FABRIC

Feasibility analysis and development of on-road charging solutions for future electric vehicles

Dynamic wireless charging for more efficient FEVs: The FABRIC project concept

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Medpower 2014, Athens
04-11-2014

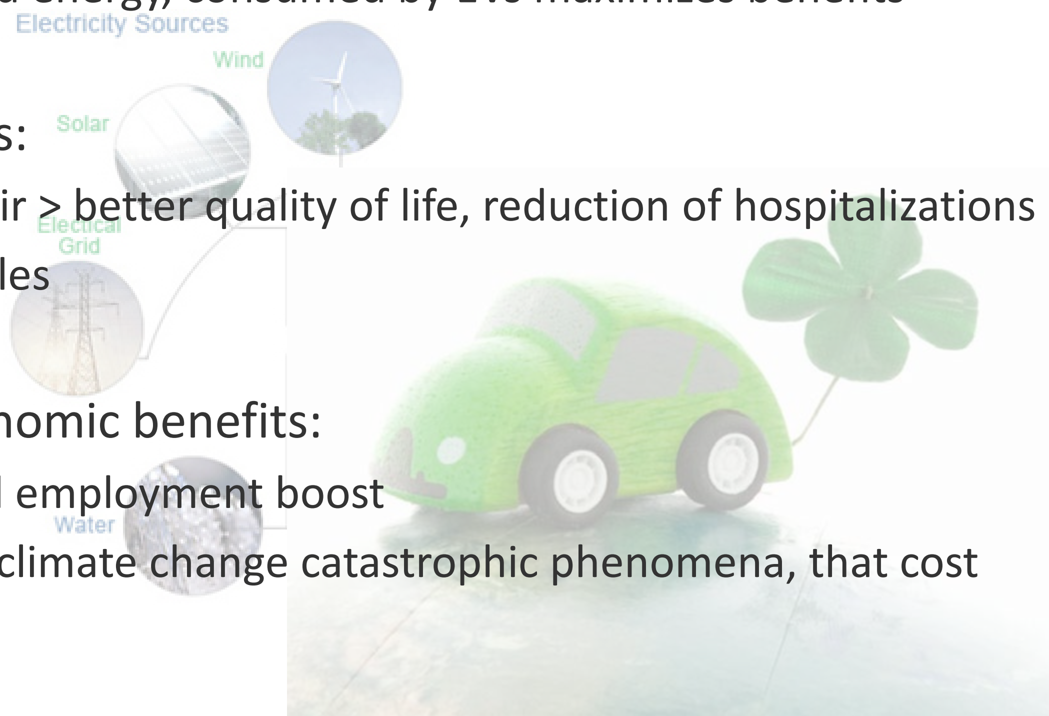
ΕΠΙΣΕΥ ICCS

Electromobility

- Electromobility or electric mobility or e-mobility is the propulsion of vehicles using electricity instead of conventional fuel.

Why Electromobility? – Social benefits

- Environmental benefits:
  - Minimization of vehicle produced air pollutants
  - Benefits increase with the cleanliness of the power production process
  - RES-produced energy, consumed by EVs maximizes benefits
- Societal benefits:
  - Cleaner city air > better quality of life, reduction of hospitalizations
  - Quieter vehicles
- Large-scale economic benefits:
  - Industrial and employment boost
  - Reduction of climate change catastrophic phenomena, that cost billions



Why Electromobility? – Grid benefits

- EVs as distributed energy storage.
- Greater penetration limits for RES.
- Bi-directional power transfer.
- Reduction of energy production costs via supply/load shaping.

Global initiatives towards electromobility

- **NORTH AMERICA**
  - The US Transportation Electrification Program represents the world's largest EV demonstration project. $400 million funding. Target: 1 million plug-in EVs by 2015. $4 billon funding for clean transport research.

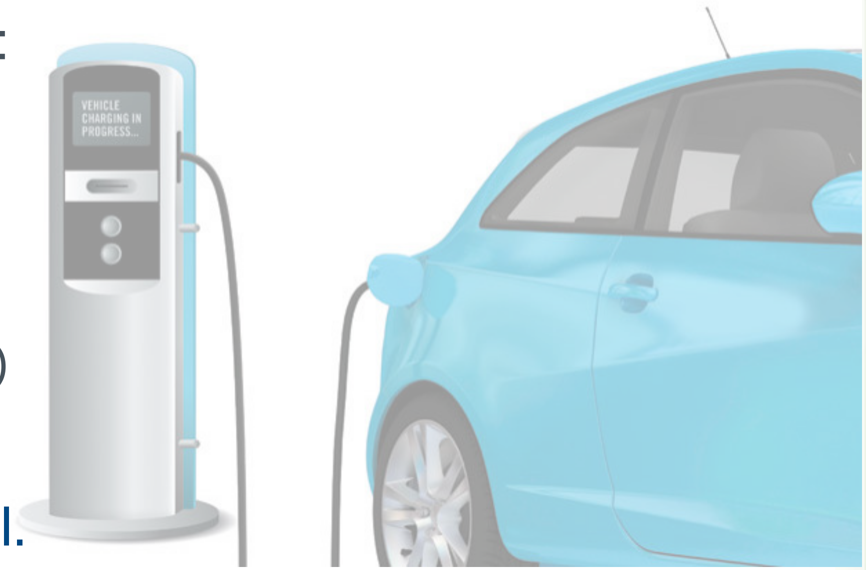
- **ASIA**
  - China, Japan, Korea: government incentives, regulations promoting awareness and adoption of EVs.
  - Toyota, Nissan, Honda, Mitsubishi joint development of charging infrastructure. Target: 8000 new normal chargers, 4000 new fast chargers.

- **EUROPE**
  - 2013 European Parliament resolution requiring member states to install a specified number of EV charging stations and hydrogen and natural gas stations by 2020. Targets: Germany 86000, Italy 72000, UK minimum of 70000.
  - Many EU funded R&D projects: EcoFEV, UNPLUGGED, FABRIC…
  - Several national projects: Fastned (NL), ELMO (EE), CLEVER (DK)…

Roadblocks for large scale electromobility adoption

EVs as percentage of the whole fleet:

- France 0.83%
- US 0.62% (96000 sold in 2013)
- Japan 0.59%
- Germany 0.25% (7400 sold in 2013)



Current penetration of EVs very small.
Reasons:

- Weight and size of batteries.
- Cost of battery manufacturing.
- EV price premium over conventional vehicles.
- Small or non-existent charging infrastructure network.
- Long duration of charging.
- Plugging the EV in is not a user friendly experience.

Solutions:

- ITS
- Novel charging technologies

ITS solutions facilitating electromobility

- Accurate range estimation.
- Robust travel planning.
- User convenience.
- Use of smaller batteries.
- New charging technologies (e.g. dynamic charging).

Why wireless charging

- Allows EV charging while travelling (dynamic) or during short stops ideal for urban environment (stationary)

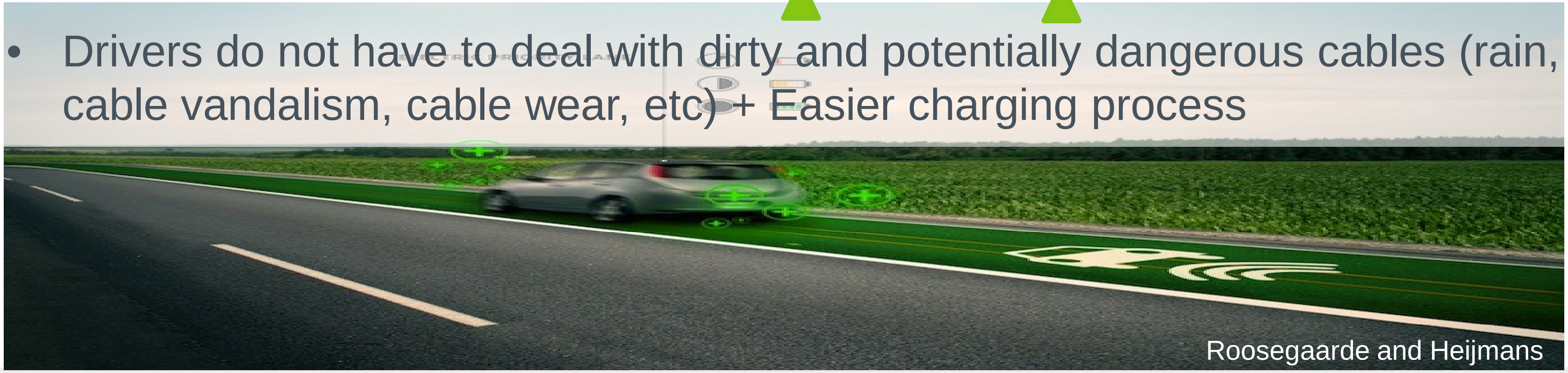
Increased range → Reduced range anxiety

Smaller batteries → Cheaper EVs

Increased mobility

No visual pollution

Driver benefits: Reduced range anxiety | Cheaper EVs | More comfort | Safer

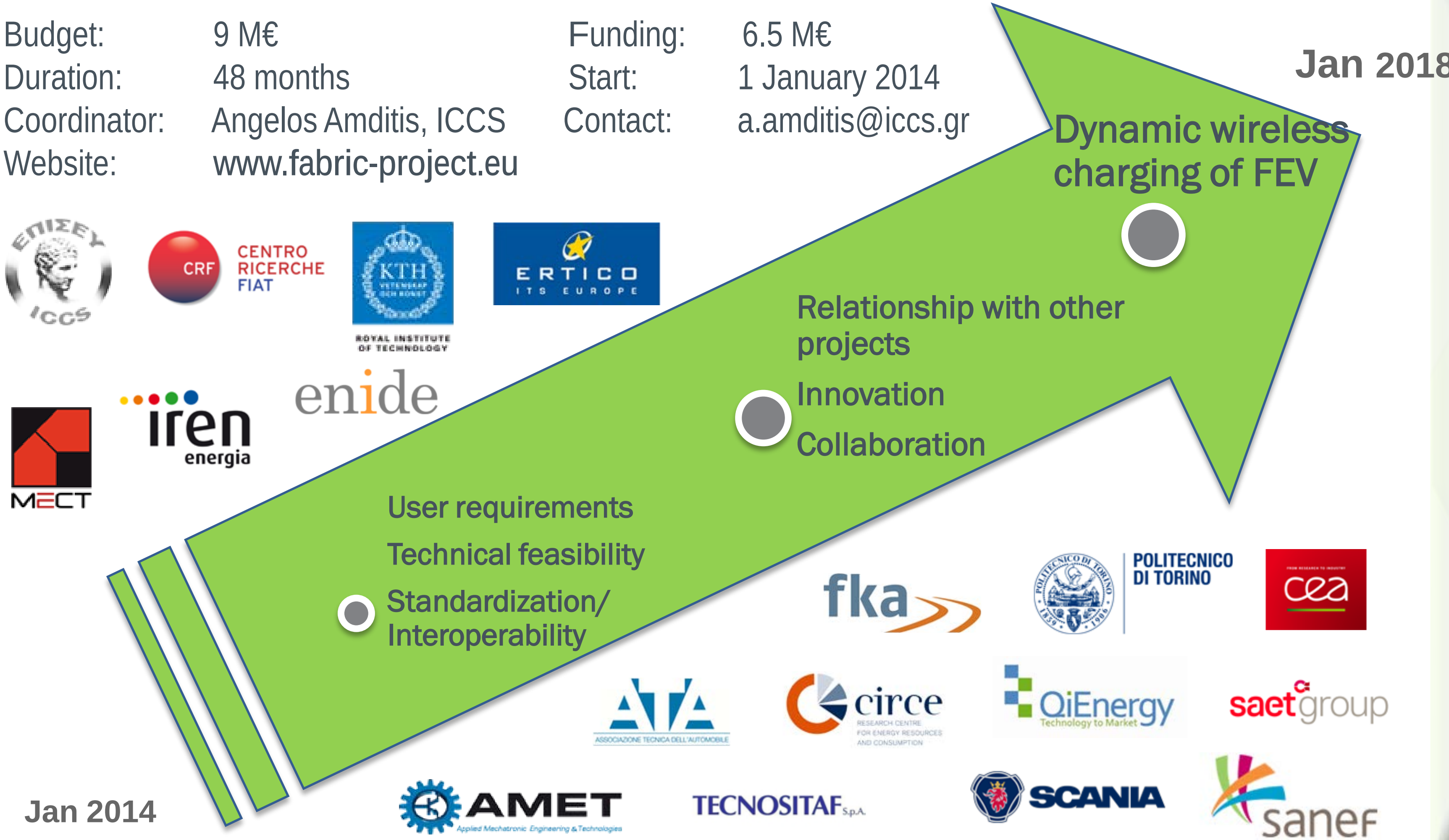


- Drivers do not have to deal with dirty and potentially dangerous cables (rain, cable vandalism, cable wear, etc) + Easier charging process

Roosegaarde and Heijmans

FABRIC Integrated Project

Budget: 9 M€
Duration: 48 months
Coordinator: Angelos Amditis, ICCS
Website: www.fabric-project.eu
Funding: 6.5 M€
Start: 1 January 2014
Contact: a.amditis@iccs.gr



EV charging modes (I)

Static (now)

- Example application scenarios:
  - Car parking in a garage or car park.
  - Bus parking at a bus terminus or station.
  - Freight vehicles while loading or unloading.

Parameter	Range	Comments
Vehicle speed (km/h)	0	Mode applicable if stationary for longer than 5 minutes
Vehicle acceleration (m/s^2)	N/A	
Transmitted power level range (kW)	3 to 50	
Power transmitted to which component	N/A	Power transmitted to the vehicle on-board energy storage system only
Charging time (minutes)	>5	Upper limit of charging time is subject to use, power rating and vehicle on-board energy storage system capacity
Vehicle status	N/A	Vehicle engine / power will generally be off during charging (but may be on for a short time while initiating coupling / charging process)

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EV charging modes (I)

Full battery recharging < 1hr

EV charging modes (II)

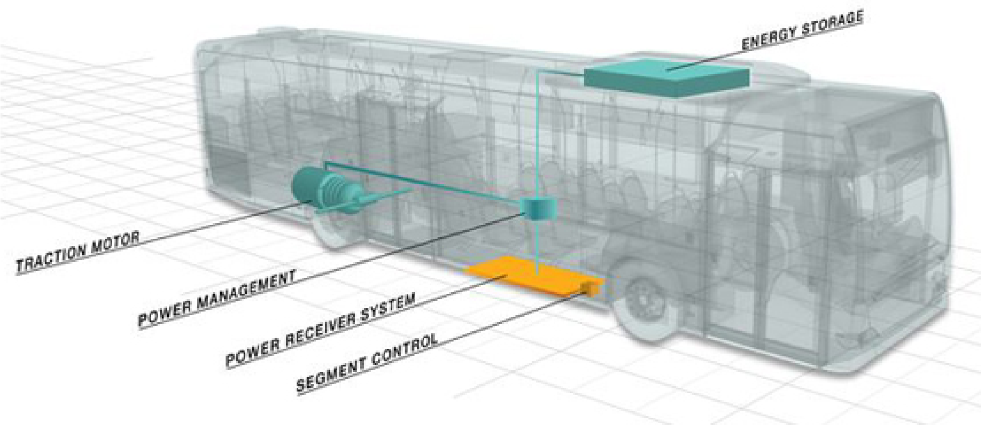
Stationary (near future)

- Example application scenarios:
  - Taxis queuing in a taxi rank
  - Bus stopping at bus stops
  - Vehicles stopping at junctions, rail level crossings, etc…

Parameter	Range	Comments
Vehicle speed (km/h)	0	Mode applicable if stationary for less than 5 minutes
Vehicle acceleration (m/s^2)	N/A	
Transmitted power level range (kW)	20 to 200	
Power transmitted to which component	N/A	Power transmitted to the vehicle on-board energy storage system only
Charging time (minutes)	<5	Upper limit of charging time is subject to use, power rating and vehicle on-board energy storage system capacity
Vehicle status	N/A	Vehicle engine / power can be on or off depending on the vehicle powertrain control and exact application

EV charging modes (II)

Operational in Braunschweig, Germany since 2013
200kW inductive stationary charging



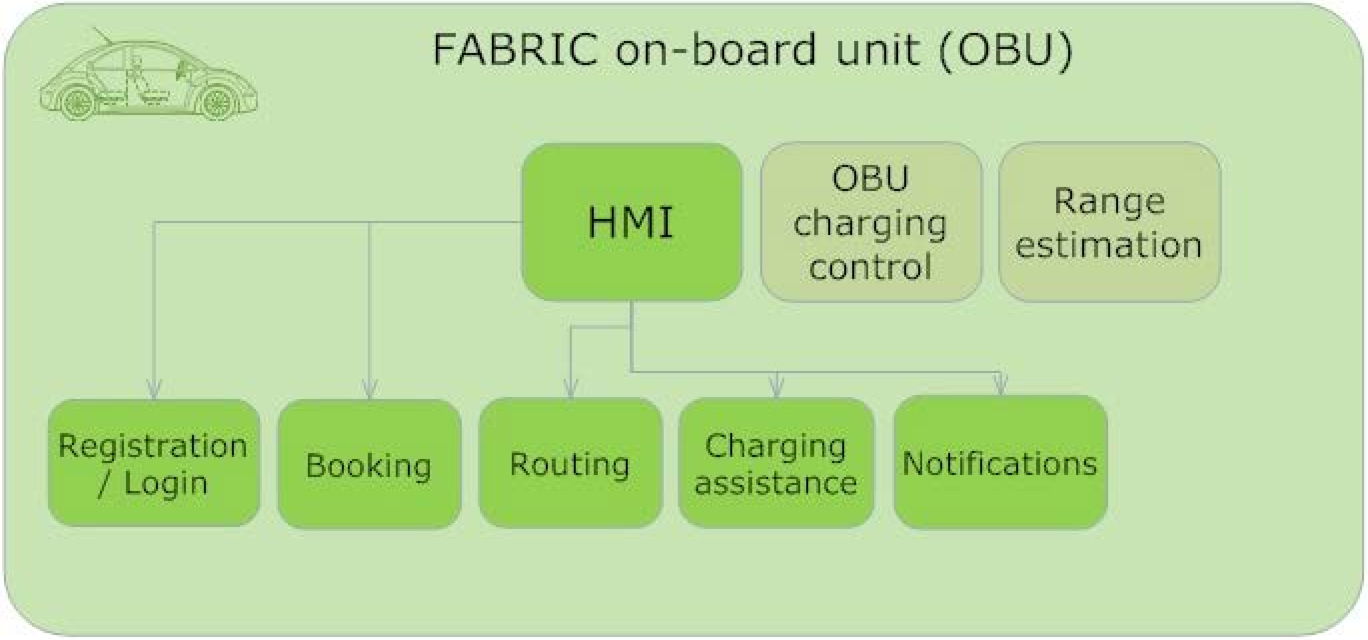
EV charging modes (III)

Dynamic (distant future)

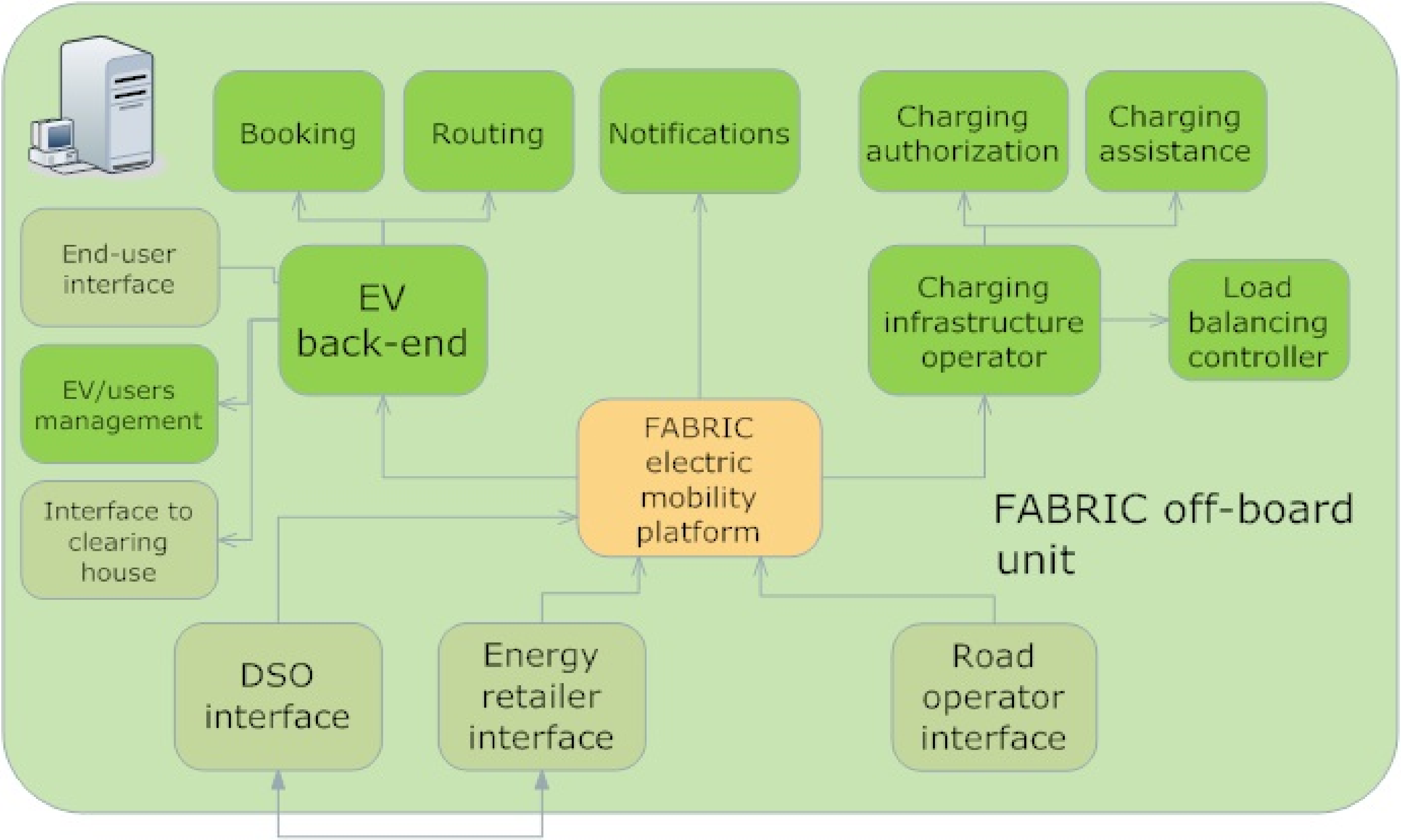
- Example application scenarios:
  - Highways (multiple lanes).
  - Urban roads with dedicated charging lanes.
  - Dedicated vehicle type, mode lanes.

Parameter	Range	Comments
Vehicle speed (km/h)	0 < v < 130	
Vehicle acceleration (m/s^2)	-	Range covers possible accelerations of vehicles ranging from cars to trucks
Transmitted power level range (kW)	20 to 360	
Power transmitted to which component	N/A	Power transmitted either to the vehicle electric drive or, to the on-board energy storage system or, both
Charging time (minutes)	<5	Depends on vehicle speed and dimensions of the primary charging infrastructure.
Vehicle status	N/A	Vehicle engine / power is on during the power transfer process

FABRIC preliminary ICT architecture (I)

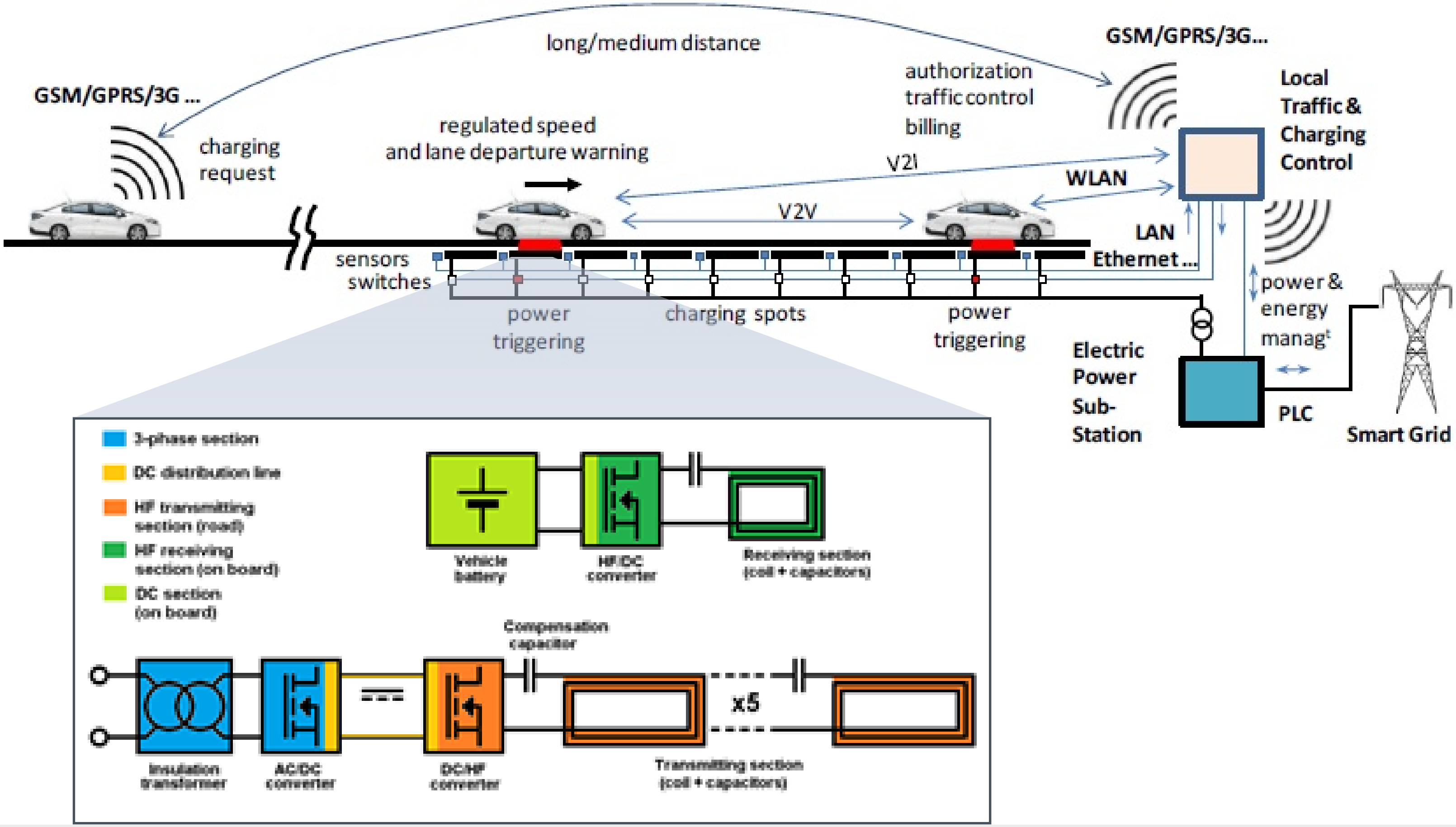


FABRIC preliminary ICT architecture (II)



FABRIC prototypes – POLITO, IT (I)

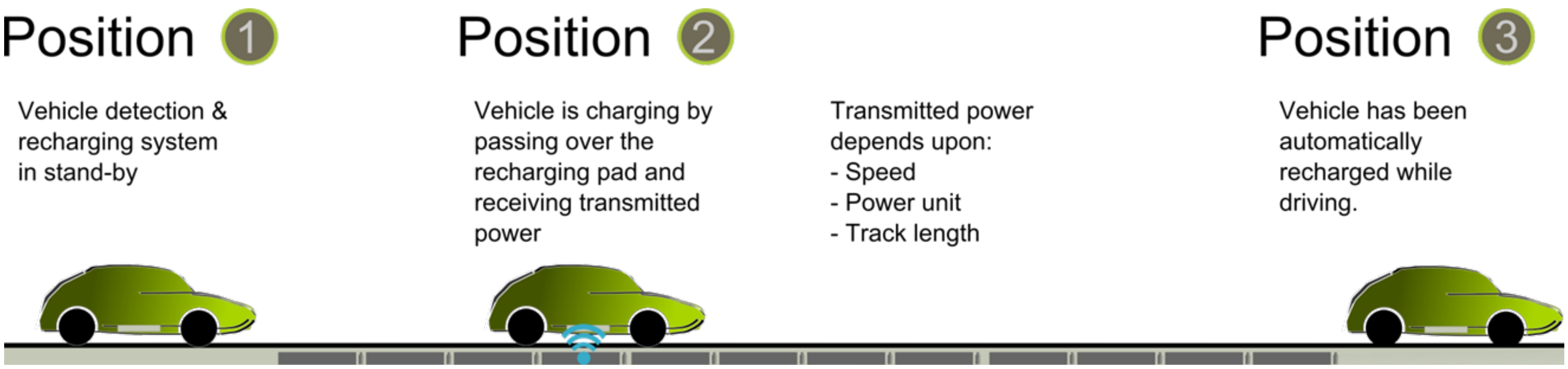
Development of dynamic charging prototype no1 – Italy (POLITO, CRF)
- 200m test track, 20kW, ~150kHz



FABRIC prototypes – SAET, IT (II)

Development of dynamic charging prototype no2 – Italy (SAET)

- *50m, 10-150kHz load-resonant power frequency*



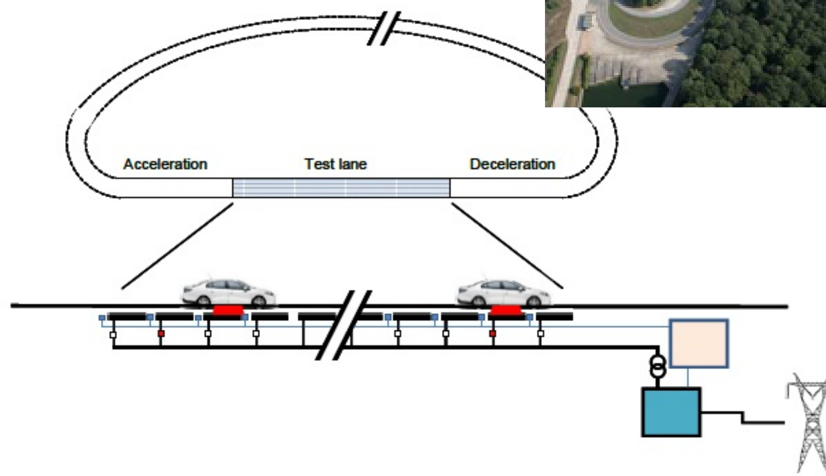
Source: SAET

FABRIC prototypes – VEDECOM, FR (III)

3. Development of dynamic charging prototype no3 – France (QUALCOMM, VEDE (IFSTTAR, RENAULT, PSA PEUGEOT CITROËN, IFP Energies nouvelles, ParisTech, INTEMPORA))

- *100m test track, QUALCOMM charging pads in series, 85kHz, >20kW*

Qualcomm halo
Wireless Electric Vehicle Charging



Dynamic charging challenges (I) - Road

Road adaptation – electrification

- Initial investment
- Maintenance costs
- Lifecycle assessment
- Traffic impact assessment

Dynamic charging challenges (II) - Grid

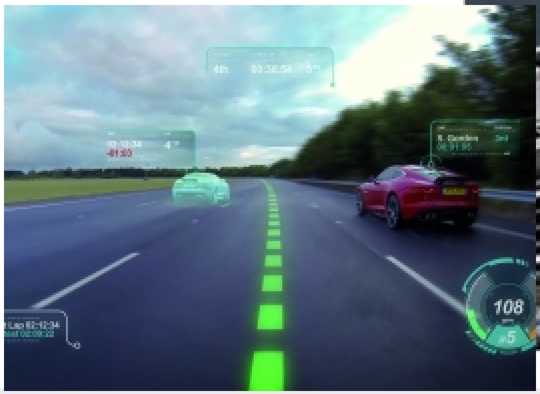
- **Increased demand**
  - RES penetration increase necessary
  - Investments on new base units
  - Incentives to charge during off-peak hours
    - Need for robust communication network with the end users

- **High frequency demand fluctuations**
  - Need for energy storage systems
    - Size, cost and feasibility assessment

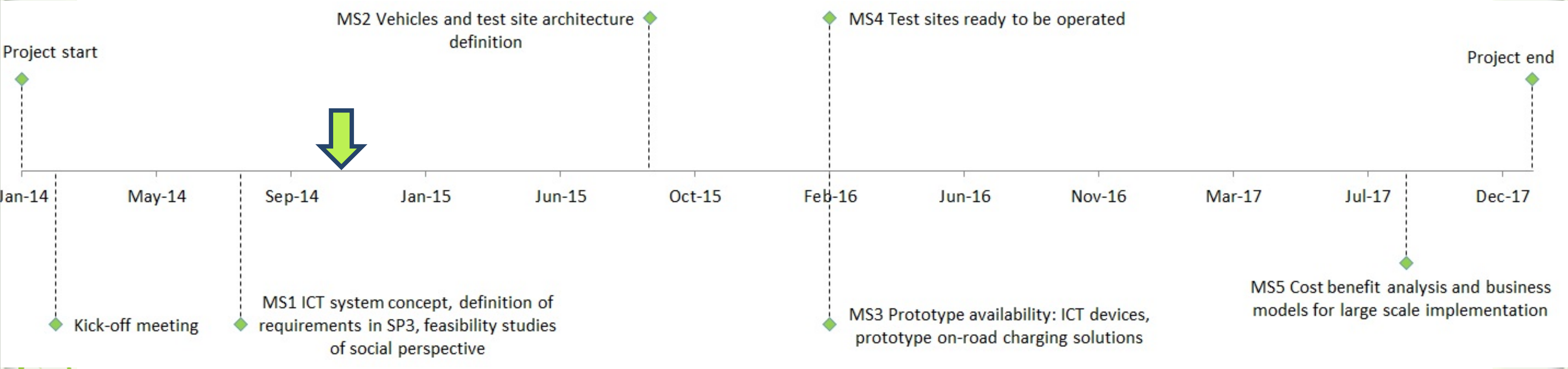
- **Smart grid necessary**
  - Potential new security vulnerabilities

Dynamic charging challenges (III) - ICT

- Need for fast (real time) V2I communications
- Real time load balancing and charging management
- Unobtrusive, non-distracting user interfaces



FABRIC major milestones



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Thank you!

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