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

Minutes of

FABRIC Workshop meeting

Validation of most promising scenarios related to an extensive adoption of on-road charging solutions for EVs (dynamic charging)

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LIST OF PARTICIPANTS

No.	NAME	ORGANISATION	POSITION	FABRIC partner	External participant
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2	Andrew Winder	ERTICO	Project Manager	X	
3	Feng Chen	KTH	Department of Civil and Architectural Engineering	X	
4	Juan de Blas	QI EUROPE	Partner	X	
5	Javier Medina	QI EUROPE	Partner	X	
6	Giovanni Dotelli	POLIMI	Associate Professor, Chemical Department	X	
7	Benedetta Marmiroli	POLIMI	Senior Scientist at Institute of Inorganic Chemistry	X	
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MEETING AGENDA

09:40	**Welcome coffee**
10:00	**Overview of the FABRIC project** • Dr. Angelos Amditis (ICCS, FABRIC Coordinator)
10:10	**Introduction to the Assessment in FABRIC** • Dr. Feng Chen (KTH, SP5 leader - Assessment)
10:20	**Workshop objectives and methodology** • Mr. Andrew Winder (ERTICO)
10:30	**Section 1. E-corridors Demand and assumptions** • Mr. Juan de Blas (QI Europe, Workshop Coordinator and task leader)
10:45	**Discussion**
11:10	**Section 2. Life Cycle Costing (LCC) and Life Cycle Assessment (LCA)** • Mr. Juan de Blas (Qi Europe). LCC • Mrs. Benedetta Marmiroli (Politecnico di Torino / Milano). LCA
11:40	**Discussion**
12:10	**Section 3. SWOT Analysis and Supply Chain impact** • Dr. Panagiotis Lytrivis (ICCS). SWOT – Strengths, Weaknesses, Opportunities, Threats • Mr. Andrew Winder (ERTICO). Supply Chain
12:30	**Elaboration of SWOT table in small groups**
13:00	**Lunch: S'Wacke Hiesel restaurant and close**

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MINUTES

Note that slides are available for each presentation at the FABRIC website so please refer to these for further details.

10:00 Overview of the FABRIC project by the Coordinator, Dr. Angelos Amditis *(ICCS - Institute of Communication and Computer SystemsGreece)*

Dr. Amditis introduced the different technologies for electric vehicle charging explaining the pros and cons (plug-in static, conductive dynamic and inductive dynamic). The goals of the workshop were then described, can be summarised as:

- Raising awareness of current project findings
- Identifying the drivers and barriers towards implementation of on-road charging
- Bringing together experts and technicians.

He also explained the current situation of the FABRIC project, indicating that it is now in the full implementation phase of first specific scenarios and the topics to be validated in the workshop:

- Life-Cycle Cost (LCC);
- Life-Cycle Analysis (LCA);
- Strengths, Weaknesses, Opportunities, Threats (SWOT) Analysis;
- Demand for e-roads forecast;
- Concerns.

10:10 "*Introduction to the assessment in FABRIC*", Dr. Feng Chen *(KTH – Royal Institute of Technology, Sweden)*

Dr. Chen substituted the FABRIC SP5 Leader (Prof. Sebastiaan Meijer, KTH). He explained the major challenges faced by the FABRIC project to be discussed and validated at the Workshop. He drew special attention to the following uncertainties:

- Consequences for owners / operators;
- Traffic patterns: few changes on routing and demand;
- Lock-in effects of choosing a particular technology;
- EMF questions need pro-active proof of safety;
- Is the local / regional grid capable of providing the power?

Some other questions were also mentioned:

- What goal(s) should an e-Road deployment fulfil?
- Is the e-Road a public infrastructure or a private solution?
- How to deal with uncertainty on other tech developments?
- Who is going to pay what, for which benefits (and drawbacks)?

10:20 "*Objectives and methodology*", Andrew Winder *(ERTICO – ITS Europe, Belgium)*

The context of the workshop in the assessment phase of FABRIC was introduced, including the types of information provided in the workshop and the expected input from participants. The workshop objectives and methodology were mentioned again in more details.

10:30 Section 1. "*E-corridors demand and assumptions*". *Juan de Blas (QI Europe, Spain)*

Juan de Blas explained the factors affecting the demand for future e-corridors (roads offering dynamic on-road charging facilities):

- E-corridors are directly related to the demand for (and deployment of) electric vehicles (EVs). A critical mass of EVs is needed to justify the considerable cost of construction of e-corridors, especially on motorways. The FABRIC project has estimated a disruptive penetration of electrification on roads in the coming years in line with the most optimistic scenarios.
- There are many potential scenarios but only three of them have been selected as entry points (see below).
- The FABRIC project has highlighted the following affecting factors (among others): political incentives and support, market niches models, end-user's decision making, costs-benefit analysis and competing innovative technologies.

The three main scenarios selected as entry points are:

- Urban buses: Expected massive deployment in 2030. They have their own lane in the cities. Those cities already with trolleybuses could make use of their current electric catenary infrastructure.
- Heavy duty goods vehicles close to cities from logistic centres to the city centre or connecting cities at distances of around 200-300 km. Expected deployment in 2040.
- Light vehicles foreseen for 2050 onwards on major motorways with dense traffic using a lateral green corridor (TEN-T working group is promoting a green lane in major motorways of Europe). The e-corridors will be placed within the green corridors or beside them in a dedicated e-lane for dynamic charging with a length of 25 km. Distances of 500 km will be perfect with one or two corridors in between to provide extended range to EVs.

The two battery strategies were highlighted:

- Reduction of battery size for heavy goods vehicles and buses.
- Keep the current size of the battery, allowing a range extension for light vehicles autonomy with the e-corridor facilities.

Juan de Blas raised some potential discussion points on assumptions:

- Technology inside EVs;
- E-road technology;
- Competing technologies (fast chargers, battery swapping, range extender trailers, etc). Different situations for trucks, light vehicles, etc.;
- Associated costs;
- Business scenarios;
- Will conventional (internal combustion engine) vehicles also be able to drive in the e-lane?
- What will the traffic vehicles be?
- The distance between consecutive EVs in the e-corridors is important for the business model
- Average speed on the e-corridors?
- Self-driving EVs on the e-corridors for efficient charging and optimal headway (keeping safe inter-vehicle distance)?
- Conductive dynamic charging?
- Battery prices?
- E-corridors costs?
- Oil prices evolution?
- Depreciation period?

Summary of the topics/issues raised and/or highlighted during the audience discussion that followed (anonymised):

- Power Transfer technology in winter is an issue.
- 11 to 15kW/h is needed for auxiliary services like heating, air conditioning, headlights, radio, etc.
- Agree with the range extender concept.
- If you increase speed to 120 km/h or more, consumption will go up dramatically. So will need at least 50kW/h for dynamic charging.
- Which users will use it? The scenarios for market penetration presented seem extremely optimistic.
- Many countries provide incentives for EVs purchase but some people are looking to other competing technologies.
- People will use cars, but not necessarily own them in the future. Globalisation concept. A new way of thinking is difficult to analyse in advance.
- Scenarios will differ widely depending on countries. Some simply do not have the resources to invest in these facilities in roads (or provide incentives for buying EVs).
- For higher speeds (100+ km/h) there is a need for a lane keeping system to avoid misalignment (unless there is automated driving). ADAS (Advanced Driver Assistance Services) are relevant here.
- What about distance between the cars? There is a need to keep a minimum distance but if cars are too close then too much power will be required. The legal safe headway is 2 seconds between vehicles (so at 120km/h, that is a minimum inter-vehicle distance of 66.67 metres).
- Road making technology is important. What if a road is hilly? Maintenance needs (new asphalt, etc.) also need to be considered.
- The price to the user should be 10 euro or less for a 25km charge, otherwise it will not be attractive to users, who will recharge using other less expensive means (static).
- We need different technologies for different solutions.

11:10. Section 2. "*Life Cycle Costing*". Juan de Blas *(QI Europe, Spain)*

- Preliminary LCC figures and assumptions were presented, showing the approach to analysis in Excel tables.
- One e-corridor of 25km, one lane, one direction and 25 years depreciation has been assumed.
- One external stakeholder considered that a 25 year depreciation period was not realistic.
- There are uncertainties regarding operation and maintenance of e-roads (pending data from TRL and POLITO).
- It is necessary to check costs from each partner's calculation and the expected income from e-corridors.
- How much will people pay to recharge in dynamic wireless mode?
- Between 7 and 10 euro was suggested, although it could depend on the power (kW/h) transferred as well as on the business model (at-cost or subsidised provision, provision as a service by a motorway operator, or private commercial operation which is required to repay investments and make a profit).

"Life Cycle Analysis (LCA)"*. Benedetta Marmiroli *(POLITO/POLIMI – Polytechnic Universities of Turin and Milan, Italy)

- The LCA study is in progress and is aligned with the LCC.
- A description of the LCA process was given.
- Future scenarios:
  - Battery downsizing
  - Change in the daily energy demand with respect to EVs without WPT? Increasing the peak demand?
  - Marginal electricity mix

- Increased number of EVs (also non-WPT equipped) with respect to Internal Combustion Engine Vehicles (ICEVs)
- Increased e-road travel demand (due to lower operational costs? Rebound effect)
- Traffic congestion (dedicated lane? Different maximum speed?)

12:10. Section 3. "*SWOT Analysis and Supply Chain impact*", Panagiotis Lytrivis *(ICCS, Greece)*
The methodology for the SWOT analysis was thoroughly presented by Dr. Lytrivis. The specific topics he focused in, were the following ones:

- Strengths (characteristics that give such technologies an advantage over other technologies);
- Weaknesses (characteristics that place such technologies at a disadvantage relative to other technologies);
- Opportunities (elements in the environment that such technologies could exploit to their advantage);
- Threats (elements in the environment that could cause trouble for such technologies).

In addition specific examples related to all the above categories were provided by Dr. Lytrivis to support the small group discussion that followed.

"Supply chain impact"*, Andrew Winder *(ERTICO – ITS Europe, Belgium)
Mr. Winder explained the purpose of the specific task within FABRIC and the scope that included the following elements: Transmitter (road), Receiver (vehicle), DC/DC converter (vehicle), Supercaps box (power room), AC/DC converter (power room). To get the information for the supply chain impact, a questionnaire was sent to key manufacturers asking them about the key bottlenecks, the level of competition (currently low), access to constitutive materials and market expectations for most important components. Questionnaire responses are limited and still coming in, but one stakeholder considered that a key barrier is the shortage of qualified and experienced technical staff in this rapidly developing technological area, and that this is a greater threat than potential unavailability of materials.

12:30. Elaboration of SWOT table in small groups
An exercise was organised distributing the participants in four groups that rotated around the room filling the following panels (strengths, weaknesses, opportunities and threats). Each group reviewed each of the four SWOT elements. Where possible, the likelihood and impact (high, medium or low for both) was estimated. The results are shown below.

Strengths	**Weaknesses**
• Solve anxiety problems / increase range (although this assumes there is a comprehensive network) *[Likelihood and impact high]* • No need to plug in *[Likelihood and impact high]* • Convenient and user-friendly procedure, saves time *[Likelihood and impact high]* • Consistent with autonomous driving *[Likelihood medium; impact high]* • Positive image (helps promote e-mobility and increase EV penetration) *[Likelihood high; impact medium]* • Potentially interoperable compared to plug-in	• EMF, EMI *[Likelihood and impact high]* • Low energy efficiency • Impact on infrastructure durability lifetime (for road and for systems like traffic control and switches) *[Likelihood and impact high]* • Retro-fitting • Technology maturity • Uncertainty on sustainability • Not cost-effective at this stage: high initial cost • No standards available (interoperability issue) • Health for humans • Battery technology maturity • No solid evidence for business case *[impact*

• Less visually intrusive than overhead catenary • Integration with smart grids (but demand might be uneven) • Safety (if there is more autonomous driving) • Smaller battery possible with a good range = lower cost for the user.	*high]* • Additional weight of vehicle • Safety issues (equipment below the car)
Opportunities • Possibility of local production (RES, GHG reduction…) *[Impact medium]* • Innovation potential for companies (SMEs) *[Impact high]* • Greening of transport and energy production • Road infrastructure in the future *[Impact high]* • Additional systems and businesses related to EVs (conductive) • Selling back power from vehicle to grid (conductive) • Integration with Mobility as a Service (MaaS) • Quicker trips, no need to stop.	**Threats** • Reduction of road capacity *[Likelihood and impact high]* • Alternative technologies (super-chargers, range extender trailers, battery swapping) *[Likelihood and impact high]* • Problems with dedicated lane *[Likelihood and impact medium]* • Interoperability of different systems *[Likelihood and impact high]* • EMF effects *[Urban: likelihood and impact high; Motorways: likelihood and impact low]* • EMI (electronic effects on equipment) *[Likelihood and impact medium]* • Different power transfer for heavy vehicles *[Likelihood high; impact medium]*