



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

Charging Solutions and Prototypes

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Agenda

1. Objectives of this part of the work
2. Description of the work done
3. User needs and requirements
4. Technical benchmarking
5. Specifications development
6. Architecture definition
7. Development of charging solutions
8. Verification and results

Key Objectives

1. To assess the requirements for an on-road charging solution
 - Use case based
 - Cost
 - Safety
 - Transferable power
 - Efficiency
 - Range
2. To identify necessary developments to meet the requirements
 - Feasibility of applying/modifying existing solutions
3. To design and develop charging solutions capable of meeting the requirements
4. How existing prototypes of on-road charging technology can be further developed and applied to other use cases.

Work Undertaken

1. User Needs and Requirements
 - Consider Road Owners, Grid Operators, Local Authorities, Vehicle Manufacturers, Safety
2. Technical Benchmarking
 - Review of existing solutions
 - Market Readiness
 - Gap Analysis
 - Interoperability
3. Specifications
 - Road Installation
 - Grid Connection
 - Vehicle Installation
 - Safety aspects



Work Undertaken

5. Define Architecture
 - Vehicle Equipment Architecture
 - In-road equipment architecture
 - Grid Interface Architecture
6. Design
 - Development of Test Case Systems
 - Assessment of applying the solutions to different use cases
7. Technological Verification
 - Define Testing Methodologies
 - Verification Tests
 - Analysis of Results



User Needs and Requirements

1. Road Owners and operators
 - Must not adversely affect existing road users
 - Installation and maintenance are crucial
2. Grid Operators
 - Likely highly variable demand will necessitate local storage
3. Local Authorities
 - Examined integration into local road structures
 - Will require strong cooperation and integration into local planning policy
4. Vehicle Manufacturers
 - Considered issues of integration into vehicle, compliance with existing and new standards and packaging issues
5. Safety
 - Compliance with existing safety standards crucial
 - Human exposure limits to electromagnetic fields identified in ICNIRP

Technical Benchmarking

- Review of existing solutions
 - Only one operating installation (2016), the rest at research stage
 - Efficiency (wireless) in 70%-80% range, vs >90% for static
 - Lack of cost/benefit analyses
 - Communications mostly based on IEEE 802.11p, using wired-solution protocols
 - Only conductive solutions close to “market ready”
- Gap Analysis
 - Identifies the gaps between the current solutions and user needs and requirements
 - >50 gaps identified, 25 categorised as high or very high priority
 - Significant need for standards in all areas
- Interoperability
 - Considered interoperability between 8 systems
 - Significant interoperability gaps reflect need for standards

Specifications

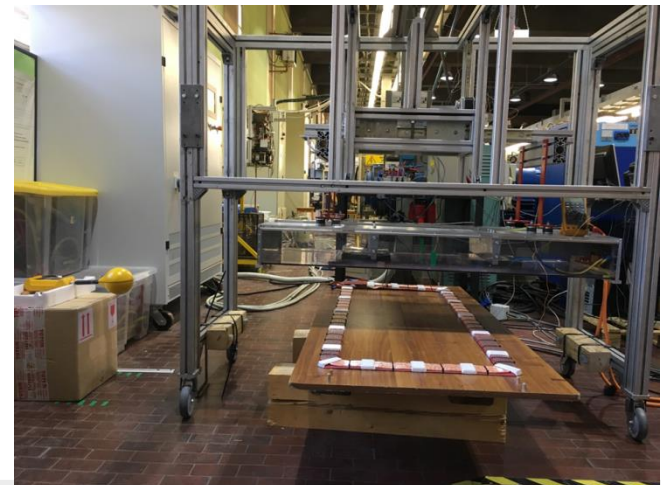
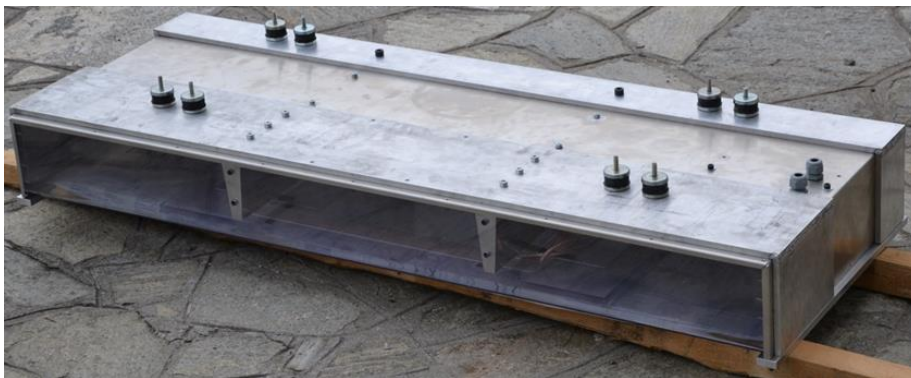
- Road Installation
 - Specifications developed based on UK road standards
 - WPT installations must meet all current standards for road installations
 - Structural integrity must be maintained
 - High temperature during laydown (up to 200°C) is a concern
- Grid Connection
 - Analysis based on electrical standards and communications for demand side management
- Vehicle Installation
 - Detailed specifications developed for 3 vehicle OEMs
- Safety Aspects
 - Analysed by 4 project partners for wireless, and 1 for conductive
 - Proposed solutions comply with standards, but still issues to address

Define Architecture

- To define vehicle equipment and on-road equipment architecture definition and evaluation, including the definition of interface between charging systems and energy distribution networks
- Vehicle equipment must satisfy electromagnetic, thermal and mechanical requirements
- Vehicle installation analysed w.r.t. NVH and passive safety
- Different on-road systems analysed to determine common architectural elements
- Interface with grid dependent on power level, not technology used
- Integration of local energy storage would be beneficial
- Findings used to define global dynamic power transfer architecture

Design

- Using specifications and architecture, design, develop and build prototype 3 DWPT systems
- Solution 1 developed by VEDECOM in conjunction with Qualcomm
 - Vehicle element installed in Renault vehicle
 - In-road elements installed at Satory test track, Versailles
- Solutions 2 and 3 developed by POLITO and SAET respectively
 - Common vehicle elements installed in Iveco Daily
 - In-road elements installed at Susa track



Design – Feasibility studies

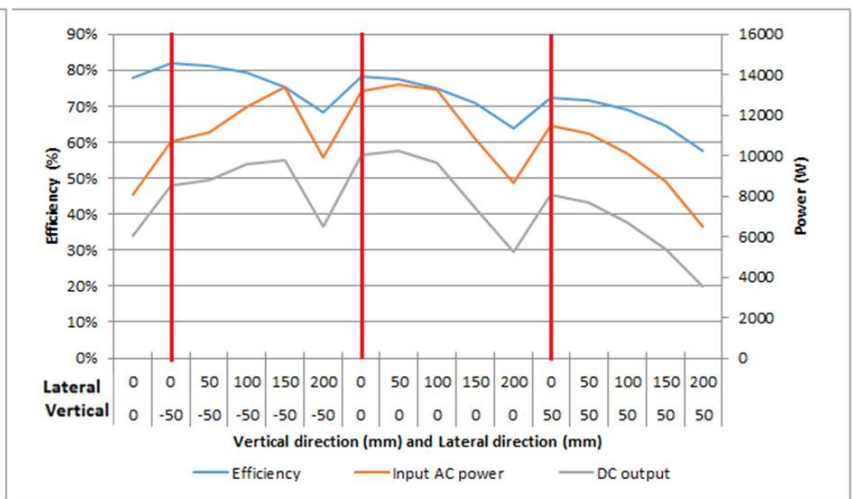
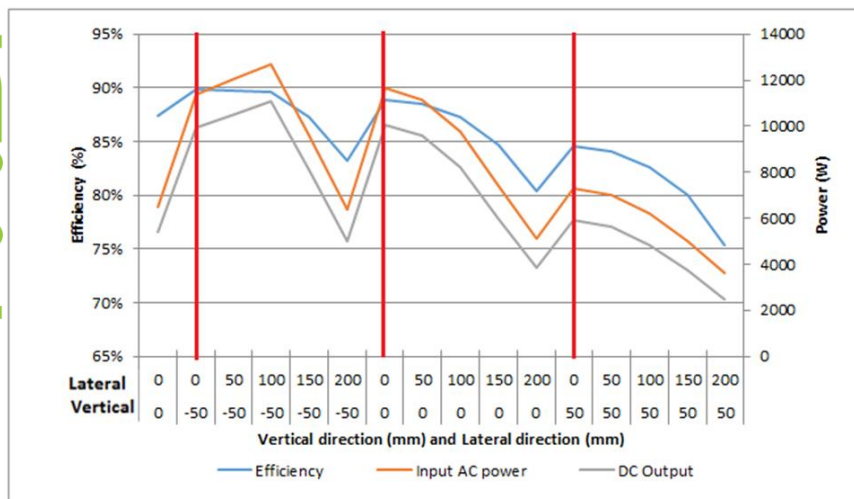
- Examine feasibility of using FABRIC solutions in other use cases:
 - Transfer of higher power levels, as required by HGVs
 - Higher vehicle speeds
 - Higher power levels will require redesign
 - Design using multiple coils more feasible
- Examine feasibility of using other solutions in FABRIC use cases
 - Alstom/Volvo conductive ERS
 - No impediments to implementing FABRIC use cases
 - Will require some adaptation to cope with all charging modes, but feasible
 - Bombardier/Scania Primove inductive power transfer
 - Existing in-vehicle hardware not suitable for cars
 - Modifications required for urban use case
 - Further development required to meet all charging modes

Technological Verification

- Produce verification specification:
 - Power transfer efficiency
 - Effect of misalignment
 - Lateral
 - Air-gap
 - Grid interference
 - Focus on total harmonic distortion
 - Impact on road and vehicle
 - Size and weight
 - Temperature
 - EMF
 - Measure EM fields for effect on user and on-vehicle electronics
 - Compliance with standards

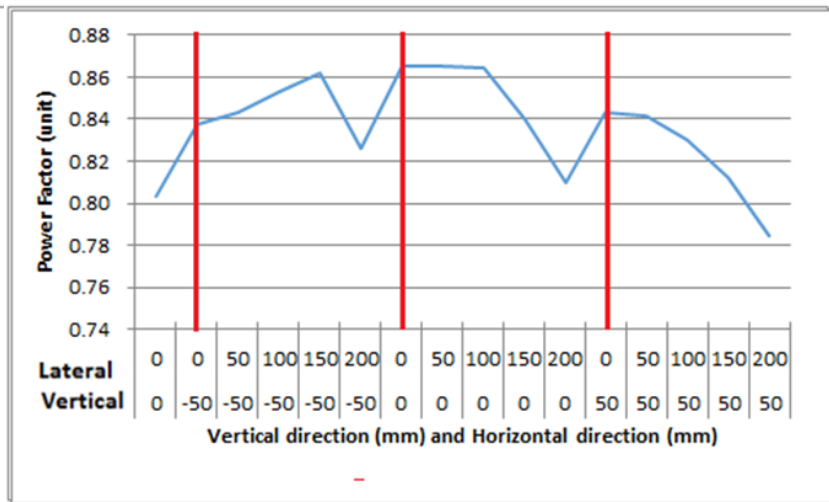
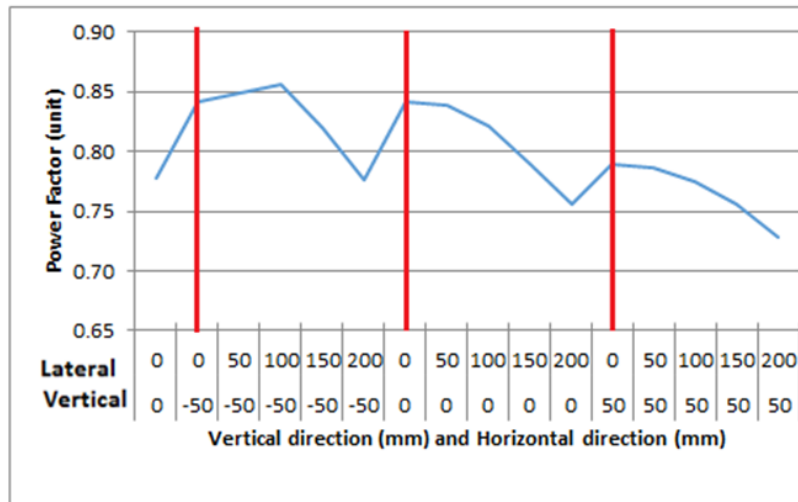
Technological Verification

- Conduct verification tests
 - Solution 1 (VEDECOM/Qualcomm) tested in Germany
 - Solutions 2 and 3 tested in Italy
 - Results from Project Victoria also considered
 - Prove design before road installation
- Analyse results from tests:
 - POLITO transfer efficiency > 90% (perfect alignment), SAET > 80%



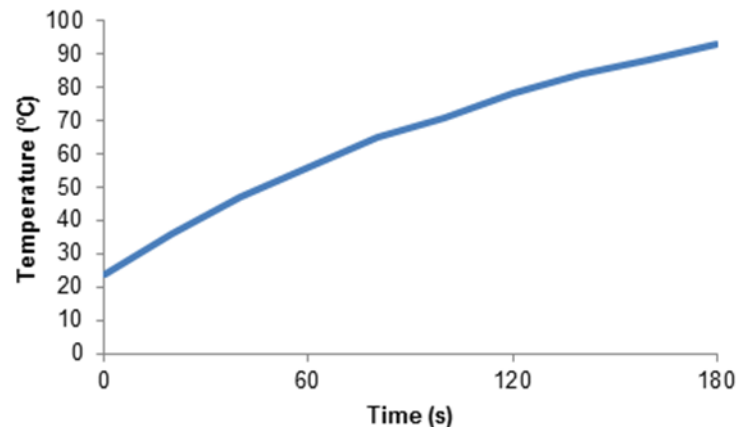
Technological Verification

- Harmonic distortion outside limits for both POLITO and SAET solutions
 - Believed caused by 6-pulse rectifier, solution s will be tested
- Power factor performance poor (<0.86), due to types of rectifiers used
 - Same solution as for distortion

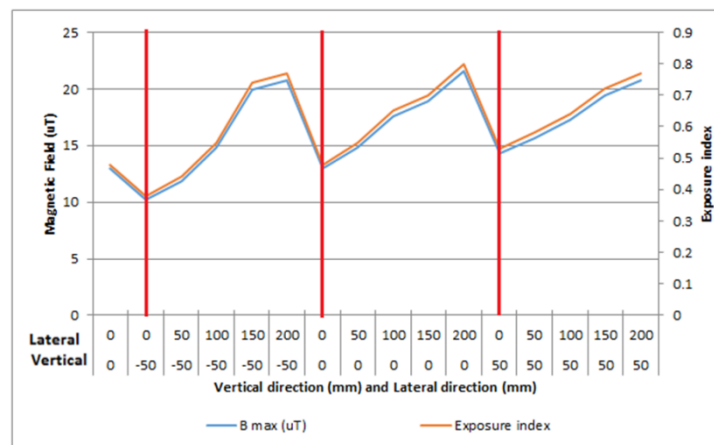
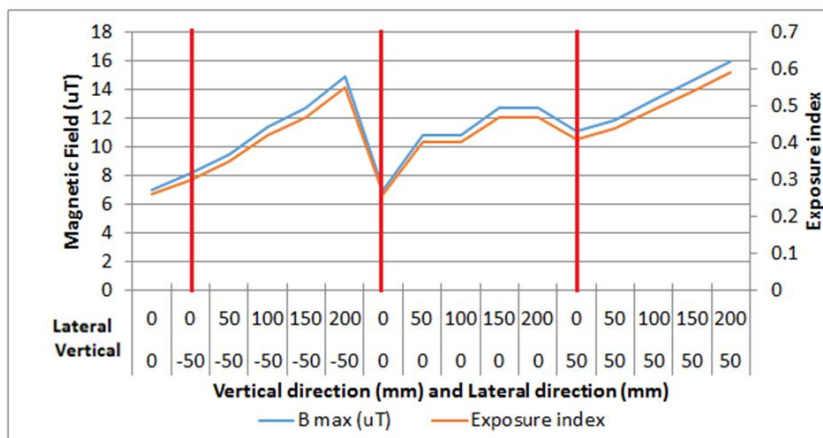


Technological Verification

- Temperature rise in primary coils mean cooling required for static applications (results from CIRCE)

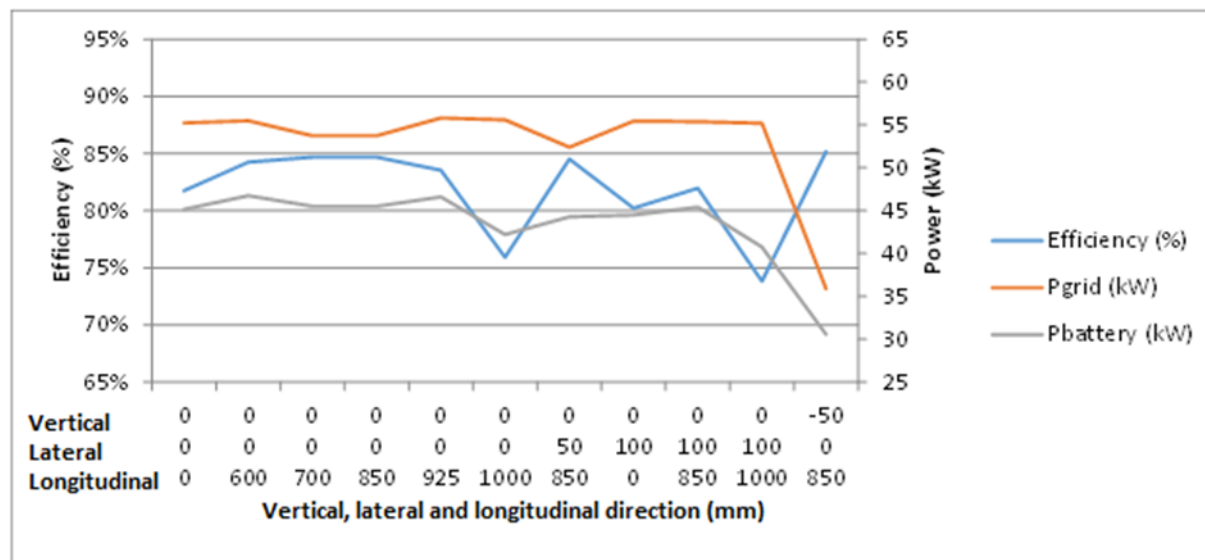


- EMF within limits



Technological Verification

- Results from Project Victoria show broadly similar results
 - Efficiency up to 85%
 - Quite tolerant of horizontal misalignment
 - Sensitive to vertical misalignment





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Thank you!



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