AGENDA

• EvolIVE Project
• CEA EVCI & PV
  • CEA EVCI
  • Charging modes
  • EvolIVE @INES
  • EvolIVE @Cadarache
• Transaction analysis
  • Transactions
  • Energy Consumption v. Transaction Duration (EC v. TD)
  • Flexibility definition & estimation
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  • Reconstruction
  • Analysis
• Smart charging
  • IT infrastructure
  • Autoconsumption rate
  • Examples of simulation results
  • First experimental results
EVOLVE PROJECT

Partners
RTE : Réseau de Transport d’Electricité
CEA: Commissariat à l’Energie Atomique et aux Energies Alternatives

Objective
This project aims to synchronize the charge of a fleet of EVs with an “off-site” photovoltaic production.

Tasks
1. Defining the experimental framework
2. Design and setup equipments, IT infrastructure and control algorithms
3. Monitor and evaluate the experiments

Planning
Kick-off: January 2020
Tasks 1 & 2 : 01/2020 -> 05/2021
Task 3 : 06/2021 -> 05/2022
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### CEA CENTERS

- **Civil centers**
- **Military centers**
- **INES Chambéry**
- **Technological platforms**

#### Technological platforms

- **Saclay-Fontenay-Aux-Roses**
  - 7500 p – 160Ha
- **Chambéry - INES**
  - 500 p – 8Ha
- **Grenoble**
  - 3700 p – 67Ha
- **Cadarache**
  - 2500 p – 900Ha

#### Military centers

- **Toulouse**
  - 50 p – 2Ha
- **Marcoule**
  - 1500 p – 250Ha

#### Civil centers

- **9 research centers (5 civil / 4 military)**
- **8 technological platforms**
- **20 181 employees (included 1 233 PhD students and 176 postdoctoral researchers)**
- **Budget of 5 billion euros**
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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: [1]
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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: [1]
THE PLUG AND SOCKET ZOO – MODE 2

Type E (CEE 7/17) Mono-p 230V
Blue: « camping » socket Mono-p 230V
Red: Industrial socket Tri-p 400V

Plug – grid side

Tesla coupler
Type 1 coupler
Type 2 coupler
EV-side coupler

AC
IC-CPD
AC

Grid

on board Charger
Battery

AC
DC

Depends on the vehicle

www.NEEMO-project.eu
@NEEMOproject

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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: [1]
THE PLUG AND SOCKET ZOO – MODE 3 B

Type 2 outlet
- 7@Toulouse
- 42@Grenoble
- 18@INES
- 40@Saclay
- 81@Cadarache
- 16@Marcoule

Type 3 outlet
- 9@Grenoble

Tesla coupler

Type 1 coupler

Type 2 coupler

Depends on the vehicle

AC

plug – EVSE - side

EVSE

Grid

AC

on board Charger

Battery

AC

DC

Source: [1,2]
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THE PLUG AND SOCKET ZOO – MODE 3 C

Tesla coupler

Type 1 coupler

Type 2 coupler

Source: [1,2]
THE PLUG AND SOCKET ZOO – MODE 4

Tesla plug

CHAdEOMO (DC only)
2@Toulouse
1@INES

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

Source: [1,2]

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ELECTRIC VEHICLE CHARGING INFRASTRUCTURE (EVCI)

- **Mode 1&2**
- **Mode 3 (and 1&2)**
- **Mode 4**

### INES + CADARACHE

- ¼ of the 81 AC-EVSE in INES: 20 EVSE
- 100% of the 20 AC-EVSE in Cadarache: ~ 20 EVSE

$$\text{INES + CADARACHE} = 40 \times 22\text{kW AC mode 3 (and mode 1&2)}$$
EVCI & PV @CEA-INES

- 20 parking places
- 12 of them are above a 21kWp solar carport
- 10-15 EV users

INES research center @Chambéry
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5500 workers

1600 Ha 900ha fenced (22 km of fence)

480 buildings and 500 000 m² de planchers

70 Km of paved roads, 6 km of landscaped footpath, around 5500 people / day on site

29 Bus lines carrying a thousand employees

75 km of water distribution network (drinking water station, industrial water, purification station)

Private power network

- 63kV / 15kV substation
- 18 MV loops (85km of 15kV underground lines)
- EVCI : 81 charging points at 22kVA
- 3kV public lighting network
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MÉGASOL PLATFORM (13 MWP)

PV Plant 1: **PV + HCPV 6,2 MWp**, since 2017
- O&M optimization, environmental integration

PV Plant 2: **PV 2,3 MWp + Storage 60kW**, since 2018
- Grid & market integration

PV Plant 3: **PV 4,3 MWp**, since 2018
- Grid & market integration

PV Plant 4: **1,5 MWp + Storage project**
- Grid & market integration

PV Plant 5: **1 MWp project**
- Innovatives electrical architectures and modules
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EVCI CADARACHE – CHARGING STATION

30 EV charging areas

5 areas participating at EvolVE

G2Mobility (now Total EV Charge)
Diva (2*22kW)

Setup mid-2016
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**EVCI CADARACHE – EV**

<table>
<thead>
<tr>
<th>Modele</th>
<th>Nombre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zoé</td>
<td>126</td>
</tr>
<tr>
<td>M3</td>
<td>4</td>
</tr>
<tr>
<td>MS</td>
<td>3</td>
</tr>
<tr>
<td>Kangoo</td>
<td>14</td>
</tr>
<tr>
<td>Golf GTE</td>
<td>3</td>
</tr>
<tr>
<td>Twizy</td>
<td>4</td>
</tr>
<tr>
<td>Fortwo</td>
<td>2</td>
</tr>
<tr>
<td>Leaf</td>
<td>11</td>
</tr>
<tr>
<td>Berlingo</td>
<td>4</td>
</tr>
<tr>
<td>Autre</td>
<td>14</td>
</tr>
<tr>
<td>e208</td>
<td>2</td>
</tr>
<tr>
<td>Ion</td>
<td>1</td>
</tr>
<tr>
<td>Partner</td>
<td>1</td>
</tr>
<tr>
<td>Ioniq</td>
<td>2</td>
</tr>
<tr>
<td>C-Zéro</td>
<td>1</td>
</tr>
<tr>
<td>330e</td>
<td>1</td>
</tr>
<tr>
<td>E-Niro</td>
<td>1</td>
</tr>
<tr>
<td>Outlander</td>
<td>2</td>
</tr>
<tr>
<td>Think city</td>
<td>1</td>
</tr>
</tbody>
</table>

67 service vehicles  
51 personal vehicles  
3 taxis  
5 external companies vehicles

<table>
<thead>
<tr>
<th>Type</th>
<th>#</th>
</tr>
</thead>
<tbody>
<tr>
<td>External companies</td>
<td>17</td>
</tr>
<tr>
<td>Personal</td>
<td>85</td>
</tr>
<tr>
<td>Service</td>
<td>90</td>
</tr>
<tr>
<td>Taxi</td>
<td>3</td>
</tr>
</tbody>
</table>

**TOTAL= 195**

Figures at march 2020  
Increase ~50 EV /year
<table>
<thead>
<tr>
<th>Model</th>
<th>Battery capacity (kWh)</th>
<th>Max AC charging power (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zoé</td>
<td>{22;41;52}</td>
<td>22 or 43 (Mode 3) or 2.3 (Mode 2)</td>
</tr>
<tr>
<td>Leaf</td>
<td>{24;30;40;60}</td>
<td>6.7 or 3.3 or 2.3</td>
</tr>
<tr>
<td>Tesla M3</td>
<td>{52;77}</td>
<td>11 or 2.3</td>
</tr>
<tr>
<td>Tesla MS</td>
<td>{40;60;70;75;85;90;100}</td>
<td>22 or 16.5 or 11 or 2.3</td>
</tr>
<tr>
<td>Smart</td>
<td>17.6</td>
<td>22 or 2.3</td>
</tr>
<tr>
<td>Golf GTE</td>
<td>35.8</td>
<td>3.6 or 2.3</td>
</tr>
<tr>
<td>Twizzy</td>
<td>{6;8}</td>
<td>3.3 or 2.3 (mode 1)</td>
</tr>
<tr>
<td>Berlingo</td>
<td>22.5</td>
<td>6.7 or 3.3 or 2.3</td>
</tr>
<tr>
<td>Kangoo</td>
<td>{22;33}</td>
<td>7 or 3.7 or 3.2 (mono)</td>
</tr>
</tbody>
</table>
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Raw data can be downloaded from the user interface

Log of charging sessions (.xls):

Data analysis
• **EvolVE Project**
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## LOG OF CHARGING SESSIONS

<table>
<thead>
<tr>
<th># of the user</th>
<th>Name of the charging station</th>
<th>HD: Date/Time at the beginning of the session (UTC)</th>
<th>HF: Date/Time at the beginning of the session (UTC)</th>
<th>ID: Value of the powermeter at the beginning of the session (Wh)</th>
<th>IF: Value of the powermeter at the end of the session (Wh)</th>
<th>Badge</th>
<th>IndexDebut</th>
<th>IndexFin</th>
<th>TypedePrise</th>
</tr>
</thead>
<tbody>
<tr>
<td>07/06/2016 11:38</td>
<td>07/06/2016 13:31</td>
<td>CU-BAT1011-13CEA-3</td>
<td>07/06/2016 13:31</td>
<td>7490E56D</td>
<td>75873</td>
<td>80847</td>
<td>T2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>08/06/2016 06:15</td>
<td>08/06/2016 11:43</td>
<td>CU-BAT1511-13CEA-3</td>
<td>08/06/2016 11:43</td>
<td>CE14E7E</td>
<td>74156</td>
<td>76878</td>
<td>T2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>08/06/2016 11:47</td>
<td>08/06/2016 11:52</td>
<td>CU-BAT1011-13CEA-3</td>
<td>08/06/2016 11:52</td>
<td>7490E56D</td>
<td>80906</td>
<td>81679</td>
<td>T2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>08/06/2016 12:02</td>
<td>08/06/2016 13:46</td>
<td>CU-BAT1011-13CEA-3</td>
<td>08/06/2016 13:46</td>
<td>7490E56D</td>
<td>81679</td>
<td>91062</td>
<td>T2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>08/06/2016 12:22</td>
<td>08/06/2016 17:17</td>
<td>CU-BAT1011-13CEA-2</td>
<td>08/06/2016 17:17</td>
<td>D527CEE3</td>
<td>29009</td>
<td>35782</td>
<td>T2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>08/06/2016 12:34</td>
<td>08/06/2016 15:23</td>
<td>CU-BAT1511-13CEA-3</td>
<td>08/06/2016 15:23</td>
<td>85F1D2E3</td>
<td>76878</td>
<td>81364</td>
<td>T2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>08/06/2016 12:42</td>
<td>08/06/2016 12:57</td>
<td>CU-BAT8371-13CEA-2</td>
<td>08/06/2016 12:57</td>
<td>6468EB6D</td>
<td>2686</td>
<td>3142</td>
<td>T2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>08/06/2016 12:59</td>
<td>09/06/2016 08:38</td>
<td>CU-BAT8371-13CEA-6</td>
<td>09/06/2016 08:38</td>
<td>6468EB6D</td>
<td>3145</td>
<td>66192</td>
<td>T2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>08/06/2016 13:04</td>
<td>08/06/2016 13:08</td>
<td>CU-BAT8371-13CEA-6</td>
<td>08/06/2016 13:08</td>
<td>6503DCE3</td>
<td>765</td>
<td>1566</td>
<td>T2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Energy Consumption (kWh) = (IF – ID) / 1000

Transaction Duration (h) = (HD – HF)

Unreliable
GLOBAL STATISTICS

Period 01/06/2016 to 31/05/2020:
- 17045 transactions
- Sum of consumptions: 253.2 MWh
- ~1500000km @17kWh/100km
- 252 t de CO₂ avoided

Results

<table>
<thead>
<tr>
<th>Technology</th>
<th>CO₂ emissions per km</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric</td>
<td>65 g</td>
</tr>
<tr>
<td>Diesel</td>
<td>233 g</td>
</tr>
</tbody>
</table>

For more details on the assumptions and the methodology, please see T&E’s explanatory note.
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STATISTICS ON TRANSACTIONS

<table>
<thead>
<tr>
<th>Energy consumption (kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transaction Duration (h)</td>
</tr>
</tbody>
</table>

- 50kWh (Zoé 2)
- 1 day
- 1 month
Mean of the energy consumption per transaction: 14.8 kWh

Energy consumption (kWh)
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STATISTICS ON TRANSACTIONS

Full workday charging i.e.
- start after 7h and finish before 17h the same day
- and charge duration greater than 7h
  (743 occurrences (4.7%))

Full night charging i.e.
- start after 15h and finish before 9h the following day
  (430 occurrences (2.7%))
Mean of the transaction duration: 12.4h
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STATISTICS ON TRANSACTIONS

Energy consumption (kWh)

EC = Power (kW) * TD

Transaction Duration (h)
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DEFINITIONS : PARAMETERS OF CHARGE

Max Charging Power

Mean charging power

Energy Consumption

Real Charging Power = PCR => not recorded; could be estimated

Transaction duration = DT = HF - HD => recorded in the transaction file

Energy Consumption = EC = ID - IF => recorded in the transaction file

Battery capacity = Max of energy consumption = ECMax => depends on the EV model

Max Charging Power = PCM => depends on the EV model

Mean charging power = PCMean = EC/DT => can be calculated
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EXAMPLE : ALL THE ZOE

Zoe charging @ 22kW (mode 3)

Zoe charging @ 7kW (mode 3) or another vehicles?

Zoe charging @ 2.3kW (mode 2)

Flex= 4.8h?
Flex= 8.4h?
Flex= 9.6h?
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EXAMPLE: ALL THE LEAF

Leaf charging @ 6.7kW (mode 2)

Leaf charging @ 2.3kW (mode 2)
EXAMPLE: ONE GOLF GTE (PHEV)

Estimation of PCM = 1.1 kW (mode 3 with T2 connector)

EC/PCM (kWh)

Flex = 6.5h

TD (h)
In France,
Winter : Local hour = UTC+1
Summer : Local hour = UTC+2
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START/END OF TRANSACTIONS : SERVICE VEHICLE

« midday » charge
START/END OF TRANSACTIONS : PERSONAL VEHICLE

Full workday charge

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MEAN CHARGING POWER HYP. : PRINCIPLE OF RECONSTRUCTION

\[ PMC(t_n) = \frac{\text{Energy consumption } n}{\text{Transaction duration } n} \]

- Stand by energy
- Stand by duration
- Energy consumption n
- Transaction duration n

Transaction n-1

Stand by

Transaction n

13/12/2018 20:14:35
21/12/2018 15:31:02
21/12/2018 16:41:32
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MEAN CHARGING POWER HYP. : EXAMPLES

PdC: CU_BAT1011_13CEA

Index (wh) in blue
10*mean power (w) in red
MEAN CHARGING POWER HYP. : INDEX CURVES

Energy indexes of the 81 charging stations (Wh)
Total of the mean power for 81 charging stations (year 2018)

1 week

center closed
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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.
MAX CHARGING POWER HYP.: LOAD CURVES

Charging power curves during 2 weeks:

![Charging power curves chart](image-url)
Charging power curves during 3.5 years:

![Charging Power Curves](image)
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• The user connects his EV and passes his badge
• The supervision software sends an SMS inviting the user to confirm his departure time and the SOC of his car (default values are proposed).
• The EV is supplied with a test profile.
• Optimization and recharging are made on the basis of these data
 SOFTWARE ARCHITECTURE

Users and EVs database

PV Plant

Charging infrastructure

OCPP
ChargeBoxes

Set up
Follow up
Results
analysis

Web portal

Energy systems detailed description (CIM)

Measurements, Forecasts, Setpoints, external data

Calculated data, set points

Input/output config data

Simu/optim config data

User management

Input module

evsem

API – Application Programming Interface

Simulation

Optimisation

Ad hoc analysis (/battery ageing)

Users and EVs database

SIGE

Web portal

Energy systems detailed description (CIM)

Measurements, Forecasts, Setpoints, external data

Calculated data, set points

Input/output config data

Simu/optim config data

User management

Input module

evsem

API – Application Programming Interface

Simulation

Optimisation

Ad hoc analysis (/battery ageing)

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RECALL AUTOCONSUMPTION/AUTOPRODUCTION

Network + Production = Consumption

Optimisation process: maximize

selfproduction rate = (PV & consumption) / consumption
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USER INTERFACE (WEB PORTAL)

View « charging station functionning »
Simulation results

Max charging power
Mean power
Smart charging (120kWc)
PV production (120kWc)
FIRST TESTS

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REFERENCES / SOURCES

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Thank you for your attention