“Energy management based on urban micro-grid multi-source network. Coordination between energy sources and smart control strategies for system efficiency and reliability”

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Outline

- IFSTTAR outlook and institute research tasks
- Fast EV- Recharging : the Mov’eo TREVE concept (up to 200kVA)
- Need of smart, predictive and coordinated control approaches
- Towards the concept of the electrical docking station
- Highlights on two other research activities :
  - Development of mechatronic test facilities for EV powertrain traction-braking urban constraints experiments and associated predictive control
  - EV powertrain linked to testing of driving assistance concepts.
Ifsttar key data

- 1250 employees (researcher scientists, administration, Ph.D students, people under contract)
- 8 locations en France
- 25 Research units
- Budget 120 M€ (2011)
- 15 M€ of research contracts
- 59 European projects EU FP7
Transport & Mobility
Task 1: Analysis and innovation for sustainable and responsible transport and mobility.

Infrastructure
Task 2: Constructing, deconstructing, preserving and modifying infrastructure efficiently and sustainably.

Hazards and the environment
Task 3: Taking better account of climate change, natural hazards and environmental and health impacts in man-made environments.

Spatial planning
Task 4: Designing and planning sustainable cities and regions: systemic and multi-scale approaches.

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Test of EV-recharging: the *Mov’eo TREVE* concept on the Versailles Satory area: a platform …

- for the **Qualification** and **Validation** of charging and recharging plugs (V2G, G2V, V2I)
- for **Research activities** on **inductive recharging** concept
- oriented towards the energy management concept of **future electrical station-service**
- built as a first step for experimental research on… **dynamic inductive charging** (project R5G IFSTTAR…) and station-recharging for urban transport.
- Research projects on 48 months (2014 – 2017)
Today the reversible mode is working…
Grid to EV to Grid : G2V or V2G

The Charging station converter assumes the respect of the rules on Quality (PFC) and Safety
Mov’eoTREVE concept of testing platform for fast EV Recharging technologies

Power adjustment
network reinjection

Renewable energy
PV plant

Building load

Energy storage

Direct
connection

Induction
Lot 3

Smart grid Lot 4

smart and predictive control laws

Platform – Lot 1

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Electrical architecture for EV & HEV Urban Recharge Service Station
Coupling to renewable energy generators

Multi-level energy fluxes vs. profiles

High Voltage Electrical Grid

Electrical Power Station
Energy Storage System
Recharge station

Building

PV panel

Fuel cell MCG

Micro cogeneration
“Efficacy project”

AC 43kVA Charging Stations

DC 50-120kW Charging Stations

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EDF AC network
400V / 50 Hz

Variable DC bus
400 – 650V max

Current reversible
150A à 300Arms

AC network
100 à 400Hz

3-phase Synchronous actuator
60kW

Flywheel

Level 1 regulation stage:
Working scenarios and cycles

Ref. PWM modulator
(8 to 10 kHz)

Measured variables

Level 0
corrector

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Example of electrotechnical regulation Level 1 to Level 0 of one subsystem of the power plant

Battery → 3-phase H-Bridge inverter → AC Motor

Level 0

Algorithm SVPWM (FPGA-Based)

Level 1

Concordia → Park → Torque control (DTC)

Inertial Load

\[ i_d^* = 0 \]

\[ i_q^* = 0 \]

\[ v_a^* \]

\[ v_b^* \]

\[ v_0^* \]

\[ v_d^* \]

\[ v_q^* \]

\[ \frac{1}{\sqrt{3} \cdot K} \]

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Example of regulation Level 1 to Level 0 of one subsystem of the power plant

**Level 1 regulation stage:**
Power regulation of subsystem

References

\[ I_1^* = \frac{P_1}{V_1} \quad I_2^* = \frac{P_2}{V_2} \quad I_n^* = \frac{P_n}{V_n} \]

In case of a fault

**Reconfiguration strategy**

**Level 0**

PWM modulator or SVPWM
(8 to 10 kHz)

FPGA

\[ I_{\text{measured}} \]

\[ K \]
Test platform Mov’eoTREVE / FABRIC Static / Dynamic charging stations

Versailles Satory location
Sharing space & test equipments

Test platform
Static charging station
Mov’eoTREVE

Test track
Dynamic charging station

Bunker Lab.
Déptl GE MT1

Charging Test
PV panel shade
Concrete slab

Wall “Champ de tir” Satory

Green area
Existing track

5 m 19 m 28,8 m
Focus on the electric vehicle charging site

Power sub-station 200 kVA
Mov’eo-TREVE
EV charging testing platform

Low speed test ≤ 20 km/h
High speed test 50-80 km/h

Dynamic inductive charging track for FABRIC

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Achievements in Task T3.2/T3.4

- IFSTTAR LTN develops mechatronic test facilities for EV powertrain traction-braking urban constraints experiments and associated predictive control

- Fully secured environment: bunker lab.
- Modular EV powertrain architecture
- 70 kW up to 100 kW power level + network reinjection.

- Motor/Generator group MECALIX 100kW
- High speed mechanical wheel as a load

Establish control laws and reconfiguration strategies in case of critical failure (short-circuit, open circuit, machine phase fault) + predictive control approach for electro-mechatronic systems
Achievements in Task T3.2/T3.4

- IFSTTAR contribution (New technologies Laboratory) to WP3 with cooperation with IFSTTAR LIVIC and Cnrs L2S Supélec
  - designing a modular test bench for drive functionalities of an EV powertrain and linked to testing of driving assistance concepts (ABS, regenerative braking testing…) within the REGENEO project.

![Diagram of the test bench](image)

**Test bench in its preliminary development stage**

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References linked with Hycon2:


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