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

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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
• 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
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  • Use Case 3: Charging stations at home
    • Smart charging need: Autoconsumption increase
    • Principle and setup
  • Use Case 4: "Opportunistic‘ charging stations

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

Sells of full EV cars in France

<table>
<thead>
<tr>
<th>Year</th>
<th>Sells</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>184</td>
</tr>
<tr>
<td>2011</td>
<td>3k</td>
</tr>
<tr>
<td>2012</td>
<td>6k</td>
</tr>
<tr>
<td>2013</td>
<td>9k</td>
</tr>
<tr>
<td>2014</td>
<td>10k</td>
</tr>
<tr>
<td>2015</td>
<td>17k</td>
</tr>
<tr>
<td>2016</td>
<td>22k</td>
</tr>
<tr>
<td>2017</td>
<td>25k</td>
</tr>
<tr>
<td>2018</td>
<td>31k</td>
</tr>
<tr>
<td>2019</td>
<td>42k</td>
</tr>
<tr>
<td>2020</td>
<td>110k</td>
</tr>
</tbody>
</table>

Total: ~ 276485 EV from 2010
### TOP TEN SALES – FRANCE 2020

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

Total: 110900 EV (6.7%)  
Source: [1]
AGENDA

- Panorama of the french full electric vehicles (EV) market
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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)

**MODE 4**: DC connexion to dedicated Electric Vehicle Supply Equipment (EVSE)

Source: [2]
The project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 857484

AC CHARGING MODE: MODE 1, 2

MODE 1: AC Direct connection to standardized residential power outlets

MODE 2: AC Connection to standardized residential power outlets via In-cable Control and Protective Device (IC-CPD)

Source: [2]
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AC CHARGING MODE: MODE 3

**MODE 3-B:** AC connexion to dedicated Electric Vehicle Supply Equipment (EVSE)

**MODE 3-C:** AC connexion to dedicated Electric Vehicle Supply Equipment (EVSE)

Source: [2]
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THE PLUG AND SOCKET ZOO – MODE 4

Tesla plug

CHAdEOMO (DC only)

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

Source: [2,3]
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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

Source: [5]
Public charging points

<table>
<thead>
<tr>
<th>InstalledPowerCPO MW</th>
<th>NumberOfStation Units</th>
<th>NumberOfCP Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL</td>
<td>533.91</td>
<td>9260</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Own classification</th>
<th>Slow 0-4</th>
<th>Standard 4-14</th>
<th>Accelerated 14-24</th>
<th>Fast 24-51</th>
<th>Veryfast 51-151</th>
<th>Ultrafast &gt;151</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Units</td>
<td>1886</td>
<td>348</td>
<td>16431</td>
<td>1438</td>
<td>28</td>
<td>344</td>
<td>20475</td>
</tr>
<tr>
<td>%</td>
<td>9.21</td>
<td>1.70</td>
<td>80.25</td>
<td>7.02</td>
<td>0.14</td>
<td>1.68</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Avere classification</th>
<th>Normal 0-14</th>
<th>Accelerated 14-24</th>
<th>Fast 24-51</th>
<th>Very fast</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Units</td>
<td>2234</td>
<td>16431</td>
<td>1438</td>
<td>372</td>
<td></td>
</tr>
<tr>
<td>In pourcents</td>
<td>10.91</td>
<td>80.25</td>
<td>7.02</td>
<td>1.82</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Avere Data</th>
<th>Units</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7093</td>
<td>24.52</td>
</tr>
<tr>
<td></td>
<td>19959</td>
<td>69.00</td>
</tr>
<tr>
<td></td>
<td>1102</td>
<td>3.81</td>
</tr>
<tr>
<td></td>
<td>774</td>
<td>2.68</td>
</tr>
<tr>
<td></td>
<td>28928</td>
<td></td>
</tr>
</tbody>
</table>

*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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    - Principle and setup
  - 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]
How to reduce the max power bill due to the EV charging?

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

2 hours @22kW ~40kWh
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**USE - CASE 1 – SMART CHARGING 1 – MAX POWER REDUCTION – PRINCIPLE**

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

200kW → savings ~ 8000€/year
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• 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]
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USE - CASE 2 – SMART CHARGING 2 – ENERGY COST REDUCTION - PRINCIPLE

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

<table>
<thead>
<tr>
<th>Time</th>
<th>EV arrival</th>
<th>EV departure</th>
<th>Charge without management</th>
<th>Charge with management</th>
</tr>
</thead>
<tbody>
<tr>
<td>0:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6:00</td>
<td></td>
<td></td>
<td>3€</td>
<td></td>
</tr>
<tr>
<td>12:00</td>
<td></td>
<td></td>
<td>3€</td>
<td></td>
</tr>
<tr>
<td>18:00</td>
<td></td>
<td></td>
<td>2€</td>
<td></td>
</tr>
<tr>
<td>24:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Charging cost:
- Charge without management: 3€
- Charge with management: 2€

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

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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 to the house or in the parking lot of a collective dwelling.
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Cost Price (network) ~15 c€/kWh
Cost Price (PV) ~10c€/kWh
Sell Price (PV surplus) ~ 10c€/kWh
PV production : 24kW
Consumption without EV: 20kWh

<table>
<thead>
<tr>
<th>Period</th>
<th>kWh</th>
<th>Price (c€/kWh)</th>
<th>Cost c€</th>
<th>Sell c€</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morning</td>
<td>4</td>
<td>15</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>MidDay</td>
<td>8</td>
<td>10</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>MidDay (Surplus)</td>
<td>16</td>
<td>10</td>
<td>160</td>
<td>160</td>
</tr>
<tr>
<td>Evening</td>
<td>8</td>
<td>15</td>
<td>120</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>420</td>
<td>160</td>
</tr>
</tbody>
</table>

Cost Price (network) ~15 c€/kWh
Cost Price (PV) ~10c€/kWh
Sell Price (PV surplus) ~ 10c€/kWh
PV production : 24kW
Consumption without EV: 20kWh
USE - CASE 3 – SMART CHARGING 3 – ENERGY COST REDUCTION - PRINCIPLE

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

<table>
<thead>
<tr>
<th>Period</th>
<th>kWh</th>
<th>Price (c€/kWh)</th>
<th>Cost c€</th>
<th>Sell c€</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morning</td>
<td>4</td>
<td>15</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>MidDay</td>
<td>8</td>
<td>10</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>MidDay (Surplus)</td>
<td>16</td>
<td>10</td>
<td>160</td>
<td>160</td>
</tr>
<tr>
<td>Evening</td>
<td>8 +10</td>
<td>15</td>
<td>120 +150</td>
<td></td>
</tr>
</tbody>
</table>

With EV Charging Without smart charging

- 4kWh @15c€/kWh
- 8kWh @10c€/kWh
- 16kWh @-10c€/kWh
- 18kWh @15c€/kWh

+increase subscription ~6kW

Total c€: 260 +150=410
USE - CASE 3 – SMART CHARGING 3 – ENERGY COST REDUCTION - PRINCIPLE

<table>
<thead>
<tr>
<th>Period</th>
<th>kWh</th>
<th>Price (c€/kWh)</th>
<th>Cost c€</th>
<th>Sell c€</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morning</td>
<td>4</td>
<td>15</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>MidDay</td>
<td>8 +10</td>
<td>10</td>
<td>80 +100</td>
<td></td>
</tr>
<tr>
<td>MidDay (Surplus)</td>
<td>16-10</td>
<td>10</td>
<td>160-100</td>
<td>160-100</td>
</tr>
<tr>
<td>Evening</td>
<td>8</td>
<td>15</td>
<td>120</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>420</td>
<td>60</td>
</tr>
</tbody>
</table>

Total kWh: 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

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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
Ioniity: 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
REFERENCES / SOURCES


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Thank you for your attention