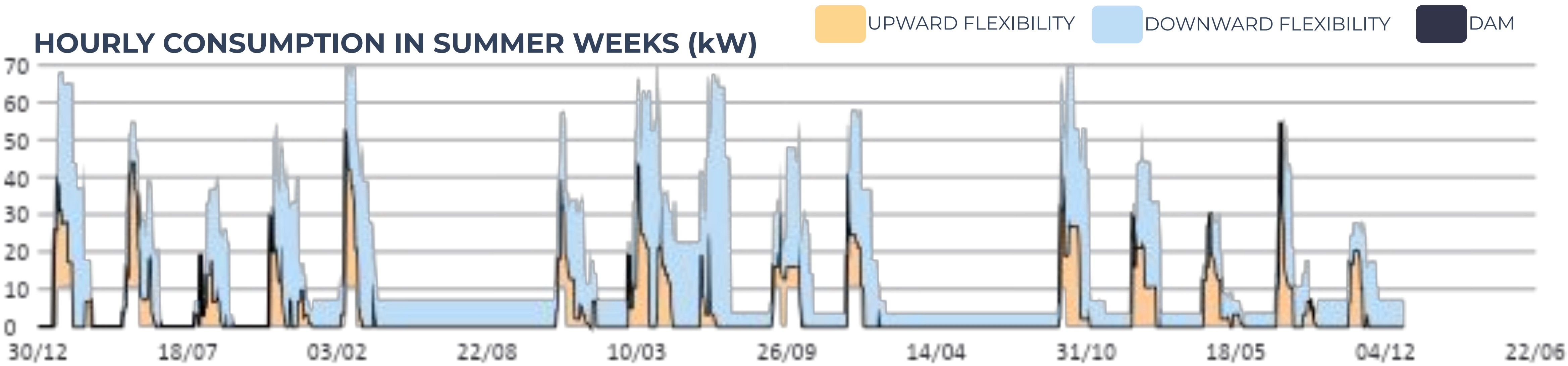


Charging infrastructure	11 * 2 charging points
Power	22 kW – AC
V2G	NO
Type of user	• Workers, • 90% employee cars, 10% fleet • Office on a Monday-to-Friday shift
Car type	Broken down into segments B, C and D
Number of cars	10 to 15 cars per week
Number of charges	35 to 50 charges per week

CASE STUDY – WORKPLACE CHARGING

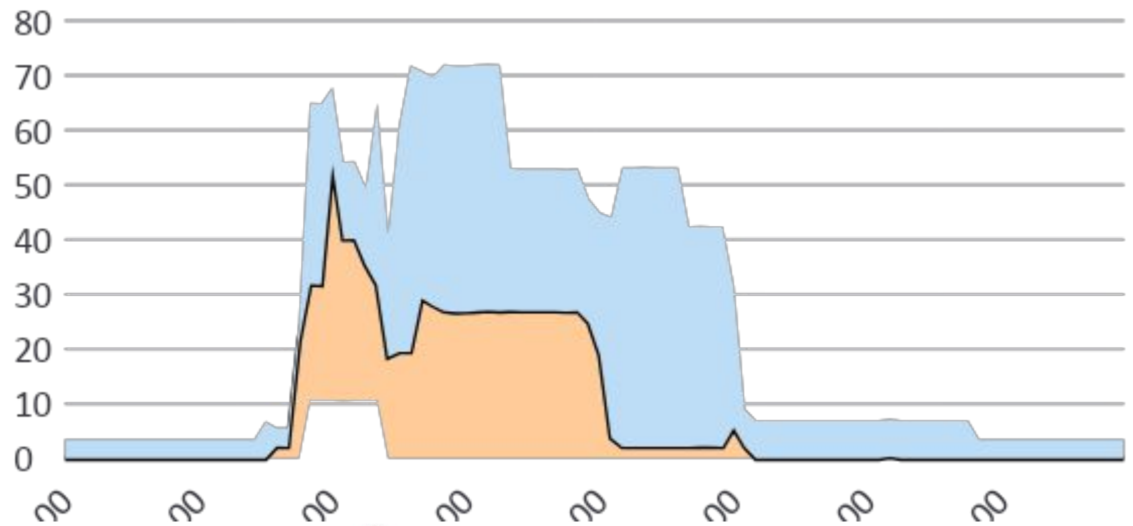
Actual charging profiles were used, with flexibility calculations

HOURLY CONSUMPTION IN SUMMER WEEKS (kW)



- Six weeks were analysed (March and June 2022)
- From the charging consumption profile, we estimated flexibility downward (increasing consumption) and upward (decreasing consumption).
- The results of three consecutive weeks with five working days and a weekend break are presented.
- Weekend flexibility is determined by the (small) number of fleet cars that remain parked in any case.

FOCUS ON A WORKING DAY

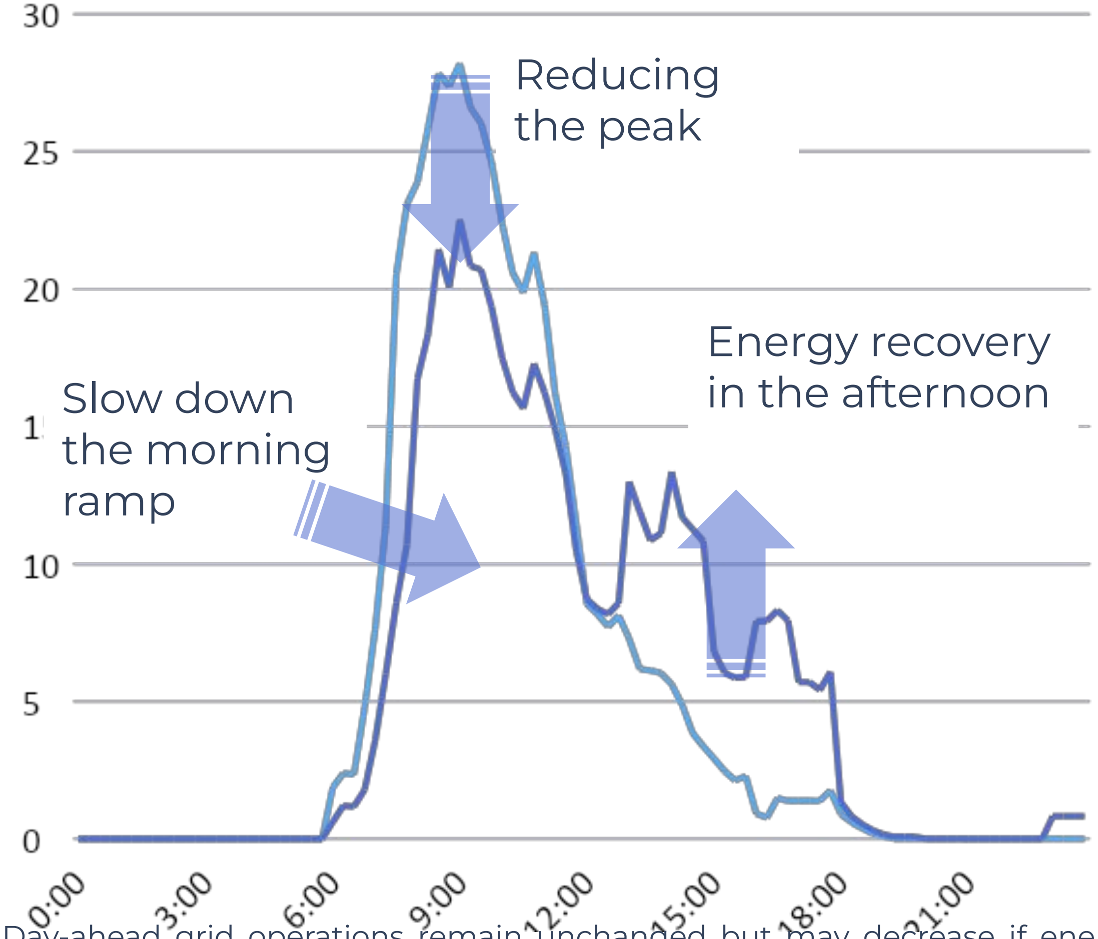


CASE STUDY – CHARACTERISTICS OF VGI AT WORKPLACES

Enabling the VGI to delay the morning peak in winter and increase daytime consumption in summer

🟦 WITHOUT VGI
🟦 WITH VGI

WINTER CONSUMPTION WITHOUT AND WITH VGI [kW]

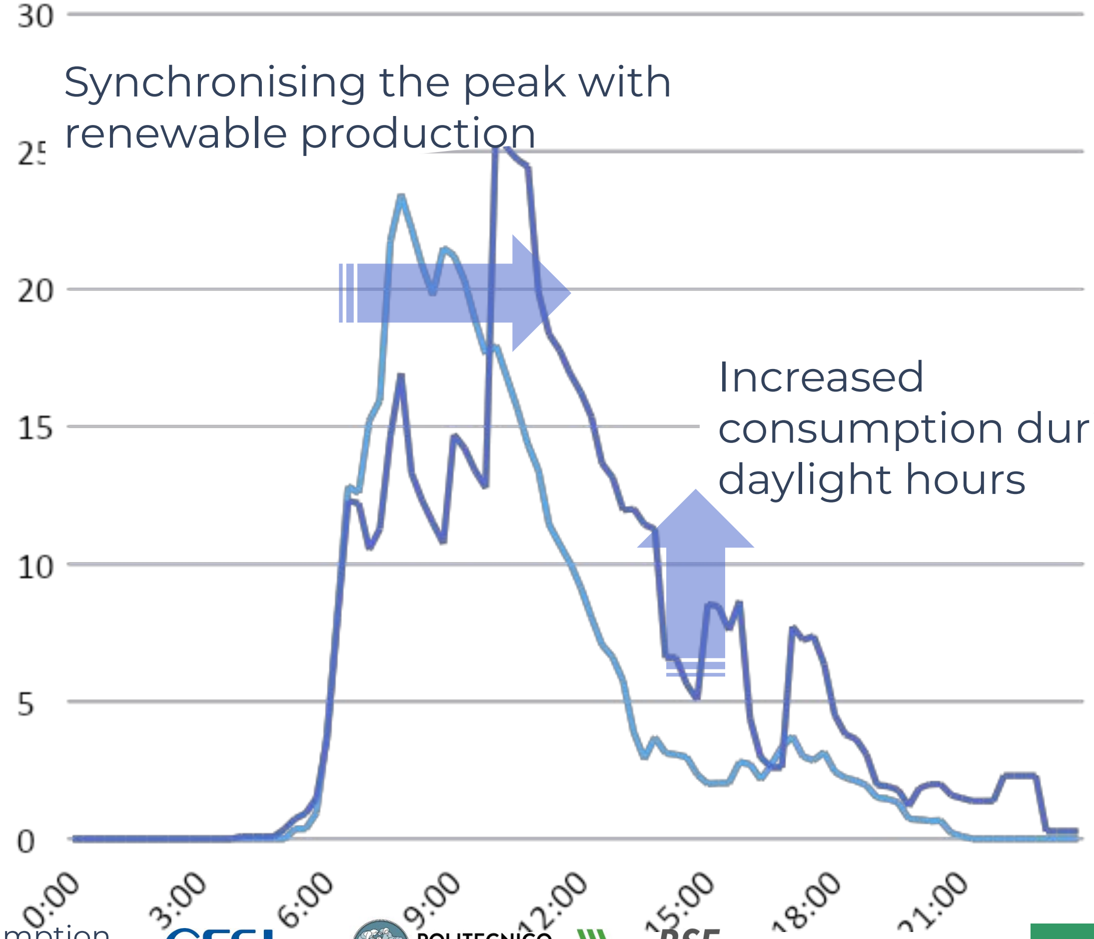


Reducing the peak

Slow down the morning ramp

Energy recovery in the afternoon

SUMMER CONSUMPTION WITHOUT and WITH VGI [kW]



Synchronising the peak with renewable production

Increased consumption during daylight hours

Day-ahead grid operations remain unchanged but may decrease if energy consumption occurs through participation in downward DSMs (increased consumption).

CASE STUDY – PROVISION OF DISPATCHING SERVICES

Simulations suggest a service provision level of 3000 hours/year, with a prevalence of downward regulation (more charging activity)

NO DISTURBANCE TO THE USER

We reference the assumptions previously discussed in the first part of the report (ensuring SOC_{target} achievement) to estimate the flexibility offered: **reliable system supply and no disruption to the user**.

IMPLICIT AND EXPLICIT ACTIONS

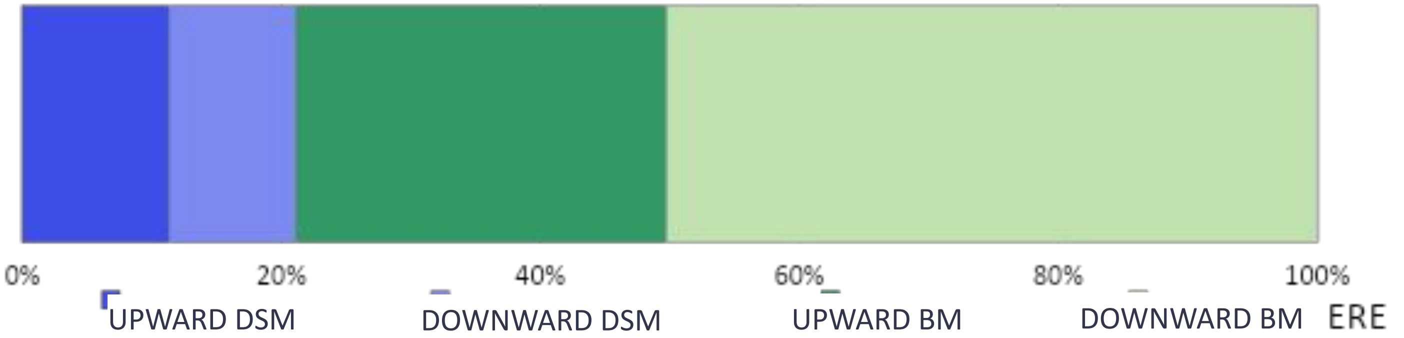
20% of grid operations are related to secondary and tertiary regulated supply. 80% of the reserve contribution from EV is implicit, without grid operations: **benefits for the system at no cost**.

SYSTEM BENEFITS

Over the course of the year (especially in the summer season), downward grid operations exceed upward operations (+50%). This **contributes to reducing the curtailment of renewables**.

Services provided	Supply direction	Number of calls	Energy [kWh]
Ex-ante adjustment	Upward	498	3332
	Downward	790	2849
BM adjustment	Upward	595	8388
	Downward	1187	14709
TOTAL provided by the fleet	Upward	1093	11720
	Downward	**1977**	**17557**

ENERGY PROVIDED FOR EACH SERVICE



- The energy and calls considered are distributed across all vehicles: individual vehicles only participate in a minimal fraction of the calls.
- In fact, the station accommodates 10 to 15 cars per week.

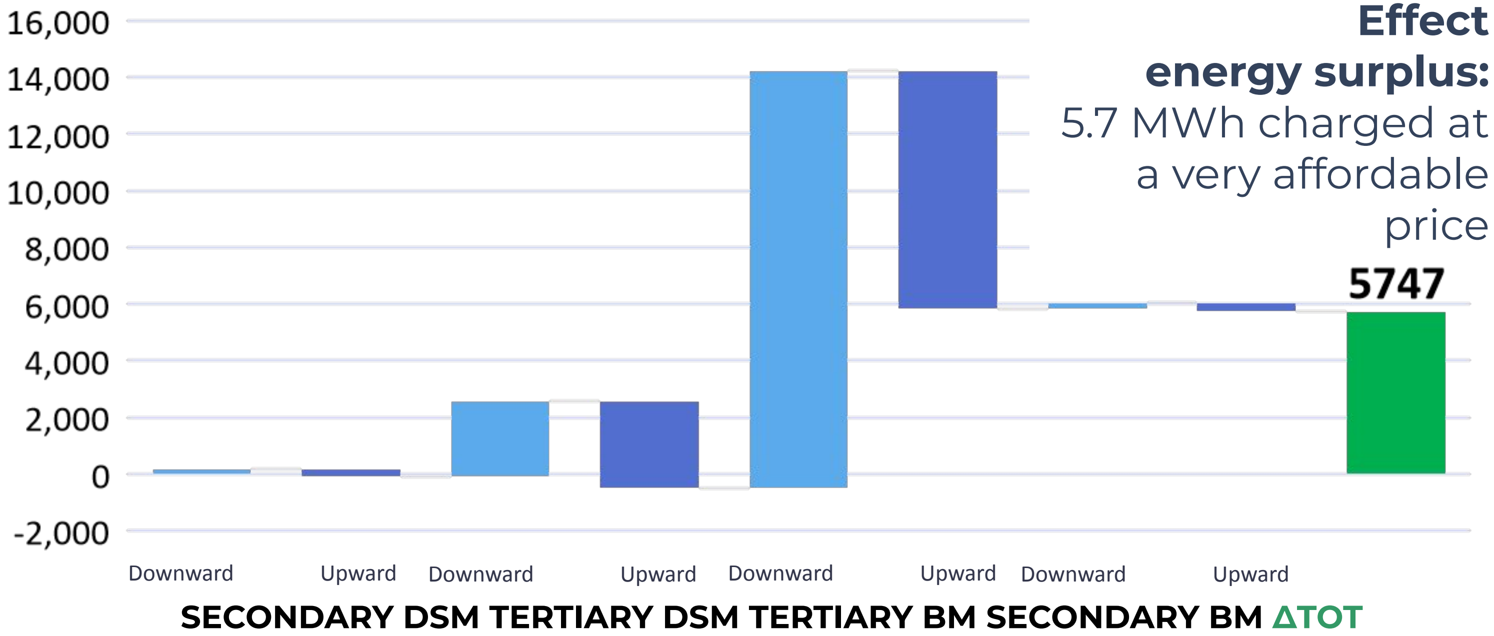
CASE STUDY – ECONOMIC BENEFITS FOR THE BSP

Revenues originate both from dispatching services and from a cheaper charging cost guaranteed by the downward service

Daytime charging modes **mainly provide downward service**: valley-filling exploits generation from renewable sources.

We can identify two revenue streams: **direct revenues from dispatching** related to the difference between offered upward and downward prices + the costs avoided due **to the provision of affordable recharging via downward regulation**.

UPWARD AND DOWNWARD ENERGY SUPPLIED (kWh)



Effect energy surplus: 5.7 MWh charged at a very affordable price

PRICING ASSUMPTIONS [€/MWh]

Upward pricing	115
Downward pricing	55 **<< 300**
Billed kWh cost	300

REVENUE [€/year]

Net dispatching revenue	339
Energy surplus effect	1724

Total annual revenue of €2063

=

€94 margin per charging station

CASE STUDY – ECONOMIC BENEFITS FOR THE BSP

The economic outlook indicates a nine-year return-on-investment period

- The economic simulation was constructed considering **costs and revenues per charging station.**
- Revenues are derived from simulations conducted on real data.
- On the cost side, we conducted a detailed assessment by interviewing sector insiders.
- Additional costs (Δ cost) are those that impact smart stations compared to non-enabled stations.
- The envisaged costs are for the establishment and management of the **Charging Infrastructure Controller (CIC)** as prescribed by CEI 0-21.
- Discount rate: 5%

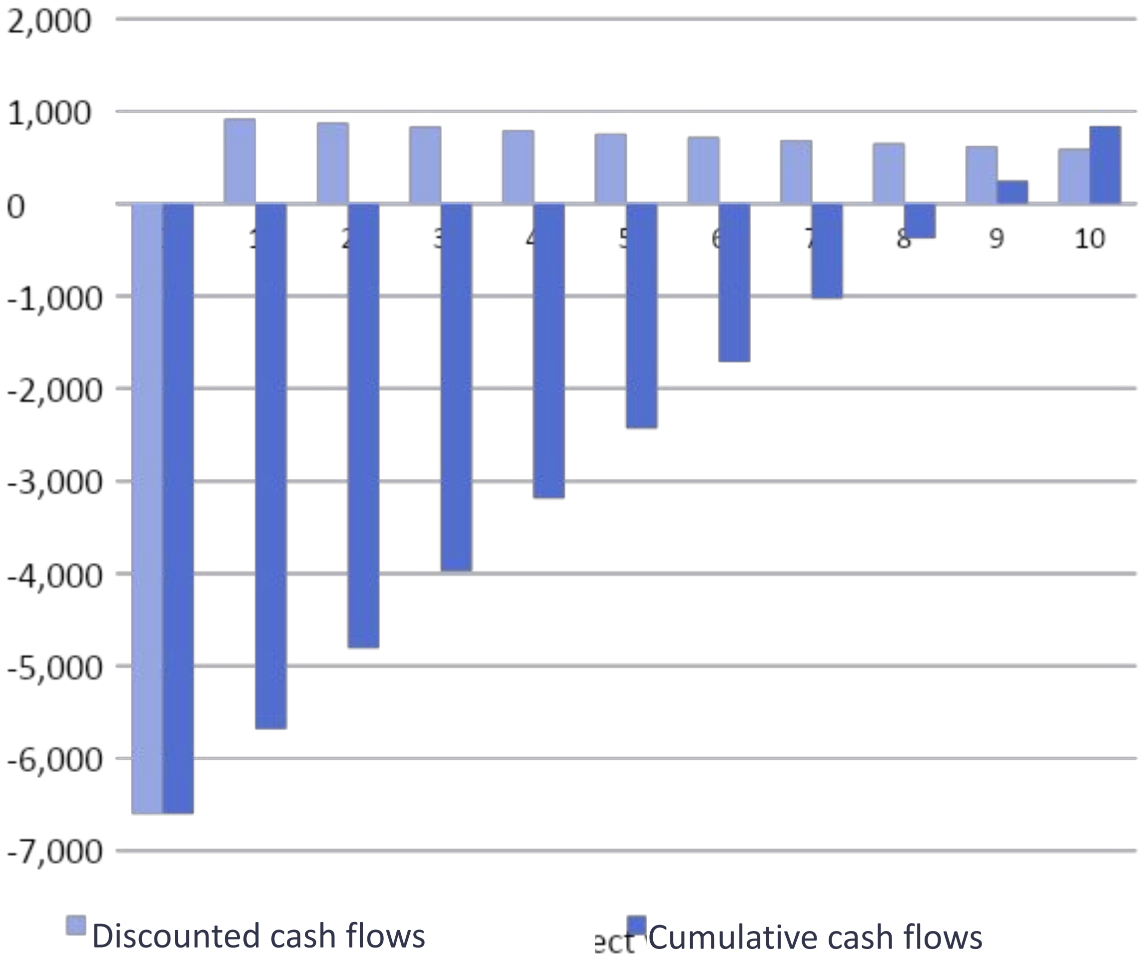
COSTS INCURRED PER CHARGING STATION

CAPEX	€300
OPEX	€50/year

MARGIN PER CHARGING STATION

€94/year

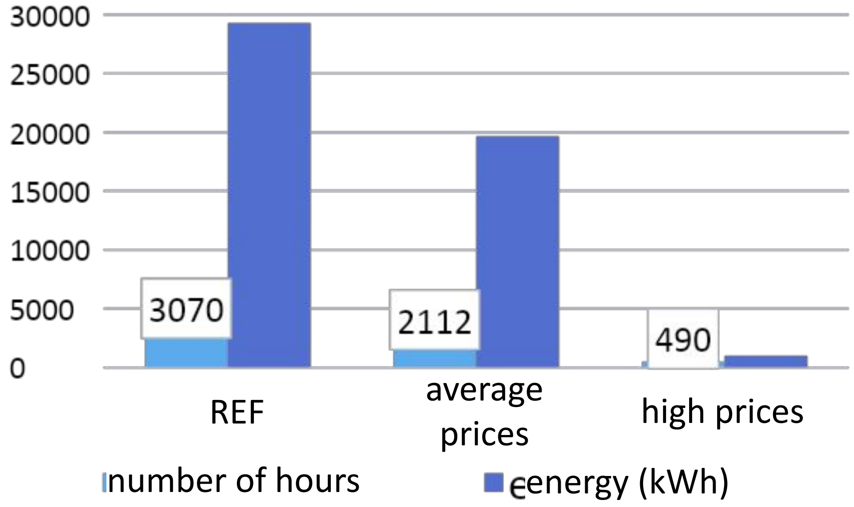
CASH FLOWS (€)



CASE STUDY – SENSITIVITY TO OFFER PRICING

By offering prices closer to the market average, aggregate provisioning is less flexibile but generates greater revenues

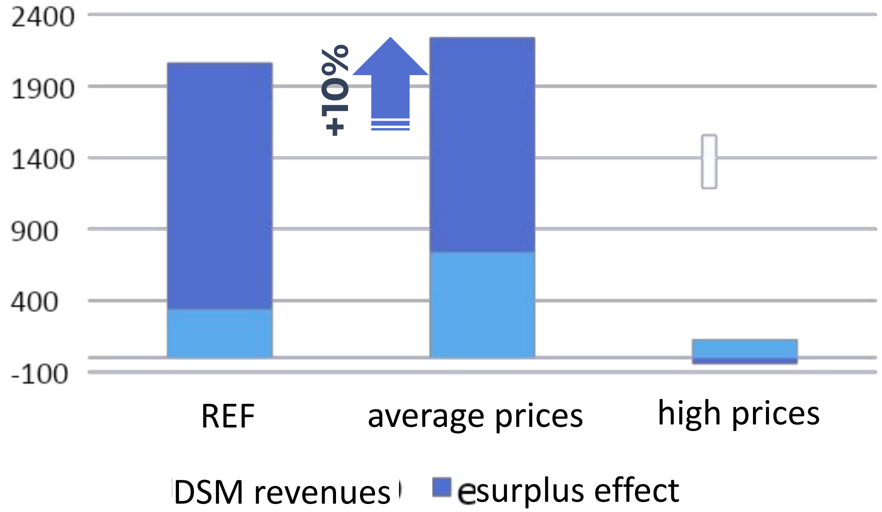
ANNUAL GRID OPERATIONS



The Day-ahead Market operates on a pay-as-bid basis, hence offering higher prices increases the revenue derived from each grid operation. The three strategies are compared based on the prices shown here:

Offered prices €/MWh	Upward	Downward
REF	115	55
Average prices	155	30
High prices	270	15

ANNUAL ECONOMIC MARGINS (€)



POSSIBLE OPERATOR STRATEGIC ACTIONS

Offering at **higher prices** (see *average price* scenario compared to *REF*) has a dual advantage:

- **higher revenues** for the charging operator,
- **fewer grid operations** required,

with less **flexibility provided to the system**.

PROPOSED SOLUTION

Introduction of **capacity remuneration** to:

- ensure **flexibility at low prices** (e.g., by introducing an energy strike price)
- **ensure stable remuneration** for the operator, ☐ achieve €100/CP/year

CASE STUDY – BEHIND-THE-METER SERVICES

Behind-the-meter flexibility: costs are controlled by modulating charging power, thus adjusting the tariff power component

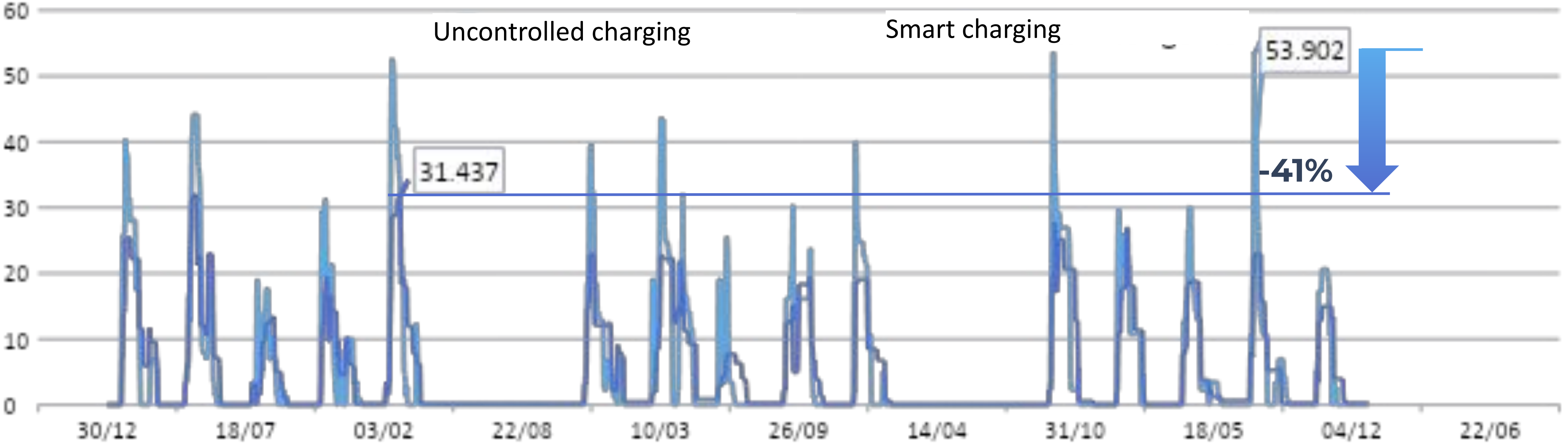
- As already shown, charging cycles can be modulated in charging modes with long dwell times (smart charging)
- Charging on a constant power basis for the duration of **the stopover significantly reduces consumption peaks**
- An app is required to signal the estimated charging end time

Power component – BTA6 tariff (2022): €57.5/kW/year
Peak consumption reduction: approx. 20 kW

Potential annual savings = 57.5 x 20 = €1150*

** This rationale is partially alternative to participation in the DSM.*

HOURLY CONSUMPTION [kW]



CASE STUDY – FINAL CONSIDERATIONS

The case study confirmed the potential of VGI, revealing an adequate reliability of the service provided by EVs

ELECTRICITY SYSTEM

- Availability of significant flexibility, exceeding 1000 kWh per kW of contract power per year
- Different types of service are provided depending also on seasonal factors (overgeneration reduction, reserve)
- In the winter period, slowing of the morning ramp-up and reduced peak consumption
- In the summer period, increased daytime load due to the provision of downward regulation
- Strong contribution to limiting overgeneration from non-programmable RES

MARKET OPERATOR

- No negative impact on charging activity, also due to the manner in which available flexibility is calculated
- Costs related to the CIC and possible user interaction software solutions
- Better financial result obtained at average prices
- To benefit from greater flexibility at reliably competitive prices, a dedicated auction procedure with capacity-based payment can be implemented
- Significant benefit is also obtained from demand-side management practices (power modulation driven by implicit price signals)

TOPICS EXAMINED

The system context and charging scenarios by 2030

The impact of charging on the electrical system

Estimation of potential benefits derived from VGI solutions

VGI-driven business opportunities

Main findings of the study and policy proposals:

- **main findings**
- policy proposals

KEY FINDINGS – IMPACT OF CHARGING

Low-voltage sections suffer from short but intense overloads, while rural networks show problems with voltage profiles

MV/LV GRID DEVELOPMENT

LV sections suffer from charge clustering phenomena (spatial and temporal), with brief but high-intensity violations

MV sections exhibit less intense but longer violations, caused by the overlapping of charging with evening time "base" demand

Urban grids suffer from line overload problems, while rural grids have problematic voltage profiles due to poor synchronisation between PV generation and charging activity

DSM COSTS

The spread of electric vehicles, while not increasing dispatching costs in its own right, does lead to an increased electricity demand (+4%) and greater uncertainty related to the expected load profile impacting the electricity system.

KEY FINDINGS – BENEFITS OF VGI FOR THE DEVELOPMENT OF MV/LV GRIDS

Smart charging practices, use of storage and synchronisation between consumption and production can halve MV/LV violations

MV/LV GRID DEVELOPMENT

Intelligent charging modes, which implement implicit *demand response* solutions guided by appropriate price signals, reduce the impact on load factors on urban and rural LV grid sections by 13%.

13% fewer load factors

The use of storage systems coupled with *quick* or *fast* charging infrastructure significantly reduces the number of violating elements (-30%) and the corresponding volumes of overload energy.

30% fewer violations

The possibility of synchronising charging energy demand with photovoltaic generation has a dual benefit in relation to overloading of grid elements and voltage profiles, particularly on rural grids

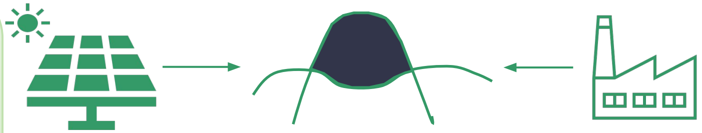
dual benefit

KEY FINDINGS – THE BENEFITS OF VGI FOR DISPATCHING COSTS

Reduction of overgeneration and availability of reserve capacity are the main factors benefiting electricity system dispatching

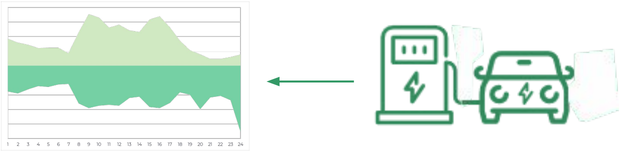
DISPATCHING COSTS

Utilising EV charging for dispatching purposes can approximately halve (-45%) PV overgeneration thanks to *ex-ante* DSM system planning.



45% less overgeneration

EVs play a central role in dispatching markets, providing significant reserve capacity (15%) and contributing to service provision (26%).



26% of services
15% of reserves

Long dwell times are particularly important, such as overnight parking (in private, shared or public facilities) and daytime stopovers (typical of workplaces and modal interchange points).

✓ **long dwell time**

KEY FINDINGS – THE BENEFITS OF VGI FOR DISPATCHING COSTS

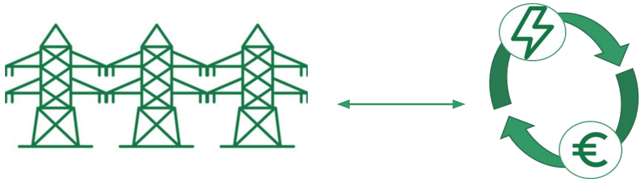
The participation of electric vehicles in the DSM offers significant economic and environmental benefits for the operation of the electricity system

DISPATCHING COSTS

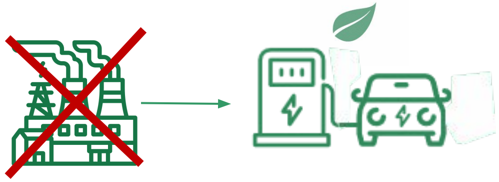
The economic benefits of VGI on dispatching amount to 800 million per year, reducing DSM costs by 40%, thanks to a charging profile which is inherently compatible with the reserve pool

Greater dispatching cost-effectiveness coincides with reduced environmental impact since resources displaced by DSM are mainly thermoelectric (-1.5 TWh/year)

Charging profiles are inherently compatible with reserve pools without needing significant *ex-ante* grid operations. The sensitivity analysis on offered prices reveals opportunities for fair revenues for electric vehicles while ensuring benefits to the system.



40% lower DSM costs



a 1.5 TWh reduction in thermoelectric generation

✔ **costs-benefits**

TOPICS EXAMINED

The system context and charging scenarios by 2030

The impact of charging on the electrical system

Estimation of potential benefits derived from VGI solutions

VGI-driven business opportunities

Main findings of the study and policy proposals:

- main findings
- **policy proposals**

POLICY PROPOSALS

Three main intervention areas can be identified

FIELDS OF APPLICATION

SMART CHARGING

Promoting smart charging practices through the use of appropriate price signals (implicit *demand response*) entails substantial benefits on both MV/LV development and dispatching costs.

RES-CHARGING SYNCHRONISATION

Encouraging optimal synchronisation between energy demand for electric charging and production from distributed RES reduces the uncertainty associated with charging and increases grid *hosting capacity*.

ENABLING FOR DSM

The enabling of all charging modes to dispatching should be encouraged, allowing operators to select which services to provide, with resource portfolio management provided by an aggregator entity.

POLICY PROPOSALS – TECHNICAL, ECONOMIC AND REGULATORY LEVERAGE

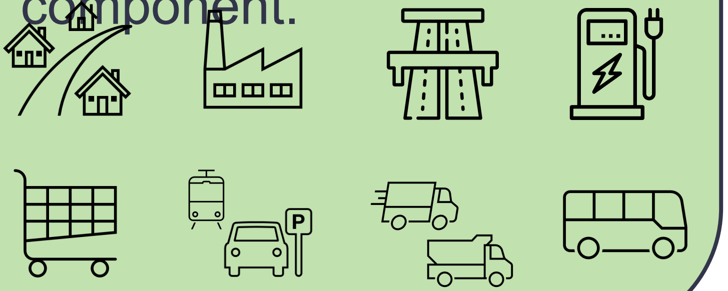
Proposal 1: application of *time-of-use* tariffs

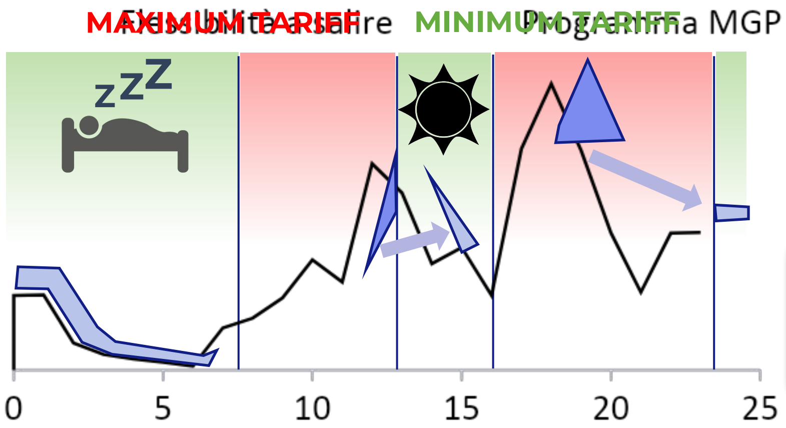
SMART CHARGING

1) At least the energy component of the electricity tariff (network costs) should be levied on a time-varying basis. During periods of strong sunshine, e.g. <u>from noon to 3 pm</u>, the <u>F3 band</u> <u>could be reduced by 30%</u>. This reduction could apply to all components, or only to certain ones, such as TRANS, DIS, and MIS. Although this approach could result in an estimated 7 to 13% reduction in EV charging revenue, the benefits to dispatching and grid development would outweigh the impact. Additionally, implementing a revenue-invariant policy would be possible by appropriately modulating the tariff without any overall impact.

USE CASES INVOLVED

All charging modes would benefit from implementation in proportion to the weight of the tariff energy component.





EXPECTED EFFECT OF TIME-OF-USE TARIFFS ON CHARGING PROFILES

BENEFITS FOR USERS

60 €/MWh □ 42 €/MWh

POLICY PROPOSALS – TECHNICAL, ECONOMIC AND REGULATORY LEVERAGE

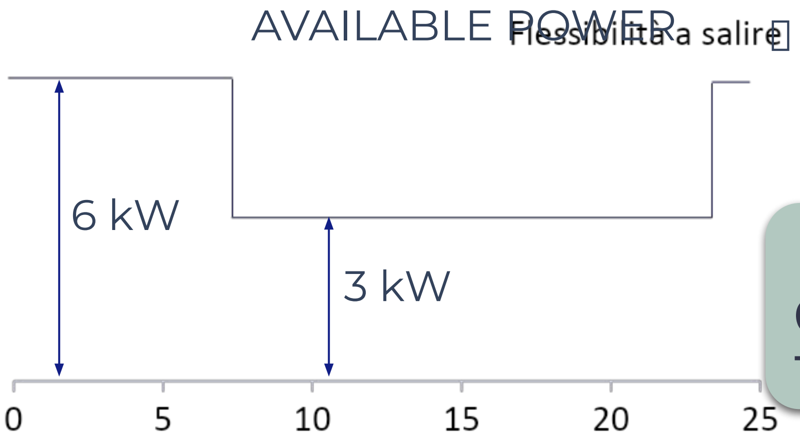
Proposal 2: Flexibility of available POD power

SMART CHARGING

2) Maximum available power at connection points should be rendered flexible, increasing it during low load periods without increasing the burden on the user. The proposal is that the period of <u>maximum technically withdrawable power</u> available at all PODs used for charging electric vehicles should coincide with the <u>F3 band</u>. Although this would entail a loss of revenue by exploiting periods when the grid is lightly loaded, it would not lead to higher system costs. Additionally, responsibility for incremental power management could be assigned to the DSO.

USE CASES INVOLVED

The charging modes that would benefit from implementation are those with low-power PODs, generally below 30 kW, and residential PODs in particular.



Extension of Resolution 541/2020 to higher power levels, also including three-phase supplies

BENEFITS FOR USERS

Connection costs: -€70/kW
Tariff costs: -€30/kW/year

POLICY PROPOSALS – TECHNICAL, ECONOMIC AND REGULATORY LEVERAGE

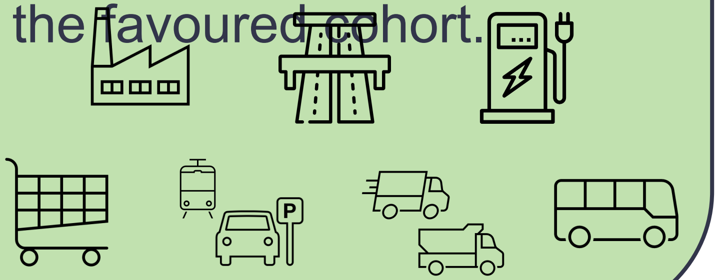
Proposal 3: The tariff power component should be time-varying

SMART CHARGING

3) <u>The tariff power component for PODs with a committed power greater than 30 kW should be levied on a time-varying basis</u>. Two or more time bands could be defined, each with corresponding tariffs and maximum available power. The final tariff could be calculated as the weighted average of the two separate tariffs applied to the two above-mentioned power levels; this tariff would then be applied in turn to the overall maximum power drawn in the month. The impact of such a scheme on the expected tariff revenue from charging is offset by a higher cost reflectivity than at present, although its application does introduce complexities.

USE CASES INVOLVED

Implementation would not be beneficial only for household PODs with limited charging power, although condominium PODs could be included in the favoured cohort.



BENEFITS FOR USERS

EXAMPLE: $\text{tariff}_1 = 0.5\ €/\text{kW};\ \text{tariff}_2 = 3\ €/\text{kW};\ P_{\max,1} = 100\ \text{kW};\ P_{\max,2} = 50\ \text{kW}$

<u>TODAY</u>: $\text{cost} = 2.5 \frac{€}{\text{kW}*\text{month}} * 100\ \text{kW} = 250 \frac{€}{\text{month}}$

<u>TOMORROW</u>: $\text{tariff} = \frac{0.5\frac{€}{\text{kW}}*100\ \text{kW}+3\frac{€}{\text{kW}}*50\ \text{kW}}{100\ \text{kW}+50\ \text{kW}} = 1.33 \frac{€}{\text{kW}*\text{month}}$

$\text{cost} = 1.3 \frac{€}{\text{kW}} * \text{MAX}(100\text{kW}; 50\text{kW}) = 130 \frac{€}{\text{month}}$

$t_1/t_2=1/6$

-50%

POLICY PROPOSALS – TECHNICAL, ECONOMIC AND REGULATORY LEVERAGE

Proposal 4: Reduce connection charges for smart installations

SMART CHARGING

4) Connection charges must be calculated to encourage the installation of smart EV charging infrastructure. For PODs exclusively dedicated to charging electric vehicles, one possible solution is to make connection charges regressive with respect to the number of charging points fed by the POD. This would then reward installations that, for the same connection power requirements, make more charging bays available and can therefore manage them according to system needs. The proposal is valid for both LV and MV connections.

USE CASES INVOLVED

Mostly PODs dedicated exclusively to high-power charging of electric vehicles would benefit from this implementation.

BENEFITS FOR USERS

EXAMPLE: proximity component = €200; power component = €75/kW; CP component = €250/CP
connected power = 100 kW; fed charging points =12 CPs

TODAY: $\text{cost} = €200 + 75\frac{€}{\text{kW}} * 100\text{ kW} = \boxed{€7700}$

-40%

TOMORROW: $\text{cost} = €200 + 75\frac{€}{\text{kW}} * 100\text{ kW} - 250\frac{€}{\text{CP}} * 12\text{ CP} = \boxed{€4700}$

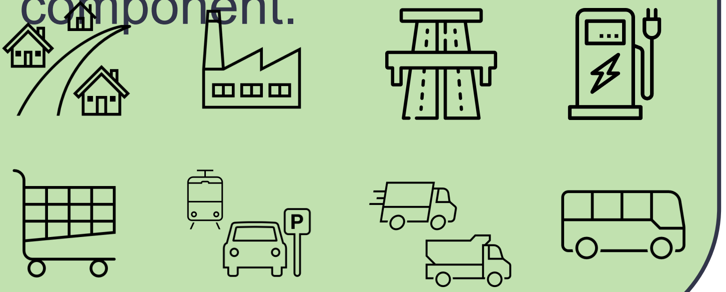
POLICY PROPOSALS – TECHNICAL, ECONOMIC AND REGULATORY LEVERAGE

Proposals 5 and 6: Encouraging smart installations

SMART CHARGING

USE CASES INVOLVED

All charging modes would benefit from implementation in proportion to the weight of the tariff energy component.



5) DSOs should define guidance criteria for the identification of areas in which charging points can be installed. This can be done on an annual basis by defining "less suitable" areas for the connection of new CPs or by publishing actual maps with areas classified according to the level of complexity of new connections ("traffic light" system). This action could also include access to non-firm connections, i.e. flexible connections, with a view to facilitating infrastructure deployment in areas that are already in readiness (procedural speed and cost-effectiveness). Non-firm connections could be regulated by constraints already included in the connection contract, i.e. by automated network management (ANM) solutions, with powers in certain periods exceeding 100 kW also in LV grids.

6) Economic incentives should encourage the simultaneous installation (fed by the same POD) of electric vehicle charging points, electricity storage systems and photovoltaic systems. A (transferable) tax credit could be granted subject to certification of the installation and use of an intelligent management system for energy flows to and from the public grid, possibly subject to DSM qualification.

POLICY PROPOSALS – TECHNICAL, ECONOMIC AND REGULATORY LEVERAGE

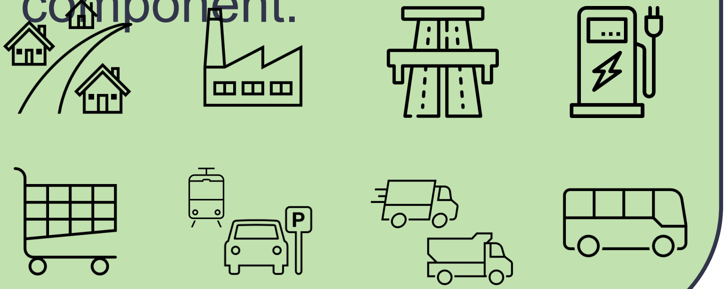
Proposal 7: Reduce connection charges for smart installations

RES-CHARGING SYNCHRONISATION

7) A specific form of incentive is needed to encourage EV charging from locally produced renewable energy sources. An over-incentive could be defined to build on that already envisaged for shared energy within Renewable Energy Communities (RECs). The over-incentive would be in line with the European Commission's *energy efficiency first principle*, favouring the efficient use of energy, as already occurs, for example, with the Energy Efficiency Certificates (EECs or white certificates). The over-incentive could be precisely adjusted to the energy efficiency that induces the use of renewable electricity for transport as opposed to fossil fuels.

USE CASES INVOLVED

All charging modes would benefit from implementation in proportion to the weight of the tariff energy component.



ESTIMATE OF REQUIRED OUTLAY

Assuming an extra-incentive of €20/MWh for local self-consumption of renewable energy to charge an electric vehicle, considering an incidence of EV charging of 10% of the total shared energy, the cost of this incentive would amount to between €4 and €8 million/year, or about 1.5% of the total presumed cost of RES incentives by 2030.

POLICY PROPOSALS – TECHNICAL, ECONOMIC AND REGULATORY LEVERAGE

Proposal 8: Short-term capacity-based auctions for DSM services

ENABLING FOR DSM

USE CASES INVOLVED

The measure would impact all charging modes and is of particular interest for heterogeneous portfolios of enabled resources.

8) The system operator (Terna) should procure the reserves needed to operate the electricity system through short-term capacity auctions (daily, weekly, or monthly). Adopting long-term remuneration models, as envisaged, for example, in the ARERA 393/2022 Consultation Document, could lead to technological lock-in, tying system operations to assets that are already remunerated (with long-term contracts), but are more costly than other system resources. This aspect is particularly relevant when considering electric vehicles, which are a resource that is expected to become increasingly widespread in the near future and which could, therefore, only be fully exploited if the resources on which Terna allocates the reserve were periodically updated.

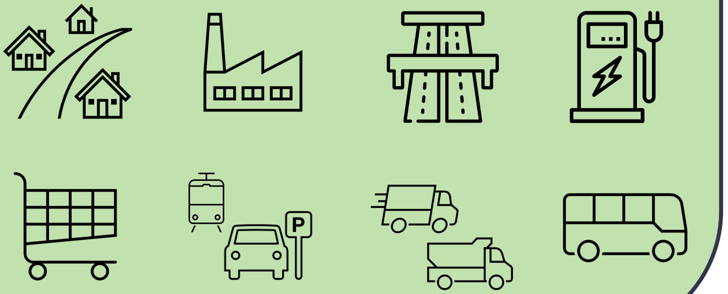
POLICY PROPOSALS – TECHNICAL, ECONOMIC AND REGULATORY LEVERAGE

Proposal 9: Clear, simple and transparent DSM participation

ENABLING FOR DSM

USE CASES INVOLVED

The measure would impact all charging modes and is of particular interest for heterogeneous portfolios of enabled resources.



9) The participation of distributed resources in the balancing of the electricity system must be promoted. In this respect, particular attention should be paid to:

9.1: clearly allocating different ancillary services to different market products, procuring them through competitive procedures;

9.2: avoiding applying technical charges or participation obligations to resources, leaving it to operators to optimise the portfolio to be made available for each service;

9.3: allowing portfolio management of resources, avoiding excessive technical requirements for the qualification and observability of resources, leaving it up to the aggregator to respect the technical constraints of the service provided;

9.4: removing the unjustified technical constraints currently envisaged for the provision of some services, such as the minimum duration of supply, the symmetry of reserve bands and the minimum power threshold that can be qualified in the market.

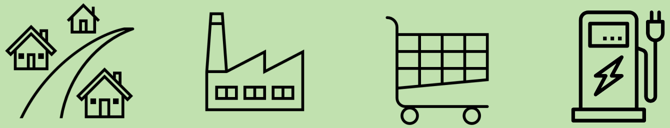
POLICY PROPOSALS – TECHNICAL, ECONOMIC AND REGULATORY LEVERAGE

Proposal 10: Finance the installation of CICs

ENABLING FOR DSM

USE CASES INVOLVED

Lower power charging modes would facilitate the transition to smart charging.



10) <u>Non-repayable financing must be provided for the installation of Charging Infrastructure Controllers (CICs)</u> for electric vehicles, as already envisaged by the Ministerial Decree of 30/01/2020. This contribution should be determined by ARERA, possibly with the help of other entities, as was already the case for the Central Plant Controller (CPC). The CIC would be useful both for observability and for the participation of the relevant charging points in the DSM.

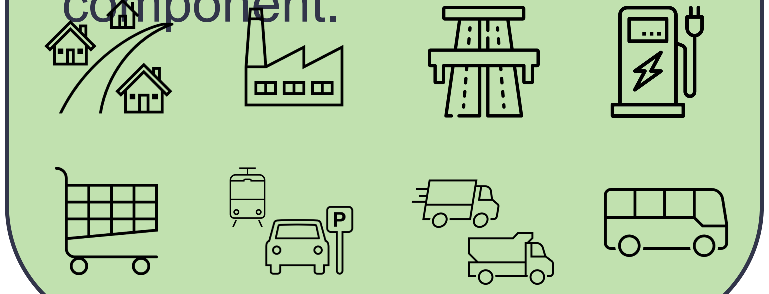
POLICY PROPOSALS – TECHNICAL, ECONOMIC AND REGULATORY LEVERAGE

Proposal 11: Reform the coverage of dispatching costs

ENABLING FOR DSM

USE CASES INVOLVED

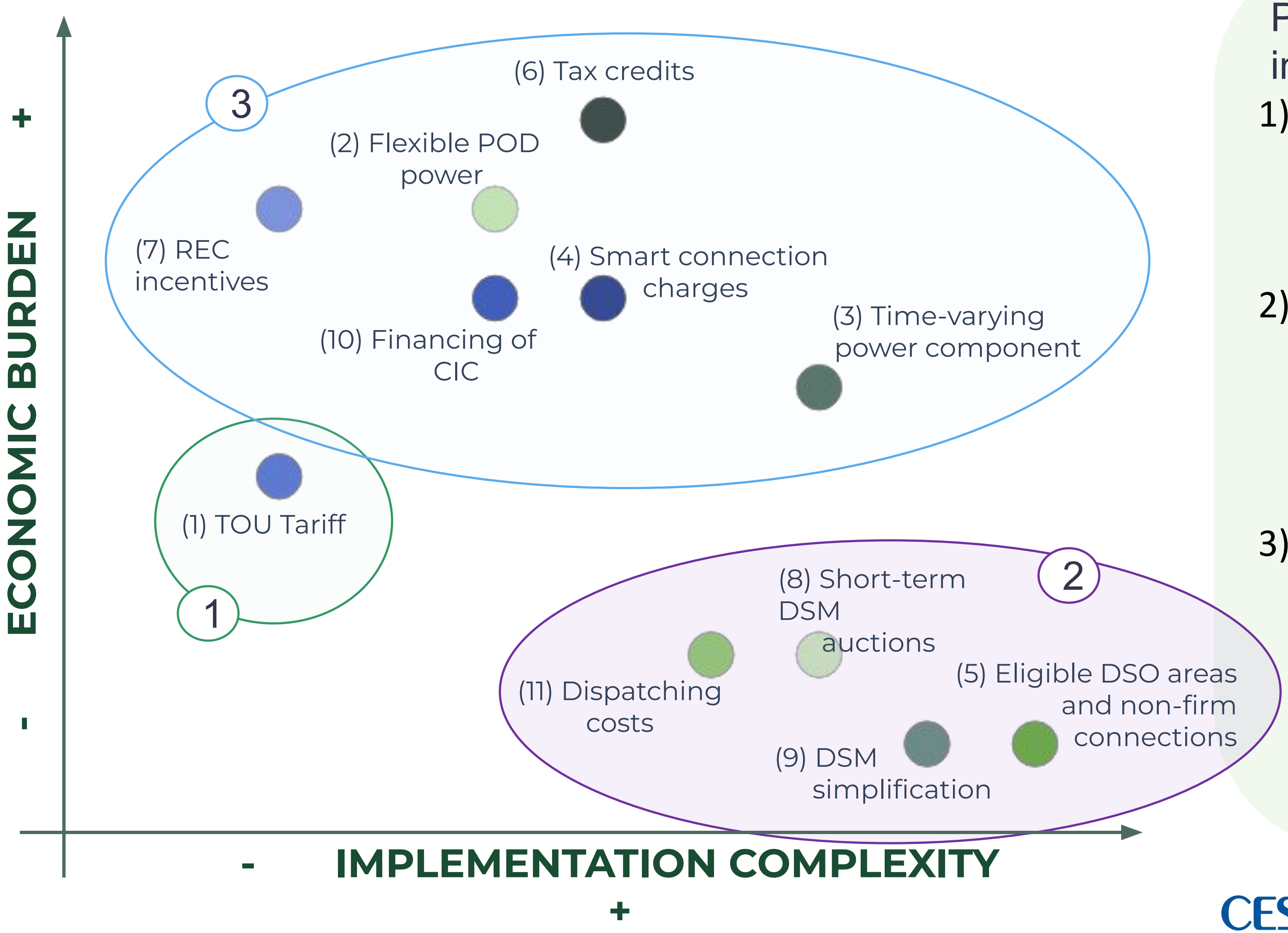
All charging modes would benefit from implementation in proportion to the weight of the tariff energy component.



11) A reform of the mechanism for applying dispatching charges is warranted. It should distinguish between DSM-enabled operators and others, as well as between energy producers and consumers, considering that the latter distinction is increasingly losing its meaning with respect to the real contribution to dispatching costs made by system-connected resources.

POLICY PROPOSALS – TECHNICAL, ECONOMIC AND REGULATORY LEVERAGE

Summary of presented proposals



Presented proposals can be classified into three intervention categories:

1) reforming the tariff energy component for network services is simple and straightforward to implement and has little impact on expected revenues;
2) a certain intervention class concerns regulatory aspects that have no impact on revenue, but are more complex to implement and therefore require technical time for reform;
3) another group of interventions involves a greater economic burden, with varying degrees of application complexity: a clear implementation roadmap must be defined for these interventions.

Report published by Motus-E in **April 2023**

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Terms and Acronyms

Acronym	Definition
AC	**Alternating Current**
ANFIA	The Italian Automotive Industry Supply Chain Association
ANM	Advanced Network Management
ARERA	The Italian Regulatory Authority for Energy, Networks and the Environment
B2C	Business-to-Consumer
BESS	Battery Energy Storage System
BEVs	Battery Electric Vehicle
BM	Balancing Market
BSP	Balancing Service Provider
BTM	Behind-the-Meter
CAPEX	Capital Expenditure
CEI	Italian Electrotechnical Committee
CI	Charging Infrastructure
CIC	Charging Infrastructure Controller
CM	Capacity Market
CP	Charging point
CPC	Central Plant Controller
DAM	Day-ahead Market
DC	Direct Current
DCO	Documento per la Consultazione (Consultation Document)
DIS	Distribution Electricity Charge Component
DSM	Dispatching Service Market
DSO	Distribution System Operator
DW	Downward

Acronym	Definition
E/P	Energy-to-Power Ratio
EEC	Energy Efficiency Certificate
ETS	Emission Trading Scheme
EV	Electric Vehicle
EV	Electric Vehicle
FD	Flexible Demand
FF55	Fit for 55
Flex	Flexibility
GHG	Greenhouse gas
HCV	Heavy Commercial Vehicle
HS	High-speed
HV	High Voltage
Inter.	Interchange
Large-Scale Retail	Large-Scale Retail
LCVs	Light Commercial Vehicle
LPT	Local Public Transport
LV	Low Voltage
MD	**Italian Ministerial Decree**
MET	Metered Electricity Charge Component
MV	Medium Voltage
MVA	Megavolt-ampere
NPRES	Non-programmable Renewable Energy Sources
OPEX	**Operation expenditure**
p.u.	per unit

Acronym	Definition
PHEVs	Plugin Hybrid Electric Vehicle
PNIEC	National Integrated Energy and Climate Plan
POD	Point of Delivery
PS	Primary Substation
PT	Power Transformer
PV	Photovoltaic
REC	Renewable Energy Community
REF	Reference
RES	Renewable Energy Sources
SOC	State of Charge
SS	Secondary Substation
Storage systems	Storage systems
TOU	Time of Use
TRAS	Transmission Electricity Charge Component
TSO	Transmission System Operator
TWh	Terawatt-hour
Uncon.	Uncontrolled
UP	Upward
V1G	Unidirectional Smart Charging
V2G	Two-way Smart Charging (vehicle-to-grid)
VGI	Vehicle-Grid Integration
VRI	Full Grid Constraints
Δ	Delta