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## Flexibility of EV charging: Use-Cases, actors and technologies

Bruno Robisson

► **To cite this version:**

Bruno Robisson. Flexibility of EV charging: Use-Cases, actors and technologies. Nemo Training Session, MCAST, Feb 2021, Saint-Paul Lez Durance, France. cea-03210993

**HAL Id: cea-03210993**

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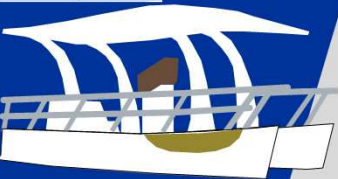
# TRAINING

## FLEXIBILITY OF EV CHARGING: USE-CASES, ACTORS AND TECHNOLOGIES



**Bruno Robisson, CEA Gadarrache**

Wednesday 3<sup>rd</sup> February 2021, 12:30-13:15 (UTC+1)



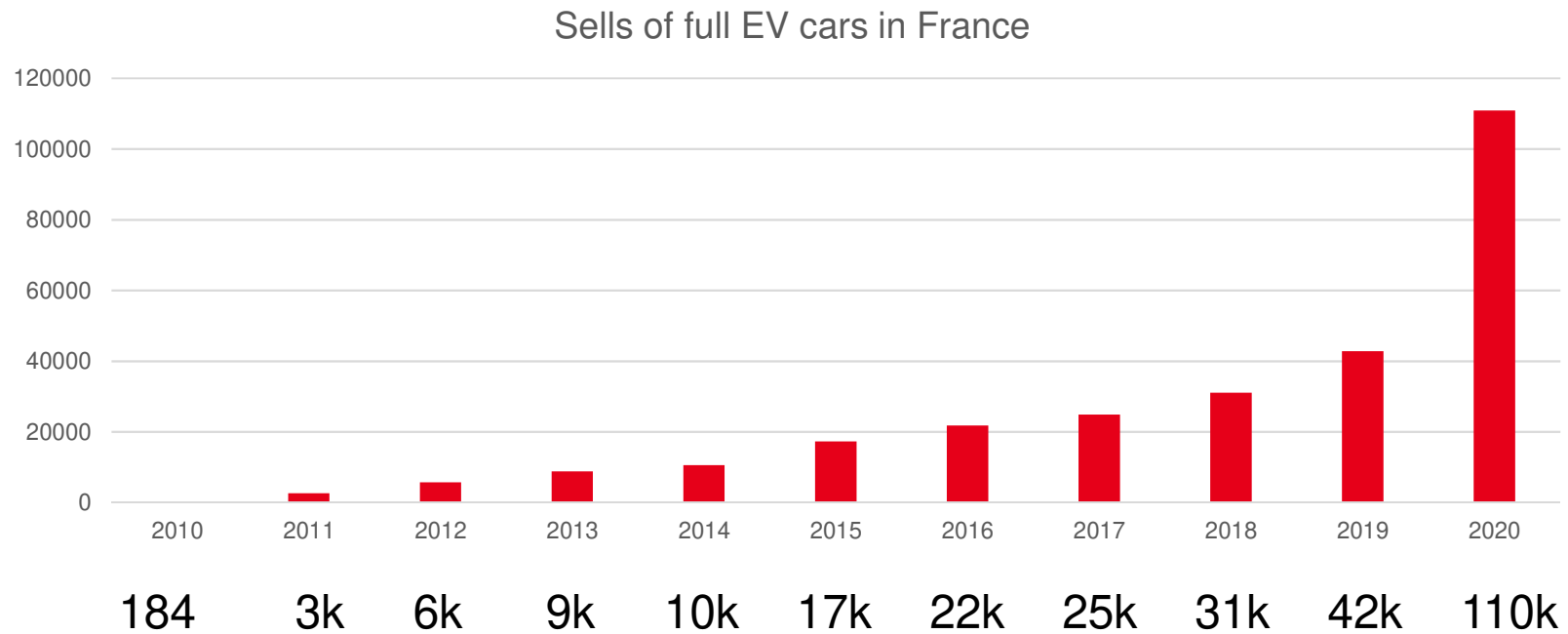
In collaboration with



The project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857484

- **Panorama of the french full electric vehicles (EV) market**
- **Charging an EV**
  - Modes
  - The plug and socket zoo
  - Wallbox and Charging stations
  - The french charging infrastructure
- **Smart charging an EV**
  - Use Case 1: Charging stations for employees within the company
    - Smart charging need: max power reduction
    - Principle and setup
  - Use Case 2: Charging commercial vehicles in depots
    - Smart charging need: energy cost reduction
    - Principle and setup
  - Use Case 3: Charging stations at home
    - Smart charging need: Autoconsumption increase
    - Principle and setup
  - Use Case 4: "Opportunist" charging stations

Sales of full Electric Vehicles (EV) in France [1]



Total: ~ 276485 EV from 2010

## TOP TEN SALES – FRANCE 2020

Manufacturer	Model	Capacity	Autonomy	Charging power		#units	price
		kWh	Km (WLTP)	AC (kW)	DC(kW)		€
Renault	Zoé	52	395	22	0-50	37409 (33.7%)	32-38k€
Peugeot	E-208	46	340	7-11	100	16557 (14,9%)	32-34k€
Tesla	Model-3	50-75	448-580	11	250	6477 (5,8%)	44-60k€
Hyundai	Kona	40-64	289-482	7	77	5156 (4,7%)	34-46k€
Kia	E-Niro	40-64	289-455	7	77	5089 (4,6%)	38-46€
Volkswagen	Id3	45	350	11	50	4187 (3,8%)	34k€
		58-77	424-549	11	100-125		38-49k€
Nissan	Leaf	40-62	273-385	6	50-100	3395 (3,1%)	35-45k€
Peugeot	E-2008	46	320	7-11	100	2933 (2,6%)	37-40k€
DS	DS3	50	320	7-11	100	2710 (2,4%)	39-46k€
Mini	Cooper	33	234	11	50	2481 (2,2%)	38-41k€

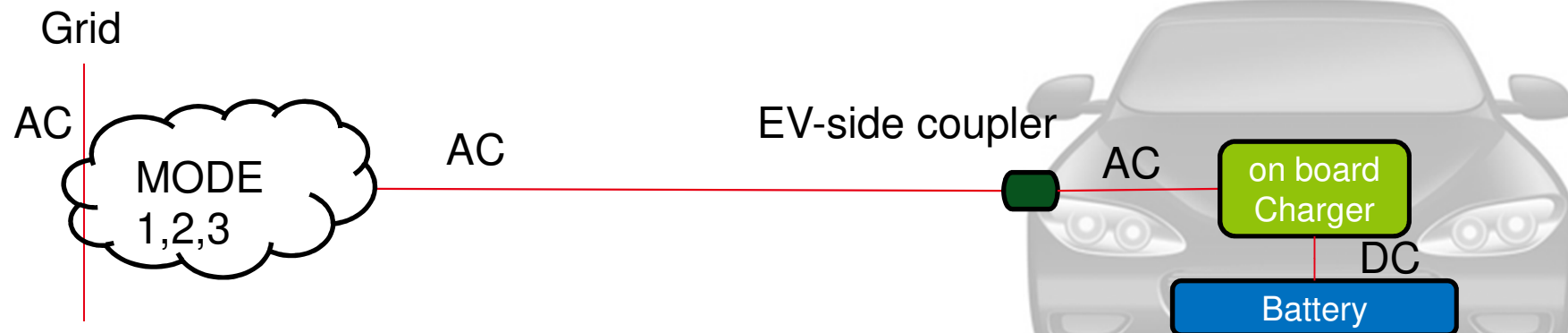
Total: 110900 EV (6.7%)

Source : [1]

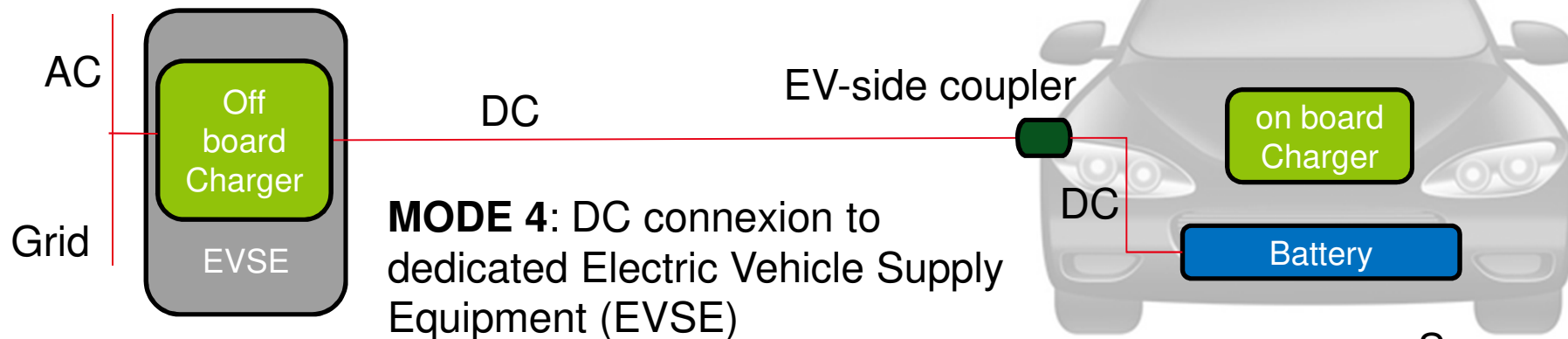
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## CHARGING MODE (IEC 61851 STANDARD)

On board charging, also called « **AC charging** »  
 From 3kW to 22kW (and even 43kW for Zoé first generation)



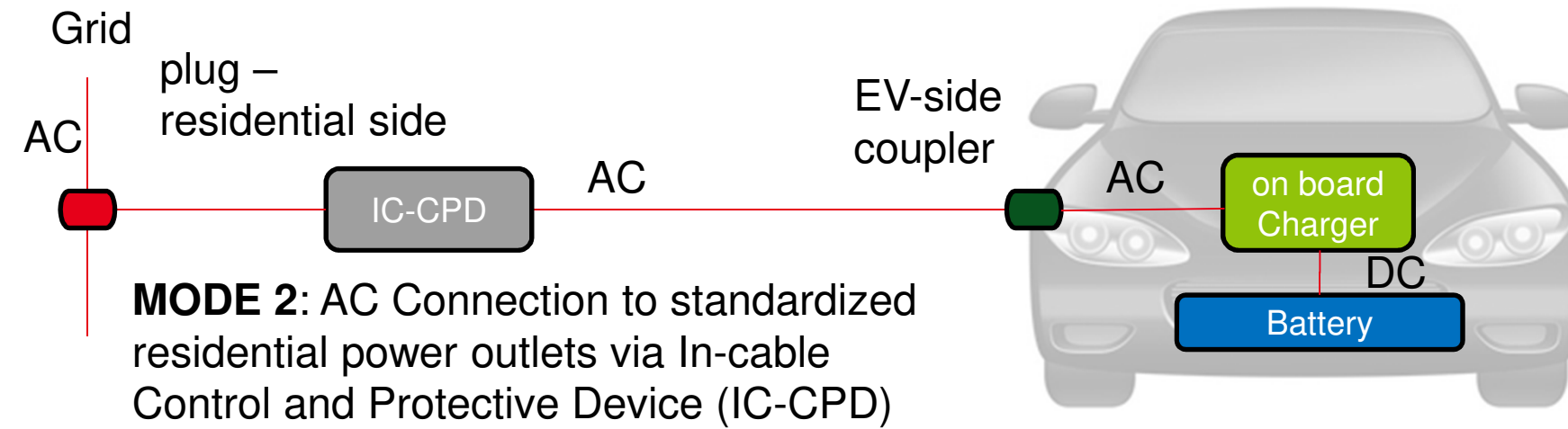
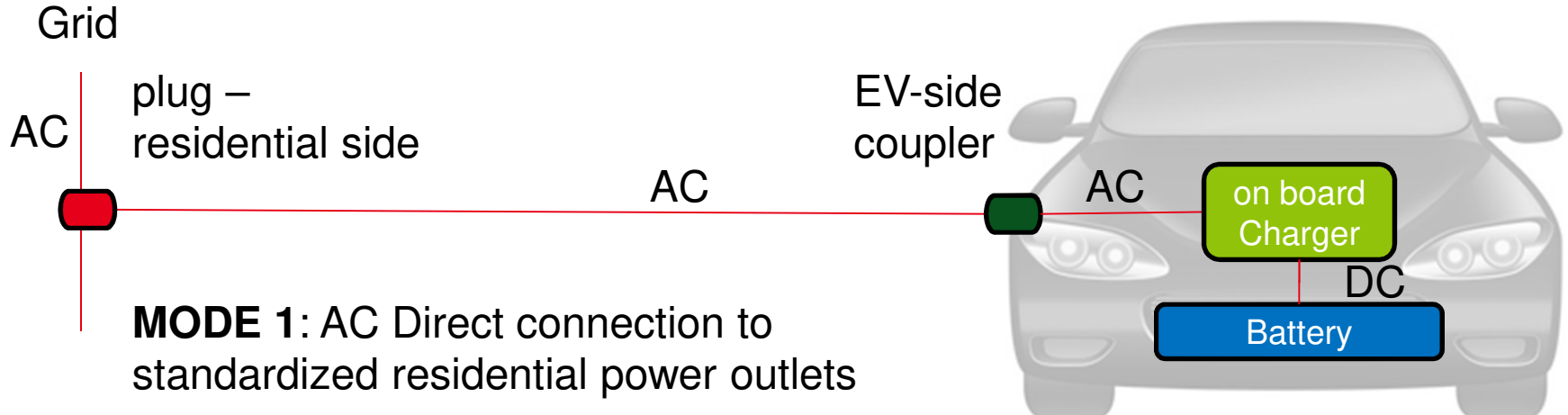
Off-board charging, also called « **DC charging** »  
 From 20kW to 150kW (and even 350kW)



Source : [2]



## AC CHARGING MODE: MODE 1, 2

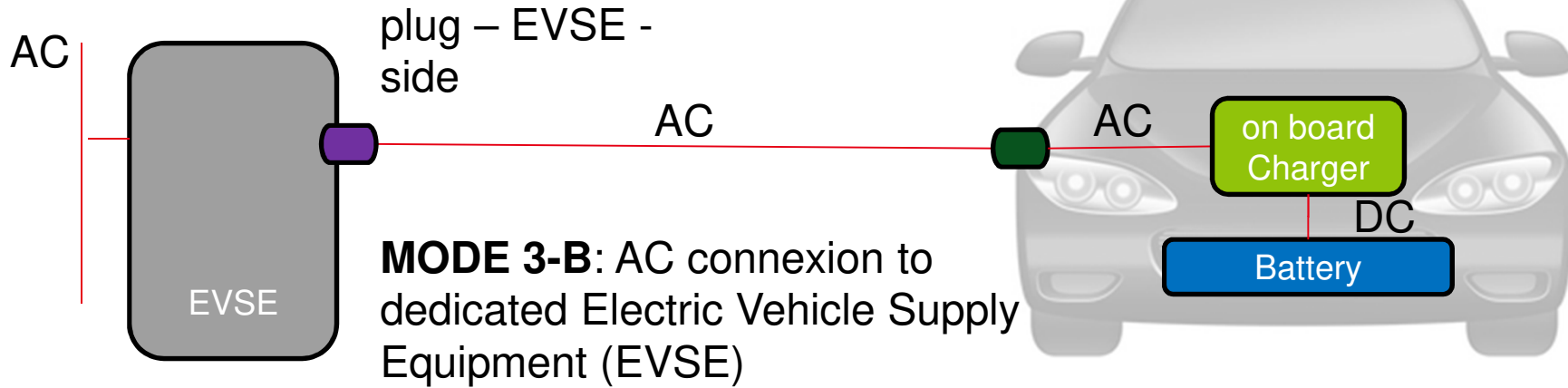


Source : [2]

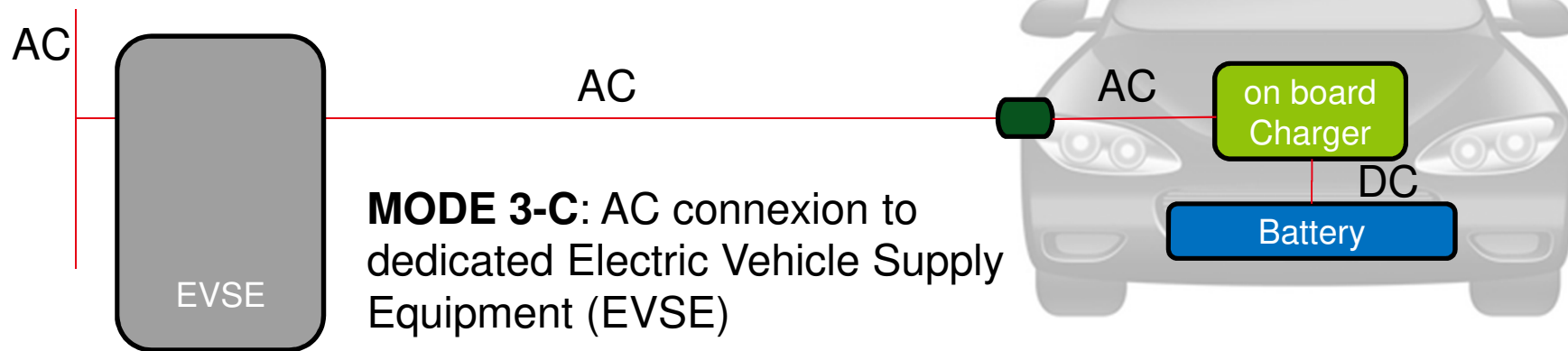


## AC CHARGING MODE: MODE 3

Grid



Grid



Source : [2]

## THE PLUG AND SOCKET ZOO – MODE 2



« Green-up » : type E  
 (CEE 7/17) Mono-p 230V



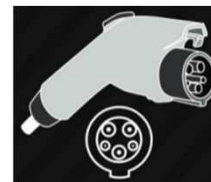
Blue: « camping »  
 socket Mono-p  
 230V



Red: Industrial socket  
 Tri-p 400V



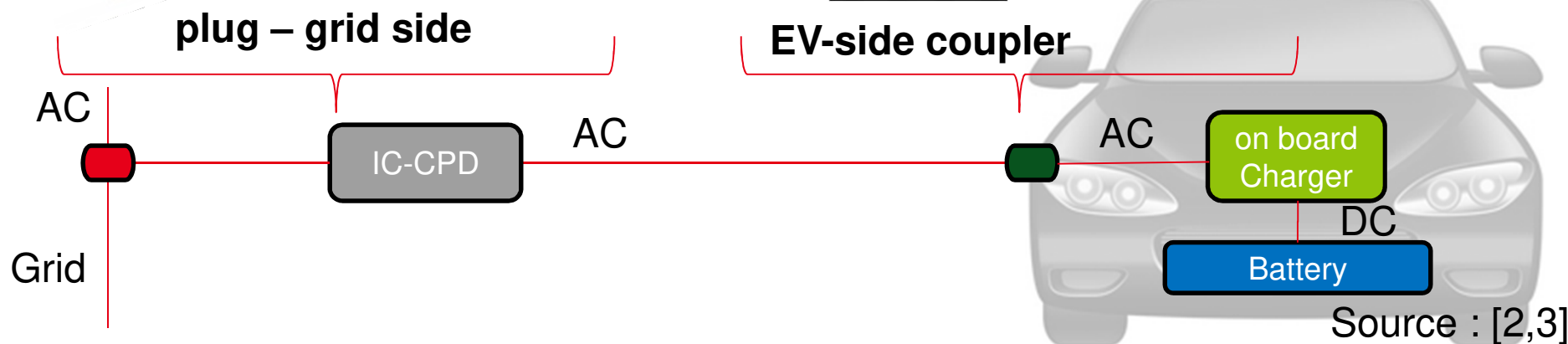
Tesla coupler



Type 1 coupler



Type 2 coupler



Source : [2,3]

# THE PLUG AND SOCKET ZOO – MODE 3



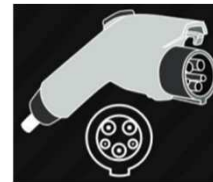
Type 2 outlet



Type 3 outlet (out of date)



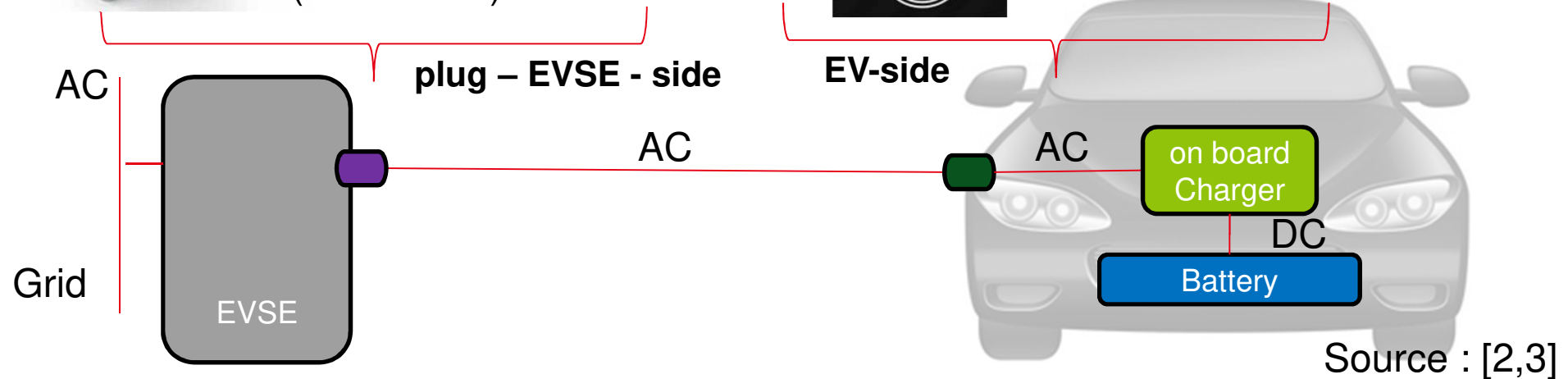
Tesla coupler



Type 1 coupler



Type 2 coupler



Source : [2,3]

# THE PLUG AND SOCKET ZOO – MODE 4



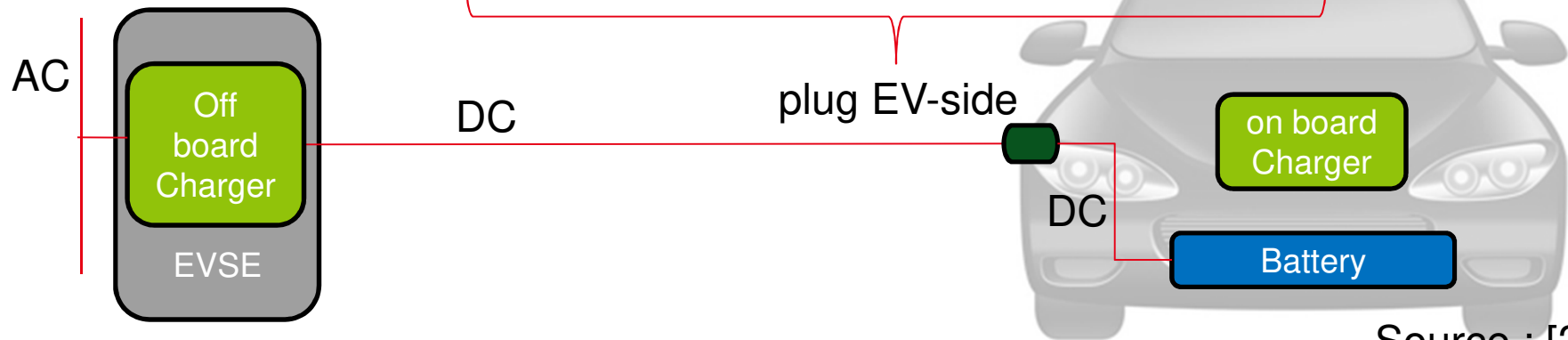
Tesla plug



CHAdeMO  
(DC only)



Combo 2 : Combined  
 Charge System CCS  
(DC+type 2)



Source : [2,3]

Cost (charging point only)

Private area

Public area

Mode 2 : < 22 kW

0.3-1.2k€



Mode 3: 7.4 kW AC (32A mono)  
 22kW AC (32A tri)  
 43kW AC (64A tri)

0.7-2k€



2-6k€



Mode 4: 22kW DC  
 150kW DC  
 350 kW DC

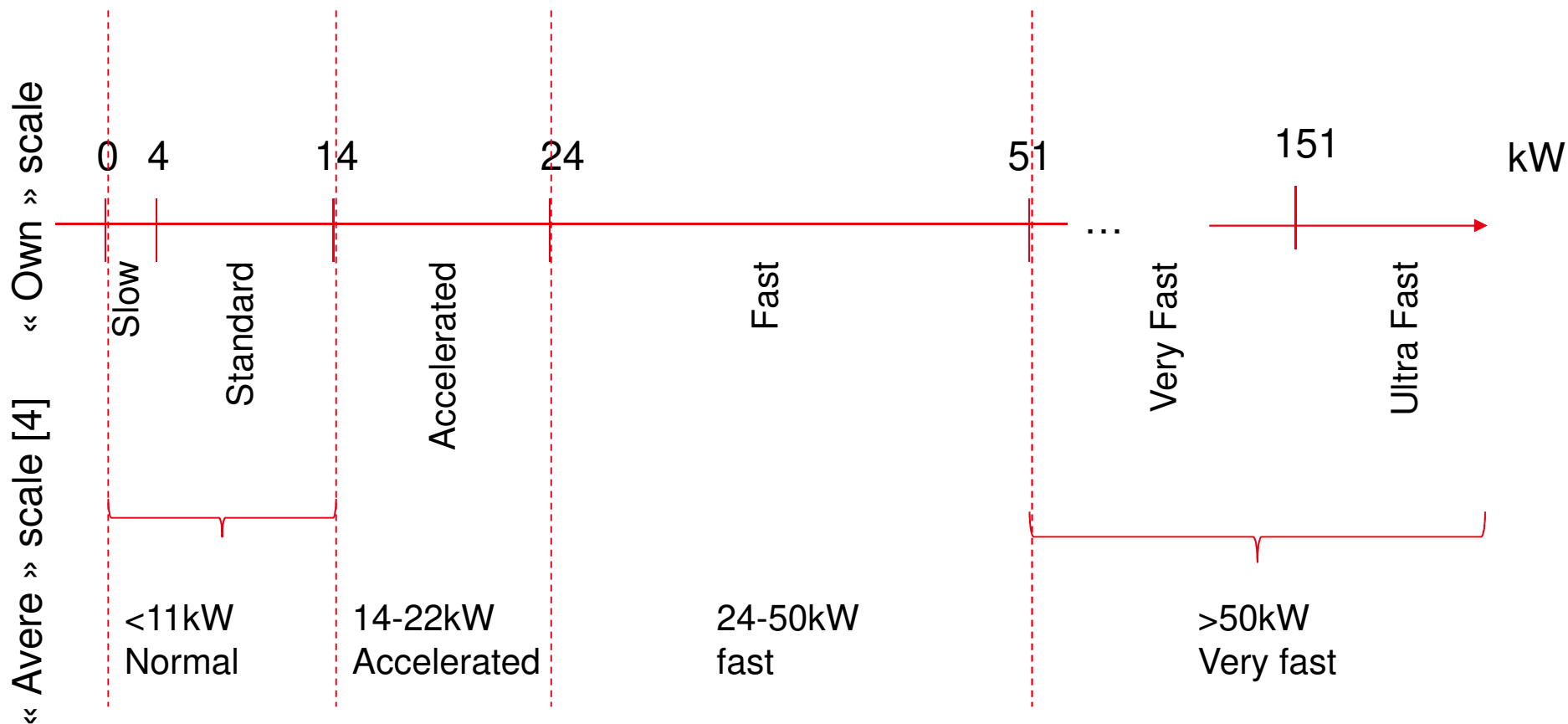
>10k€



~30k€



## Charging points speed range





# FRENCH VEHICLE CHARGING INFRASTRUCTURE DEFINITION



Number of station: 1  
 Number of Charging Points : 5  
 2\*22 kW AC Type 2  
 + 50 kW DC CHAdeMo  
 + 50 kW DC CCS2  
 + 43 kW AC Type2  
 Installed Power ( sum (on each  
 charging point) of the max power) :  
 187 kW



106 Avenue de Compiègne 02200 Soissons

## Borne #1

RECHARGE PAYANTE

Système d'identification

Badges d'accès requis

> Voir les badges compatibles

22 kW AC Type 2

**DOMESTIQUE UE**  
 Disponible  
 Standard / 3KW / Alternatif monophasé

TARIFS CHARGEMAP PASS ⓘ

Durée 0.040€ / min

**TYPE 2**  
 Disponible  
 Accélérée / 22KW / Alternatif triphasé

TARIFS CHARGEMAP PASS ⓘ

Durée 0.040€ / min

22 kW AC Type 2

**DOMESTIQUE UE**  
 Disponible  
 Standard / 3KW / Alternatif monophasé

TARIFS CHARGEMAP PASS ⓘ

Durée 0.040€ / min

**TYPE 2**  
 Disponible  
 Accélérée / 22KW / Alternatif triphasé

TARIFS CHARGEMAP PASS ⓘ

Durée 0.040€ / min

50 kW DC  
 CHAdeMo

## Borne #2

RECHARGE PAYANTE

Système d'identification

Badges d'accès requis

> Voir les badges compatibles

**CHADEMO**  
 Disponible  
 Rapide / 50KW / Courant continu

TARIFS CHARGEMAP PASS ⓘ

Durée 0.040€ / min

50 kW DC  
 CCS2

**COMBO CCS EU**  
 Disponible  
 Rapide / 50KW / Courant continu

TARIFS CHARGEMAP PASS ⓘ

Durée 0.040€ / min

43 kW AC  
 Type 2

**TYPE 2 (CÂBLE ATTACHÉ)**  
 Disponible  
 Rapide / 43KW / Alternatif triphasé

TARIFS CHARGEMAP PASS ⓘ

Durée 0.040€ / min

Source : [5]



## Public charging points

	InstalledPowerCPO MW	NumberOfStation Units	NumberOfCP Units
TOTAL	533.91	9260	20475

<https://www.data.gouv.fr/> [6]

Own classification	Slow	Standard	Accelerated	Fast	Veryfast	Ultrafast	TOTAL
	0-4	4-14	14-24	24-51	51-151	>151	
Units	1886	348	16431	1438	28	344	20475
%	9.21	1.70	80.25	7.02	0.14	1.68	
Avere classification	Normal	Accelerated	Fast	Very fast			
		0-14	14-24	24-51		>51	
Units		2234	16431	1438		372	
In pourcents		10.91	80.25	7.02		1.82	
Avere Data							
Units		7093	19959	1102		774	28928
%		24.52	69.00	3.81		2.68	

<https://www.data.gouv.fr/> \*

AVERE [4]

\*Without Tesla charging points  
 ~500 DC very fast chargers

- ➔ Predominance of “accelerated” charging points (i.e. 22kW AC)
- ➔ Few fast, very fast and ultra fast charging points

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  - Use Case 4: "Opportunist" charging stations

## USE - CASE 1 - CHARGING STATIONS FOR EMPLOYEES WITHIN THE COMPANY [7]



- The charging points are used, during the working hours, for the vehicles of employees which commutes.
- The charging points are generally "normal" or "accelerated" and located in the company parking lot.

Examples:

**SAP Labs** / Mougins Sophia-Antipolis + Caen + Paris

85 CP @ AC

2 CP @50 kW DC

1 CP @150 kW DC

~250 EV users [8]

**CEA** / Marcoule + Saclay + Cadarache

22 CP @ 3kW AC

40 CP @ 7kW AC

16 CP @ 11kW AC

80 CP @ 22kW AC

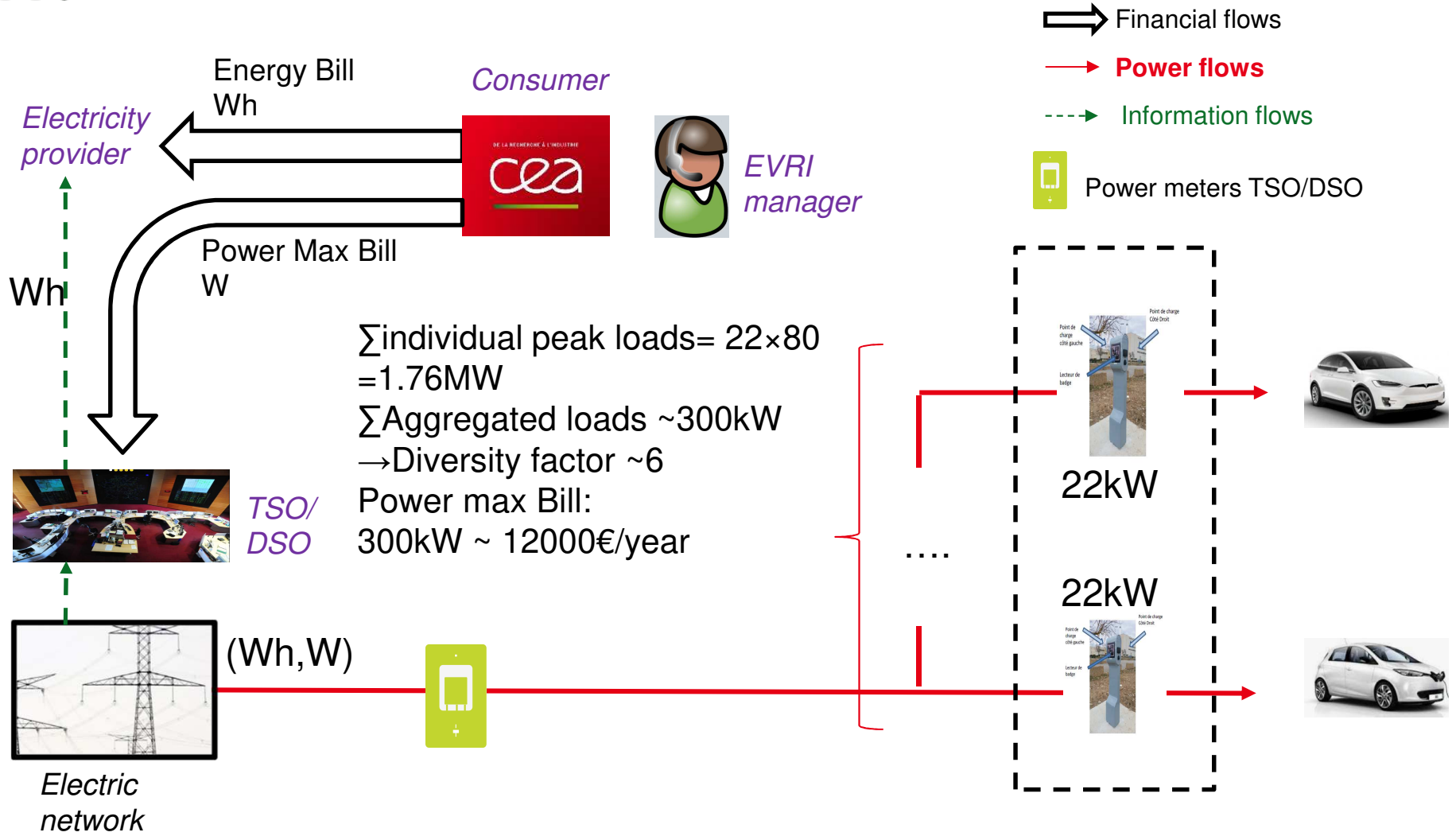
~400 EV users



source [8]



# USE - CASE 1 – SMART CHARGING 1 – MAX POWER REDUCTION

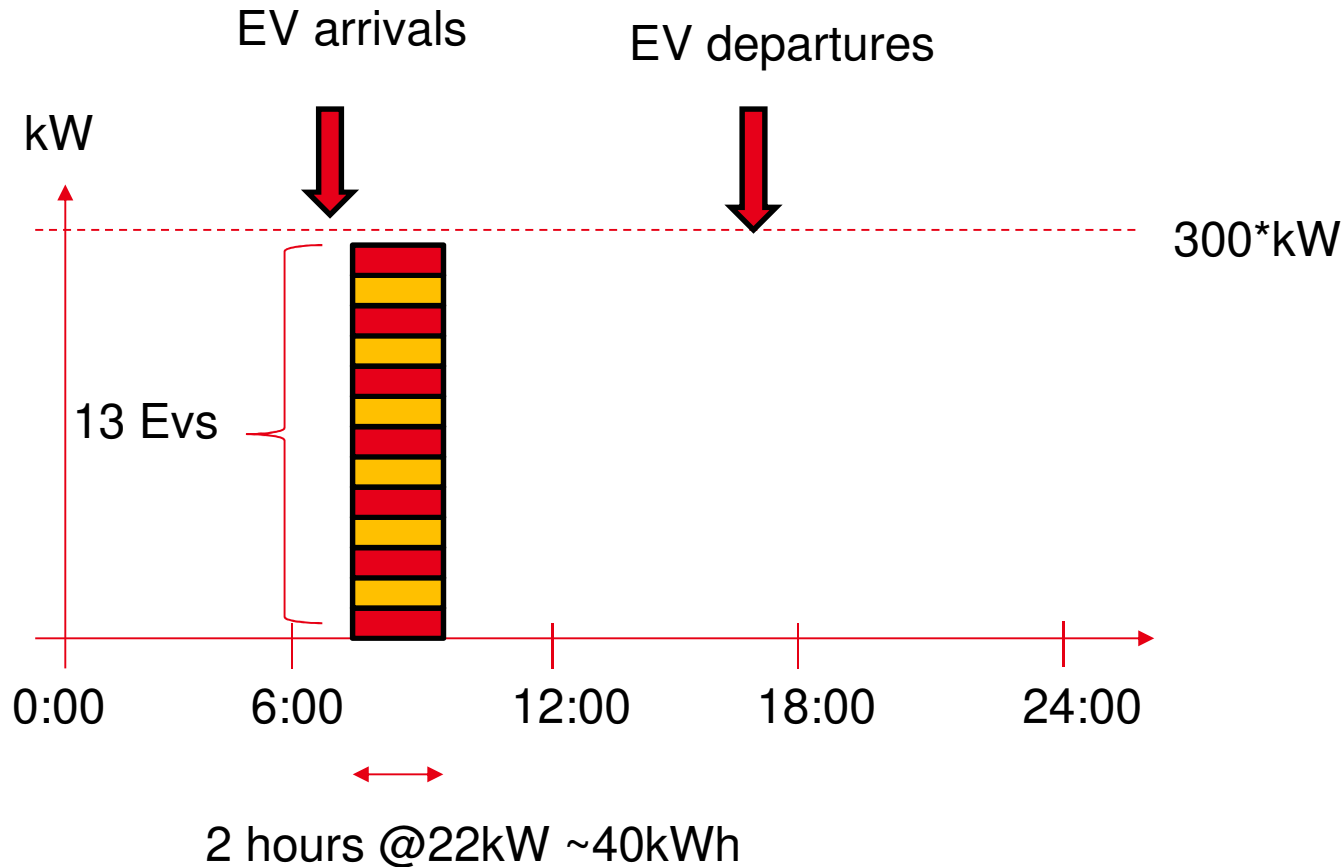


How to reduce the max power bill due to the EV charging?

# USE - CASE 1 – SMART CHARGING 1 – MAX POWER REDUCTION - PRINCIPLE



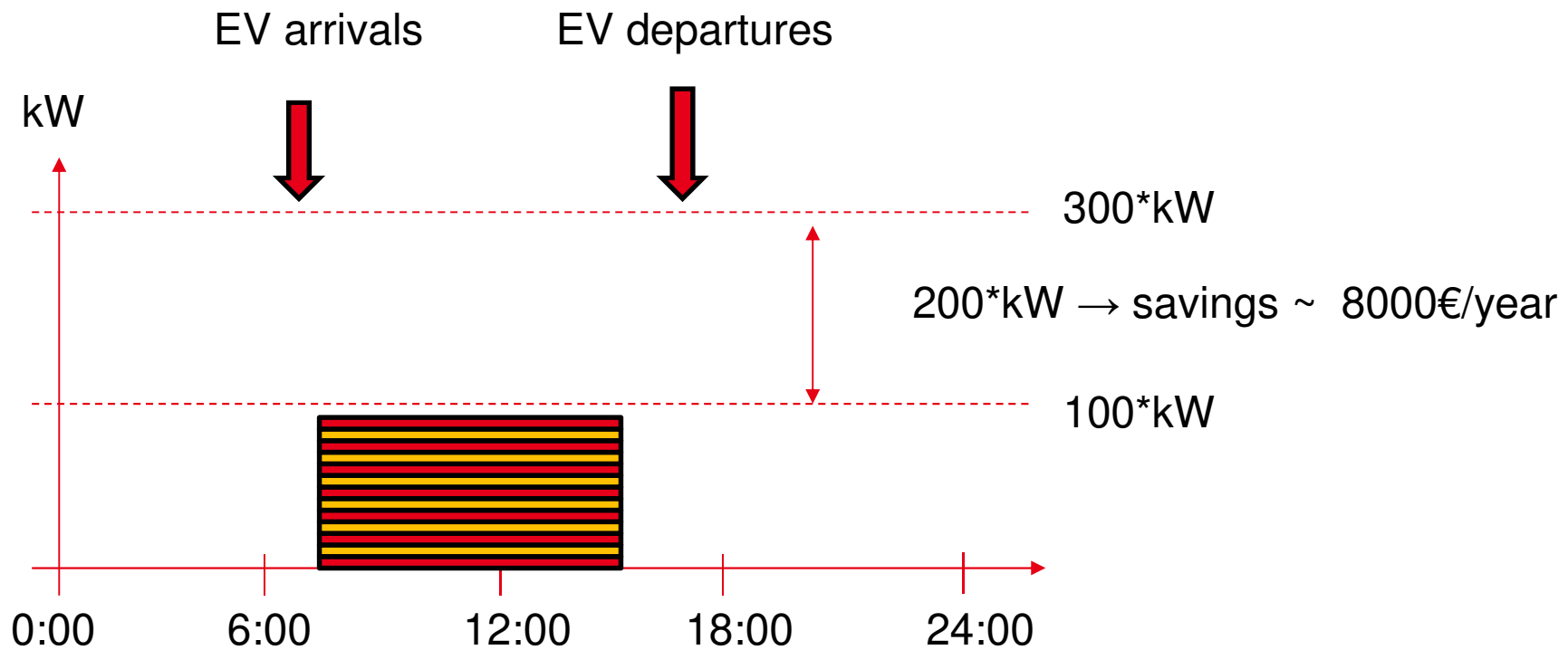
Without max power management : 13 EV Max @ 22kW charging during 8:00 and 10:00



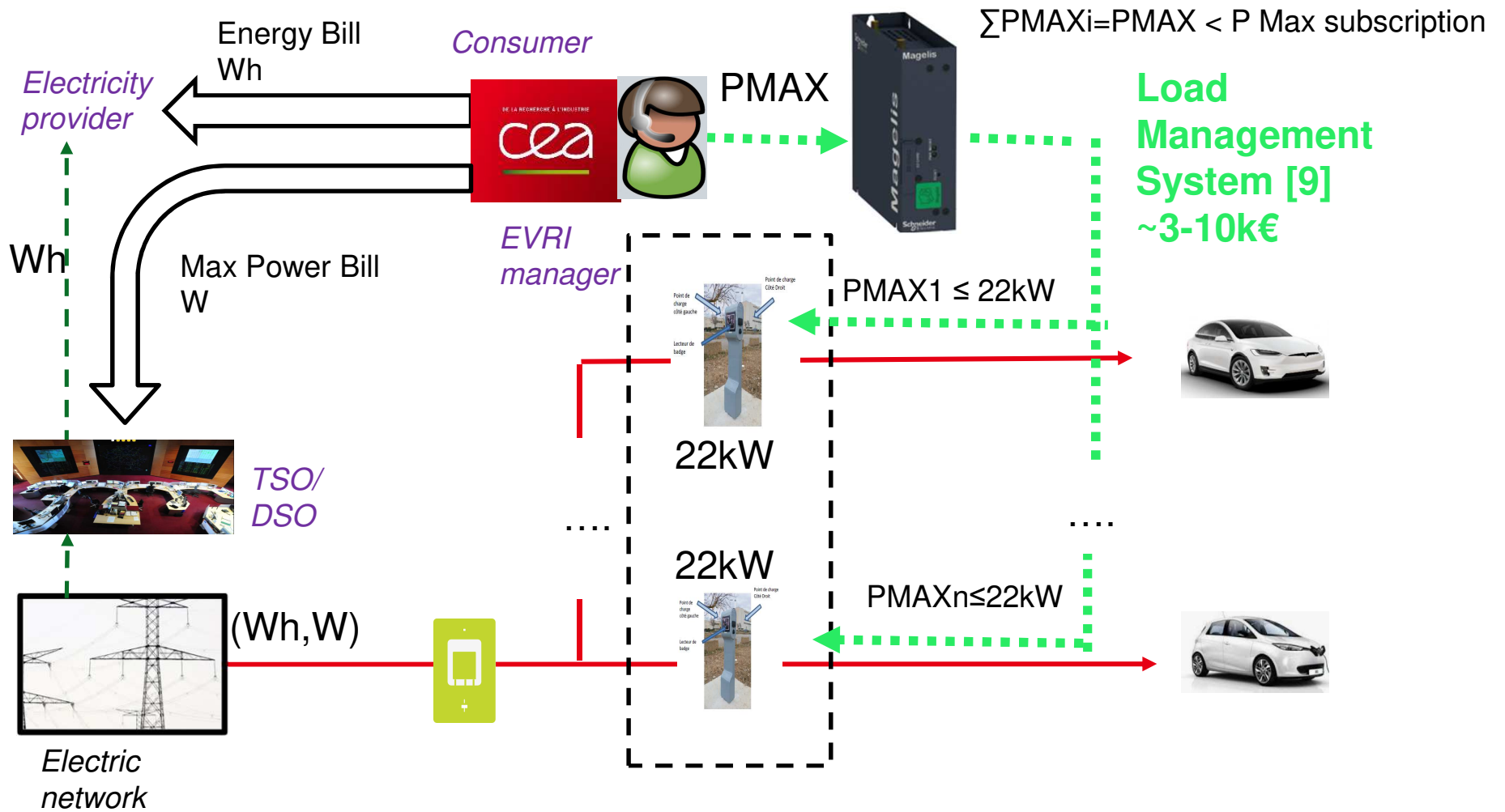
# USE - CASE 1 – SMART CHARGING 1 – MAX POWER REDUCTION – PRINCIPLE



With max power management:  
 13 EV @ 7.4kW during 8:00 and 14:00



# USE - CASE 1 – SMART CHARGING 1 – MAX POWER REDUCTION - SETUP





## USE - CASE 2 - CHARGING COMMERCIAL VEHICLES IN DEPOTS [7]

- The charging points are used, the night, for the fleets of utility vehicles (used by delivery people, postmen, repairers, bus drivers, etc.) providing their service during the day.
- The charging points are generally slow and located in the company depot.

Enedis:  
 1880 EV [10]



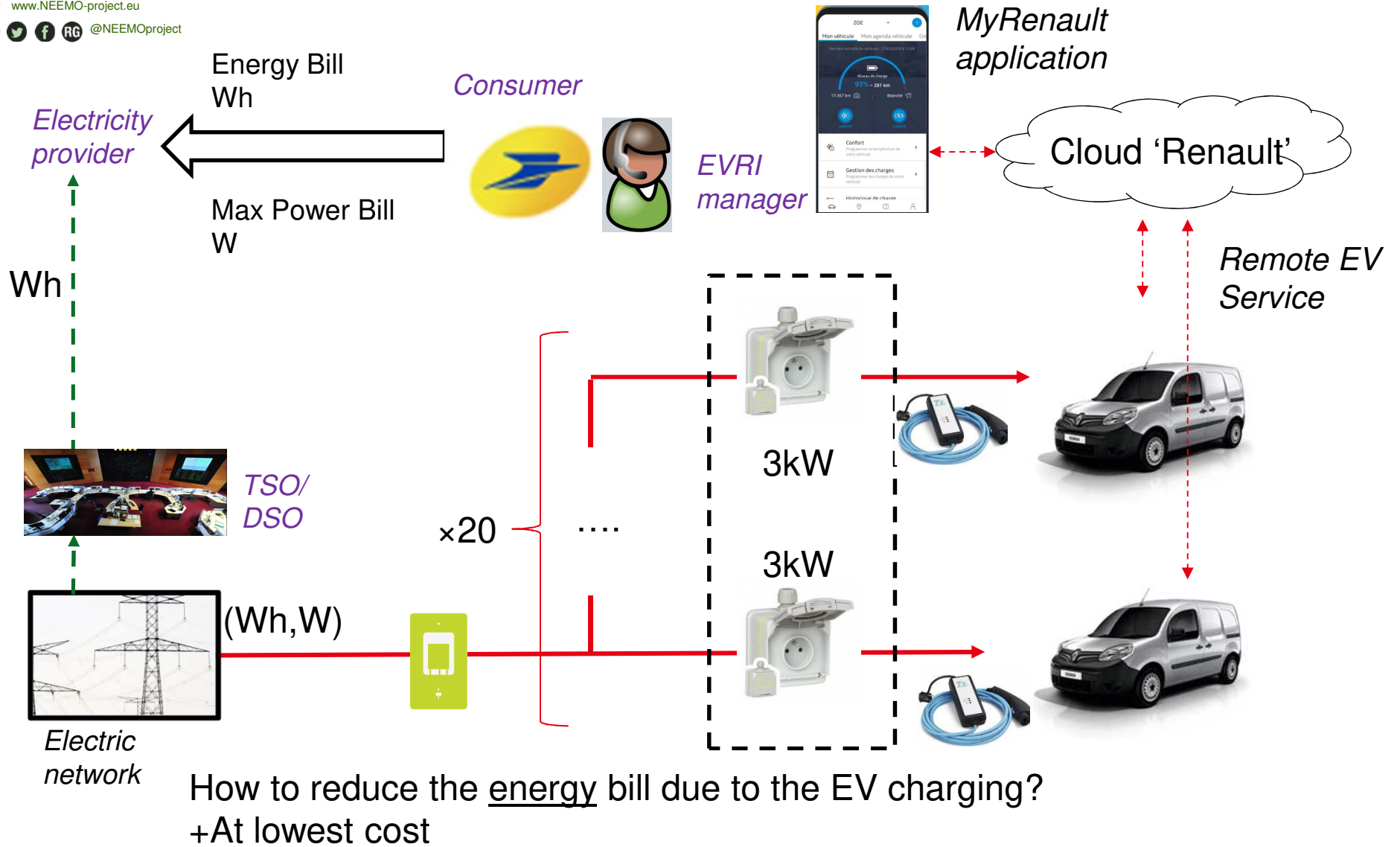
EDF / Bugey nuclear plant :  
 276 charging points  
 110 EV (Renault Zoé) [11]



La Poste :  
 300 establishments  
 7000 light commercial EV (mostly Renault Kangoo) [12]

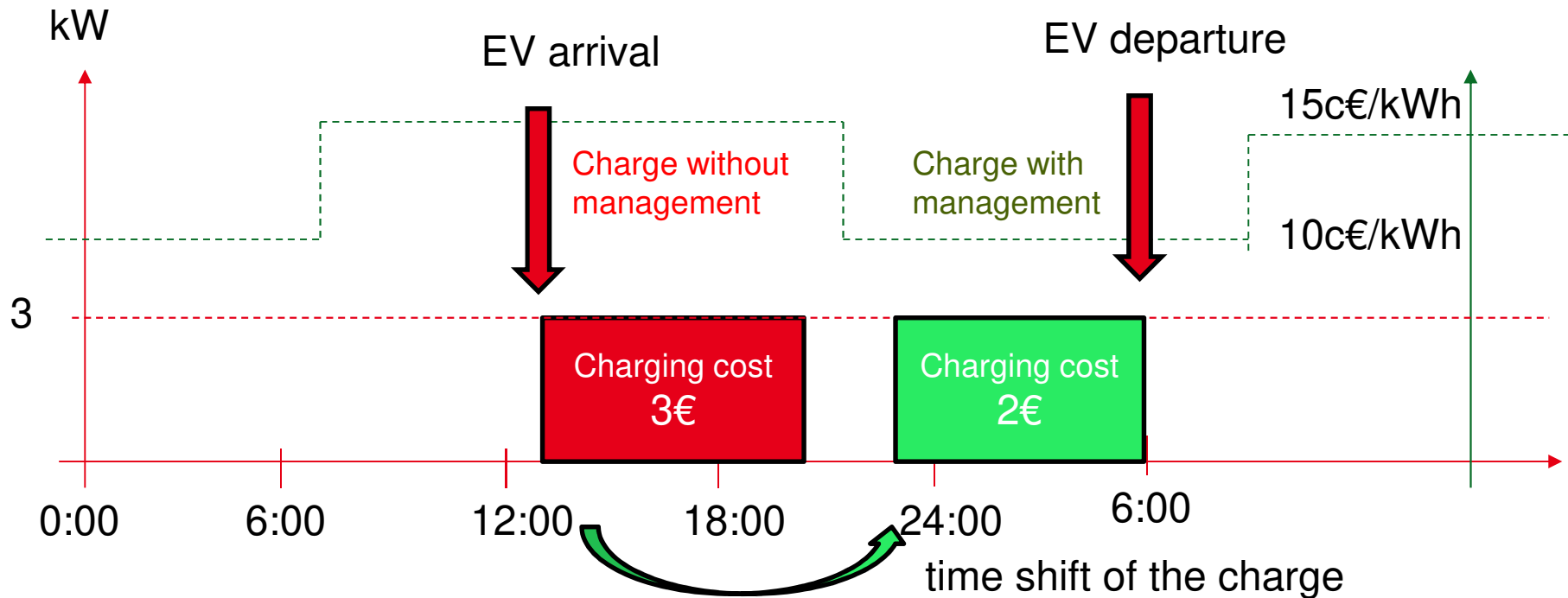


# USE - CASE 2 – SMART CHARGING 2 – ENERGY COST REDUCTION



# USE - CASE 2 – SMART CHARGING 2 – ENERGY COST REDUCTION PRINCIPLE

Postman' round from 6AM to 12AM : 120km / day / EV (~20kWh / day / EV)



Potential Savings with *peak / off-peak hours option*

Price(peak)-Price(off-peak) ~5 c€/kWh

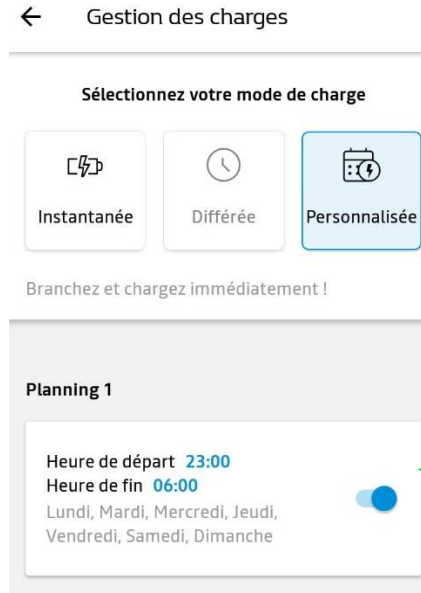
i.e. 1 € / day /EV

For 20 EV working 260 days/Years -> ~5000€/year

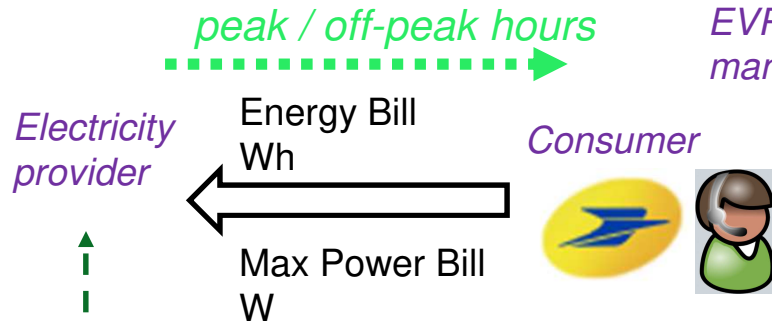
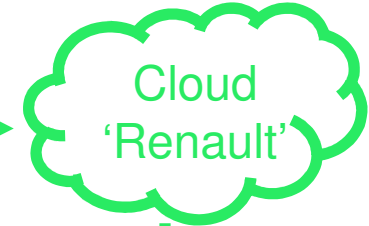
# USE - CASE 2 – SMART CHARGING 2 – ENERGY COST REDUCTION – SETUP 1



Charge management:  
 Off-board via MyRenault App or manually  
 « on board »



MyRenault application



Wh



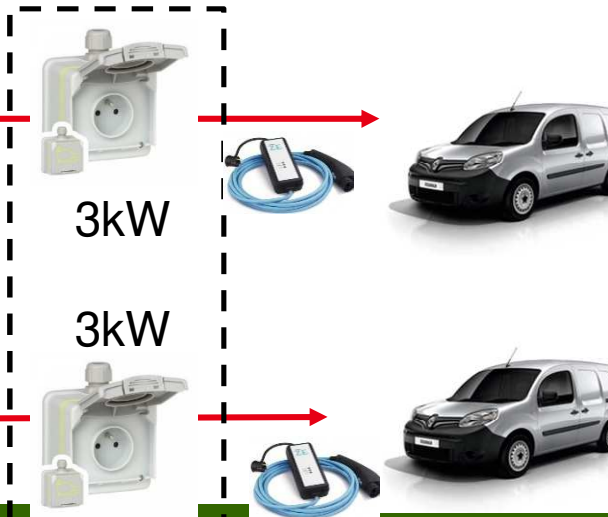
TSO/DSO



(Wh, W)

x20

....



In collaboration with



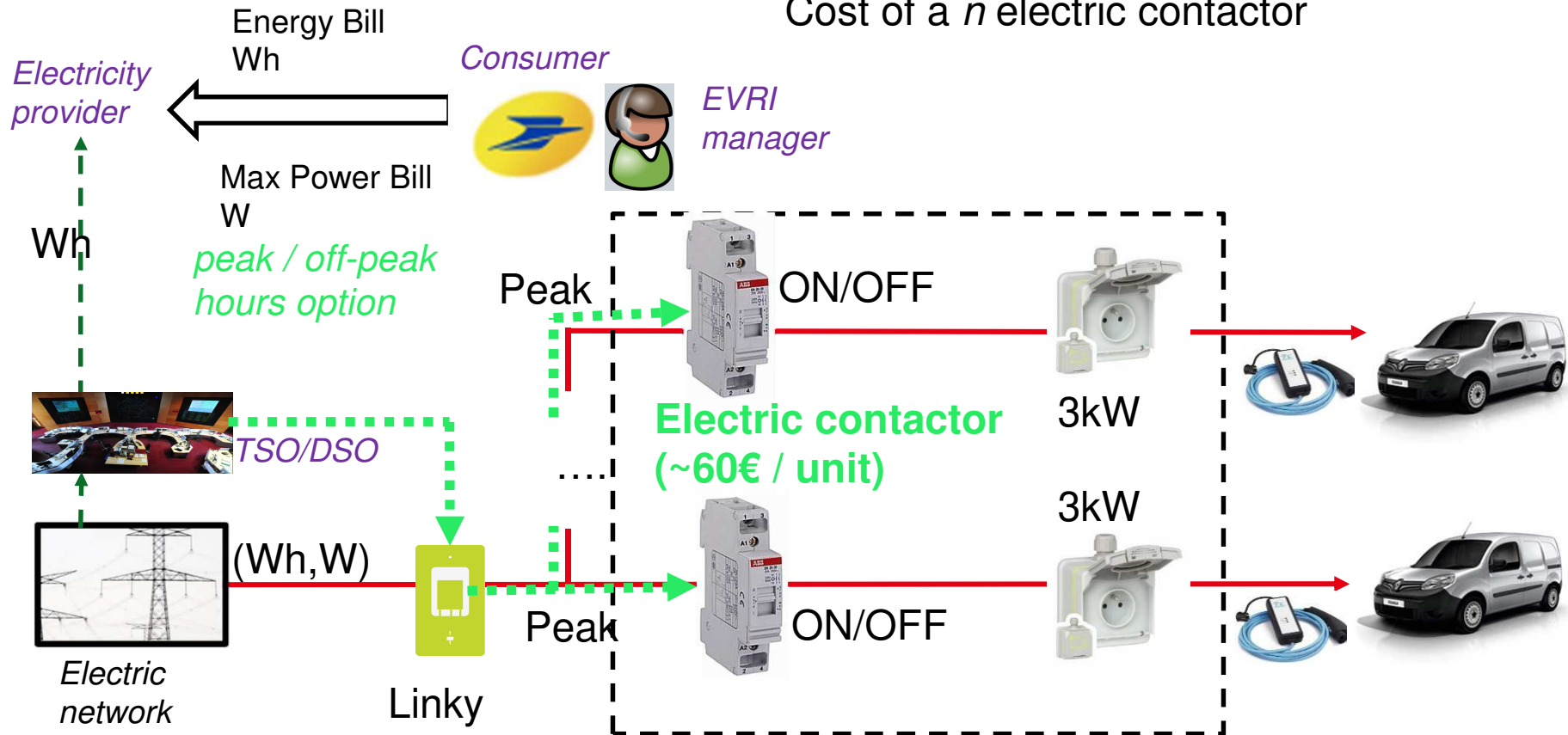
MALTA GROUP OF PROFESSIONAL ENGINEERING INSTITUTIONS



# USE - CASE 2 – SMART CHARGING 2 – ENERGY COST REDUCTION – SETUP 2



Charge management:  
 Via Linky and an electric contactor  
 Cost of a  $n$  electric contactor



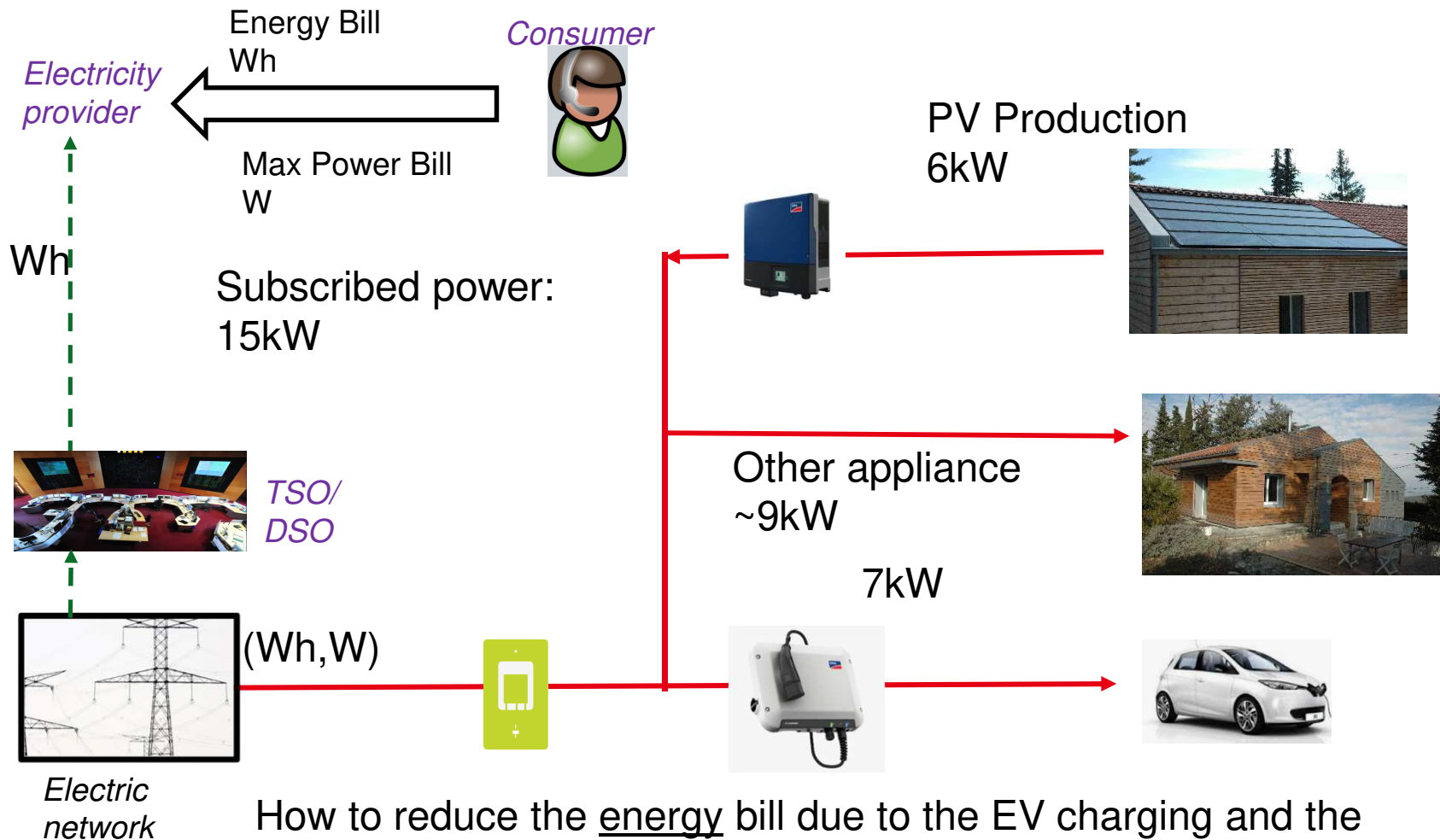


## USE - CASE 3 - CHARGING STATIONS AT HOME [7]



- The charging points are used for recharging the EV used for commuting during the working week.
- The charging points are generally slow or accelerated and located in the garage, next the house or in the parking lot of a collective dwelling.

# USE - CASE 3 – SMART CHARGING 3 – AUTOCONSUMPTION INCREASE



How to reduce the energy bill due to the EV charging and the Max power?

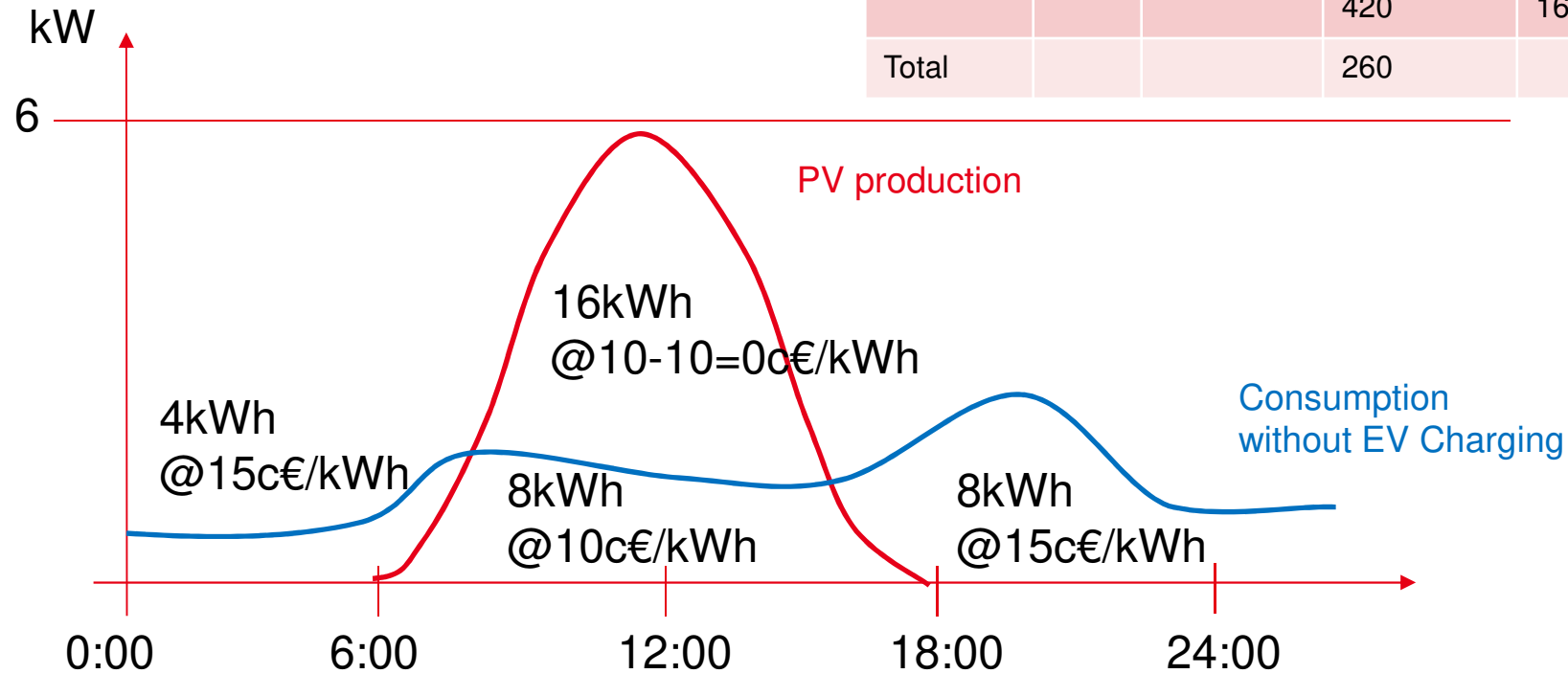


## USE - CASE 3 – SMART CHARGING 3 – ENERGY COST REDUCTION - PRINCIPLE



Cost Price (network) ~ 15 c€/kWh  
 Cost Price (PV) ~ 10c€/kWh  
 Sell Price (PV surplus) ~ 10c€/kWh  
 PV production : 24kW  
 Consumption without EV: 20kWh

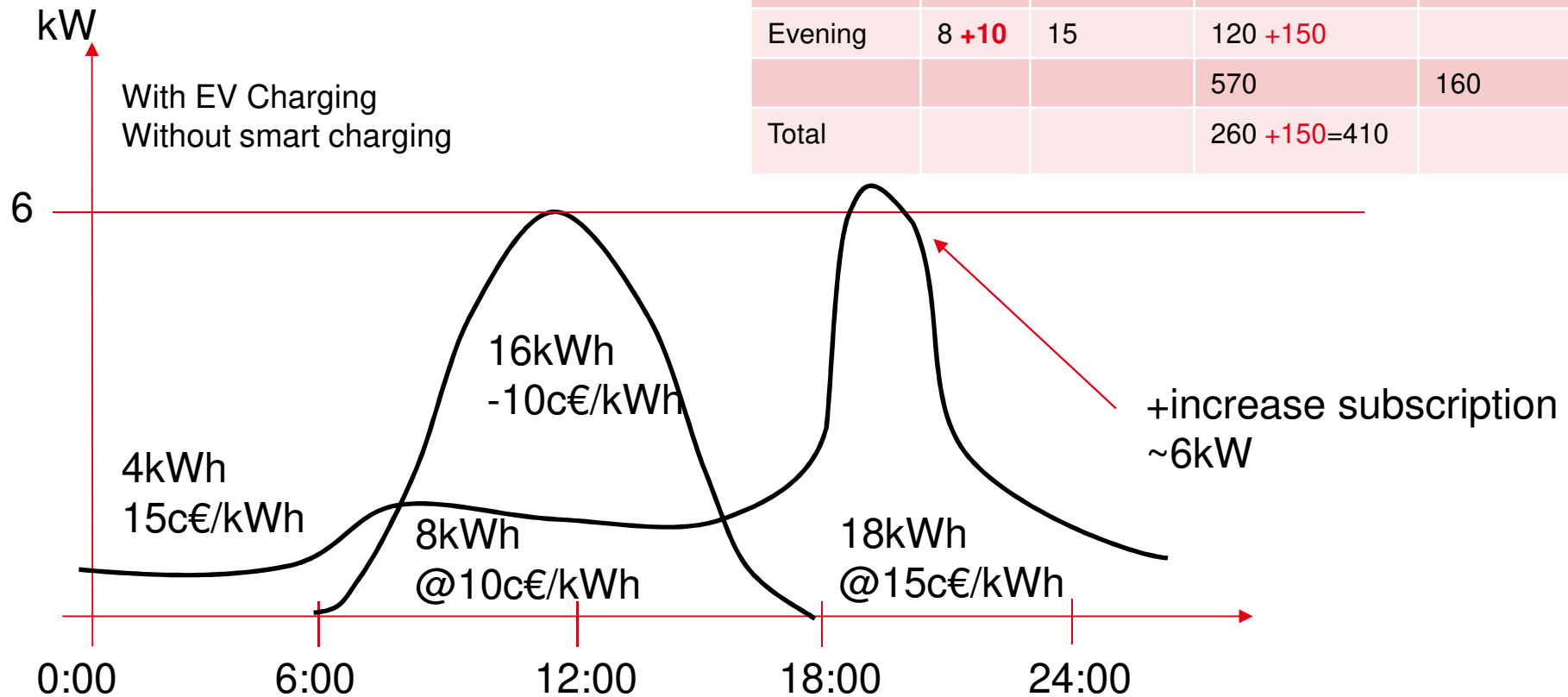
Period	kWh	Price (c€/kWh)	Cost c€	Sell c€
Morning	4	15	60	
MidDay	8	10	80	
MidDay (Surplus)	16	10	160	160
Evening	8	15	120	
			420	160
Total			260	



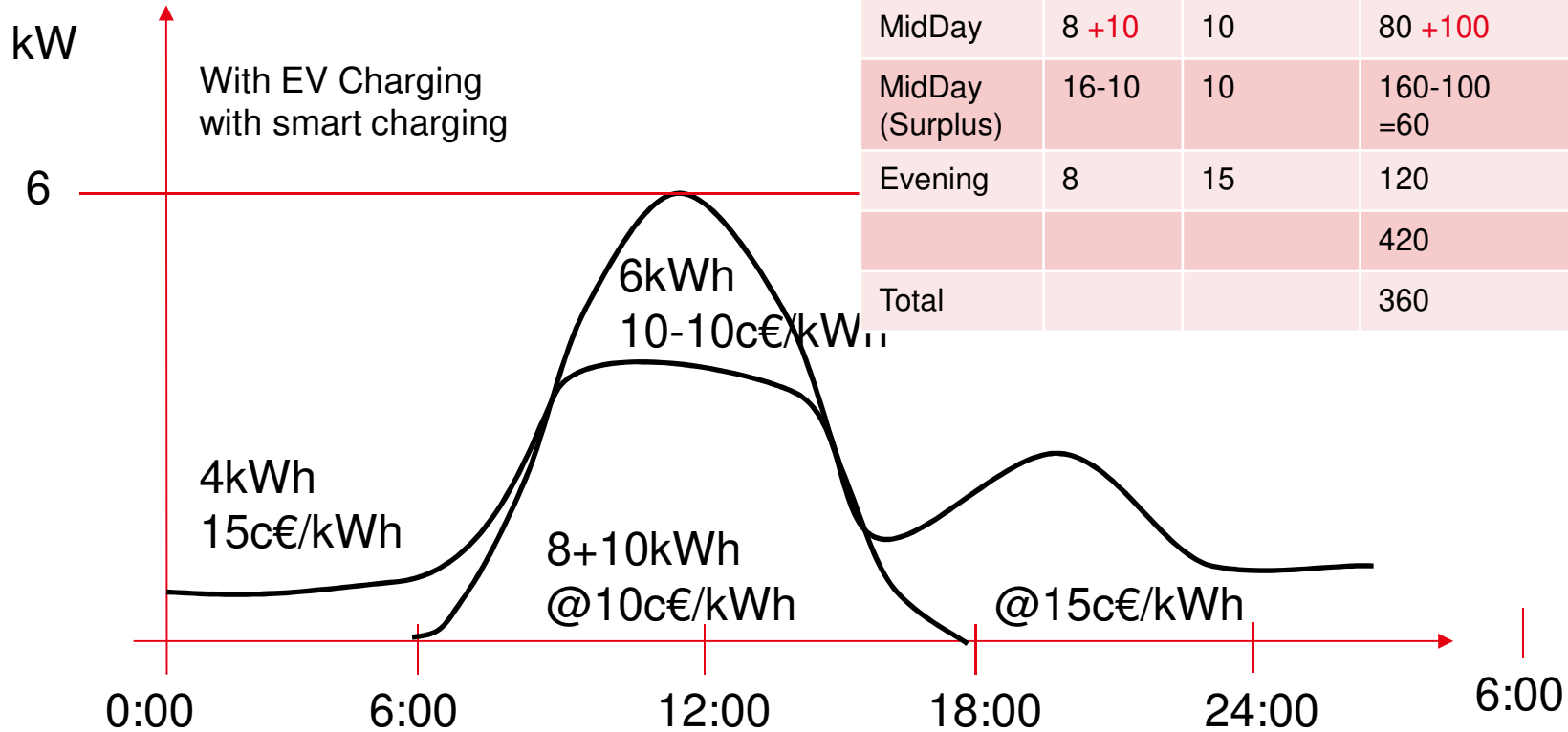
# USE - CASE 3 – SMART CHARGING 3 – ENERGY COST REDUCTION - PRINCIPLE

Consumption of EV :  
 50 km /day → 10kWh / day

Period	kWh	Price (c€/kWh)	Cost c€	Sell c€
Morning	4	15	60	
MidDay	8	10	80	
MidDay (Surplus)	16	10	160	160
Evening	8 +10	15	120 +150	
			570	160
Total			260 +150=410	



# USE - CASE 3 – SMART CHARGING 3 – ENERGY COST REDUCTION - PRINCIPLE



Period	kWh	Price (c€/kWh)	Cost c€	Sell c€
Morning	4	15	60	
MidDay	8 +10	10	80 +100	
MidDay (Surplus)	16-10	10	160-100 =60	160-100 =60
Evening	8	15	120	
			420	60
Total			360	

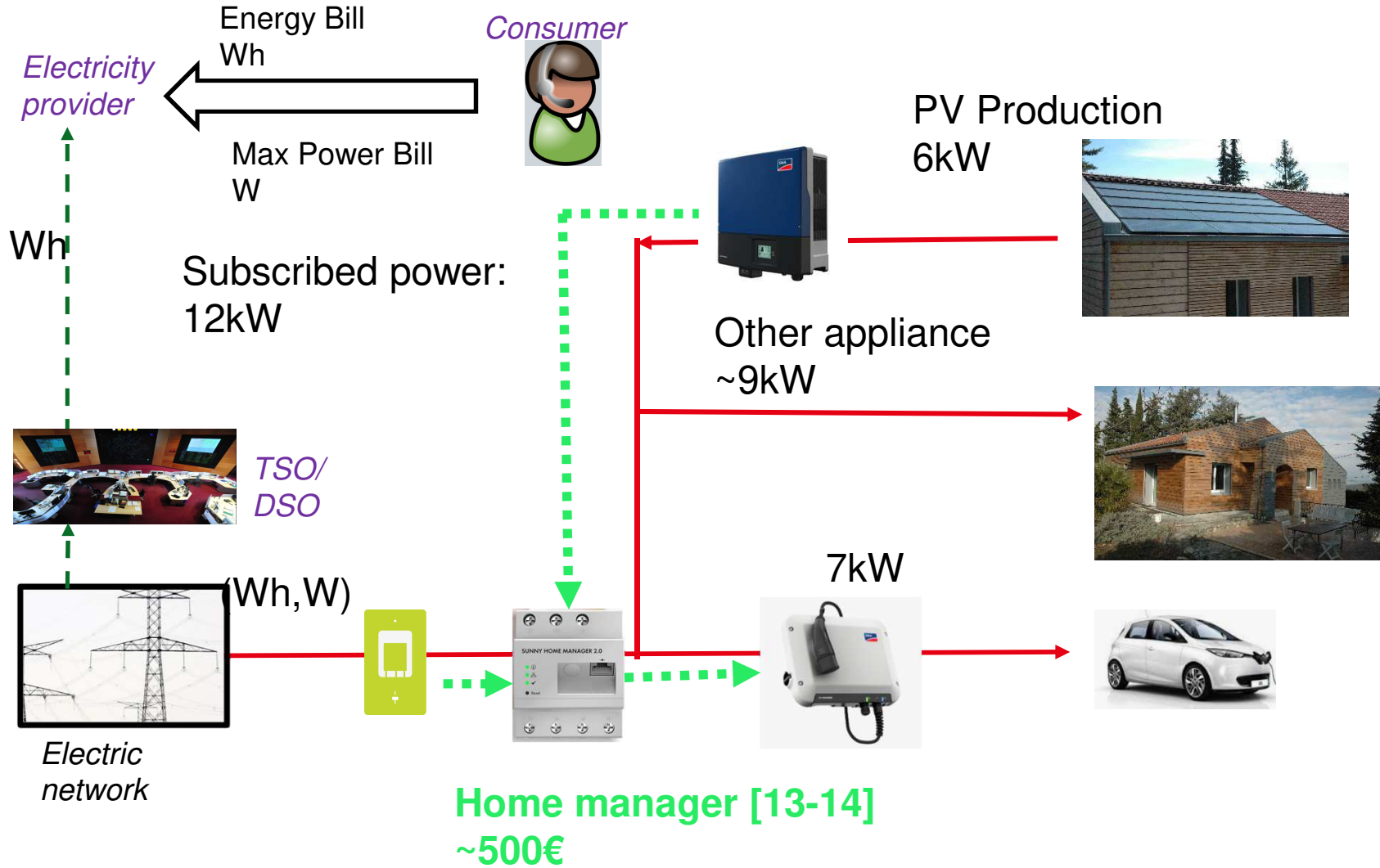
Expected savings:

Subscription 9+3=12kW instead of 9+6=15kW ~30€ /year

If 1 EV used 250 days/years : 3/5 of solar charge -> ~75€/year

} ~100€ /year

# USE - CASE 3 – SMART CHARGING 3 – AUTOCONSUMPTION INCREASE - SET-UP



## USE - CASE 4 - "OPPORTUNISTIC" USE [7]

- These stations are used on an “ad hoc” and “opportunistic” basis by passing electric vehicles.
- These charging stations are normal, accelerated or fast and are installed on public roads, in car parks of shops or shopping centers or on motorway service areas.

Owners : shops  
 Lidl: 900 charging points



Owners : territorial collectivity  
 LaRecharge (Aix-Marseille Metropole)  
 174 charging points (22kW AC)



Owners : charge point operator  
 Ionity: 350 charging points (>50kW DC)



- **Nowadays, various smart charging solutions can be setup with commercial equipments and solutions**
- **There exist cheap solutions but also very expensive ones**
- **Other « smarter » solutions exist, based on complex information systems and off-site control of the EV charges.**
  - For example, smart charging of EVs @ CEA Cadarache
- **To setup smart charging solutions, the charging needs of the users have to be precisely studied**



- [1] <https://www.automobile-propre.com/dossiers/chiffres-vente-immatriculations-france/>
- [2] [http://www.hrvojepandzic.com/wp-content/uploads/2019/09/Lecture\\_4\\_EVs.pdf](http://www.hrvojepandzic.com/wp-content/uploads/2019/09/Lecture_4_EVs.pdf)
- [3] [http://ev-institute.com/images/charged\\_mag.pdf](http://ev-institute.com/images/charged_mag.pdf)
- [4] [http://www.averre-france.org/Site/Article/?article\\_id=7923](http://www.averre-france.org/Site/Article/?article_id=7923)
- [5] <https://fr.chargemap.com/>
- [6] <https://www.data.gouv.fr/fr/datasets/fichier-consolide-des-bornes-de-recharge-pour-vehicules-electriques/>
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- [8] <https://www.tesla-mag.com/sap-labs-a-mougins-quand-la-recharge-de-vehicules-electriques-devient-tres-intelligente/>
- [9] [https://download.schneider-electric.com/files?p\\_enDocType=User+guide&p\\_File\\_Name=SE+EVlink+LMS+User+guide+EN-07.pdf&p\\_Doc\\_Ref=DOCA0163](https://download.schneider-electric.com/files?p_enDocType=User+guide&p_File_Name=SE+EVlink+LMS+User+guide+EN-07.pdf&p_Doc_Ref=DOCA0163)
- [10] [https://www.enedis.fr/sites/default/files/field/documents/enedis\\_livret\\_mobilite\\_electrique\\_hd.pdf](https://www.enedis.fr/sites/default/files/field/documents/enedis_livret_mobilite_electrique_hd.pdf)
- [11] <https://www.edf.fr/groupe-edf/nos-energies/carte-de-nos-implantations-industrielles-en-france/centrale-nucleaire-du-bugey/actualites/la-centrale-nucleaire-du-bugey-s-equipe-de-110-vehicules-electriques-et-de-276-bornes-de-recharge>
- [12] [https://www.lemonde.fr/economie/article/2019/04/08/la-poste-numero-un-mondial-des-flottes-branchees\\_5447176\\_3234.html](https://www.lemonde.fr/economie/article/2019/04/08/la-poste-numero-un-mondial-des-flottes-branchees_5447176_3234.html)
- [13] <https://www.sma.de/fr/produits/surveillance-contrôle/sunny-home-manager-20.html>
- [14] <https://files.sma.de/downloads/EVC-10-DS-en-10.pdf>

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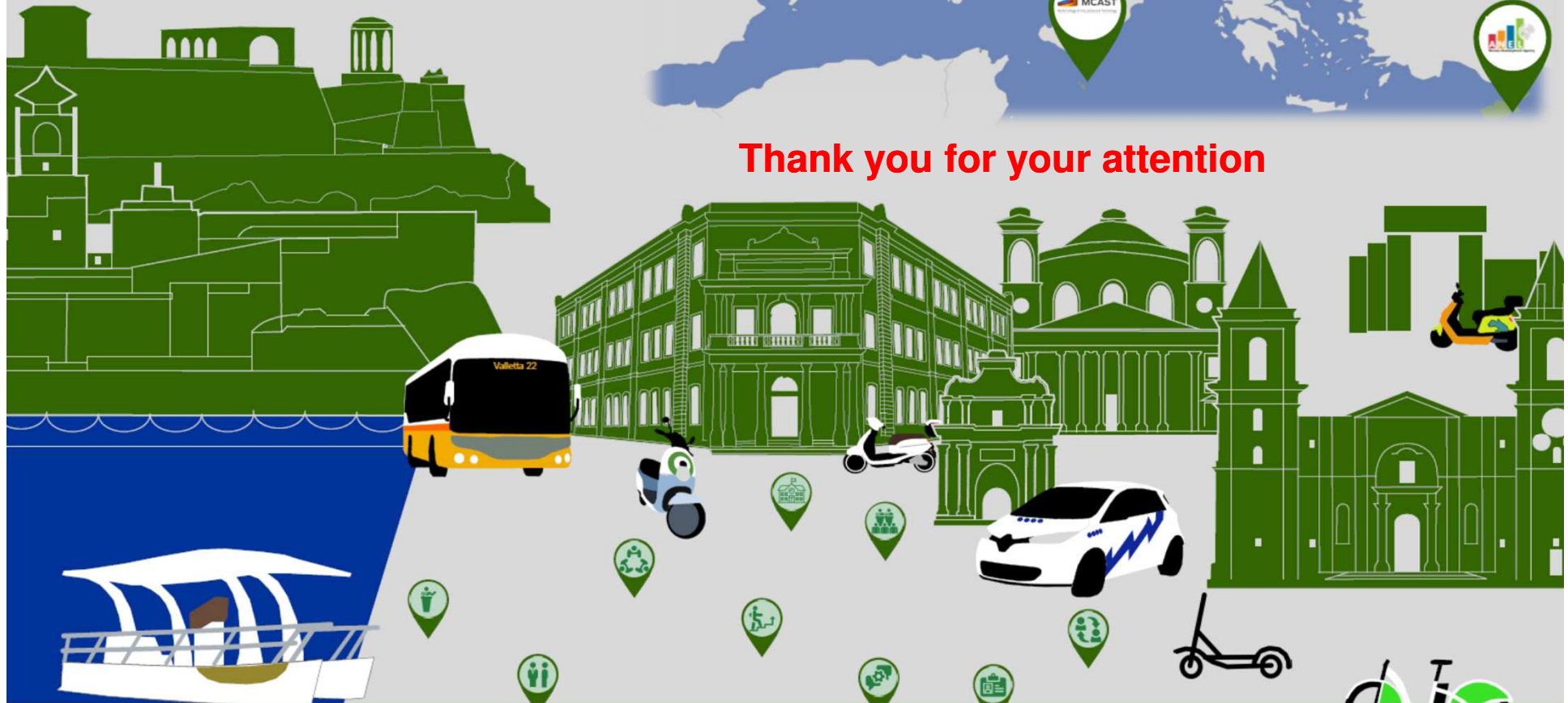
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The project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857484